NON-COMMUNICABLE DISEASE PREVENTION: EVIDENCE FOR DIABETES AND TOBACCO CONTROL POLICIES IN ECUADOR

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Lay Abstract

In Ecuador, as in many developing countries, non-communicable diseases (NCDs) represent not only a health challenge but also an economic burden. This dissertation has three goals: 1. To study the relationship between diabetes management and equity; 2. To examine the impact of tobacco packaging, stick health warnings, price changes and illicit cigarette availability on the behaviours of smokers and nonsmokers; 3. To assess consumer preferences in Ontario-Canada, Ecuador, Chile and Colombia regarding different cigarette packs. The results of this dissertation provide important economic insights and apply novel methodologies to inform evidence-based policies for the prevention of NCDs in Ecuador, with potential relevance to other countries facing similar challenges.

Abstract

Non-communicable diseases (NCDs) are a leading cause of mortality and morbidity worldwide, disproportionately affecting low-and middle-income countries (LMICs). In Latin America, NCDs account for more than 80% of all deaths, with a significant share occurring in the young population, thereby creating an economic impact. Within this context, tobacco use continues to be a modifiable risk factor, closely linked to NCDs such as diabetes. The burden of NCDs is further exacerbated by the region's reliance on out-of-pocket expenditures, which deepens income inequalities in access to prevention and disease management.

Ecuador is a clear example of these challenges. Diabetes has become one of the leading causes of mortality and hospitalization in the country. Out-of-pocket expenditure in Ecuador remains high, representing nearly a third of the total health expenditure. Tobacco use is an important contributor to the increasing burden of NCDs, with a current smoking prevalence of 10% in the adult population.

Within this context, this dissertation aims to examine how individual behaviours and systemic factors interact to influence health outcomes and policy effectiveness. The first study analyzes how prevalence and management vary with socio-economic characteristics. The second study uses a Discrete Choice Experiment (DCE) to understand the potential impact of plain packaging, health warnings, price changes and illicit cigarette availability in the adult population of Ecuador. The last study examines consumer preferences in Canada (province of Ontario), Ecuador, Chile and Colombia, using the Becker-DeGroot-Marschak (BDM) auction mechanism to measure the willingness to pay (WTP) for plain packaging, stick warning, branded packs and illicit cigarettes. Together, these three studies offer new empirical evidence that is not only relevant for Ecuador but for similar LMICs.

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I come from Ecuador, a small country in South America. Since I had the opportunity to study and live outside my country, I have always wondered why developed countries and international institutions do not recognize the research needs of Latin America and the Caribbean, which could serve as the foundation for policies. That is when I promised myself that I would always prioritize my country's research needs. And here I am, many years later, keeping my promise.

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List of abbreviations

NCDs	Non-communicable diseases
WHO	World Health Organization
GDP	Gross domestic product
GBD	Global burden of disease
T2D	Type 2 diabetes
CORRE	Cost Recovery and Revenue Estimator
BDM	Becker-DeGroot-Marschak auction mechanism
WTP	Willingness to pay
DCE	Discrete choice experiment
OOP	Out-of-pocket expenditure
UNDP	United Nations Population Division
IDF	International Diabetes Federation
MSP	Ministry of Health Ecuador
INEC	Instituto Nacional de Estadisticas y Censos
PAHO	Panamerican Health Organization
STEPS	STEPwise survey
PSU	Primary sampling units
SES	Socio-economic status
HIC	High-income countries
LMIC	Low-and-middle-income countries
FCTC	Framework Convention on Tobacco Control

Clogit	Conditional logit
LCA	Latent class analysis
VAT	Value added tax
PMI	Philip Morris International
HiREB	Hamilton Integrated Research Ethics Board
IDRC	Canadian International Development Research Centre
BIC	Bayesian Information Criterion
ME	Marginal effect
SRI	Servicio de rentas internas
OTRU	Ontario Tobacco Research Unit
KW test	Kruskal-Wallis test
OLS	Ordinary Least Squares
PPP	Purchase Power Parity

Declaration of Academic Achievement

I, Tatiana Villacres, declare that this thesis titled "Non-communicable disease prevention: evidence for diabetes and tobacco control policies in Ecuador" and the work presented in it are my own. I conceptualized the three original studies myself but received feedback from my committee members on the scope of the studies. For Chapters 2-4, I independently analyzed and interpreted the data. The data collected for Chapters 3 and 4 were part of a multi-country research project funded through a grant from the Canadian International Development Research Centre (IDRC). The original design was led by McMaster University (Dr. Emmanuel Guindon) and approved by the Hamilton Integrated Research Ethics Board (HiREB). The protocol was customized to the Ecuadorian context and then approved by the Pontificia Universidad Catolica del Ecuador's Human Research Ethics Committee (Approval #CEI-122-2021). Dr. Michel Grignon provided me guidance at all stages of this dissertation. Dr. Jeremiah Hurley provided me with thorough revisions for chapters 1-5. Dr. Emmanuel Guindon provided revisions for chapters 2-4.

Chapter 1. Introduction

This chapter presents the overall rationale, research process, and contributions of the three core studies included in this dissertation (Chapters 2-4). It begins by providing an overview of non-communicable diseases (NCDs) and smoking, a risk factor associated with NCDs, with a particular focus on the Latin American region. It then explains the rationale for selecting Ecuador as a case study. Finally, the chapter outlines the specific aims, justification and relevant contributions of each of the three studies.

Non-communicable diseases and smoking

Noncommunicable diseases (NCDs) are the leading cause of death and disability globally, placing a substantial social and economic burden on individuals, their families and healthcare systems (1). According to the World Health Organization (WHO), NCDs account for three-quarters of deaths worldwide, with the majority happening in low and middle-income countries (approximately 80% of the total deaths), affecting especially the poor and vulnerable (2,3). A 2018 study found that, over a period of 15 years, the four leading NCDs (cardiovascular disease, cancer, chronic respiratory disease, and diabetes) and mental health conditions could result in economic losses equivalent to 1.0-2.5 years of gross domestic product (GDP) (4).

It is estimated that 50% of NCDs can be prevented by addressing common modifiable risk factors, including tobacco and alcohol use, air pollution, physical inactivity and consumption of unhealthy and ultra-processed foods and drinks (5). In addition, according to the latest data from the Global Burden of Disease (GBD), diabetes and kidney diseases are emerging as significant global health threats. Among all causes of health loss, diabetes experienced the most rapid growth,

after adjusting for age and population size. As of 2021, high blood pressure, smoking, and high blood sugar were the three leading risk factors for early death and poor health in all regions of the world. Forecasts to 2050 suggest that the burden of non-communicable diseases will rise (6).

Tobacco use, in particular, is a significant risk factor not only for cardiovascular diseases, cancer, and lung complications but also for the onset of type 2 diabetes (T2D) (7). The International Diabetes Federation identifies smoking cessation as a key strategy to prevent and manage T2D (8), and the 2014 US Surgeon General's Report states that smokers have a 30%-40% higher risk of developing diabetes when compared to nonsmokers (9). Notably, tobacco use remains one of the top ten risk factors for NCDs even in the poorest countries (5).

Consistent with global trends, NCDs are also the leading cause of preventable deaths, illness and disability in Latin America. They were responsible for 80.7% of all deaths in 2019 (10). Almost 28% of these deaths happen among individuals aged 25 to 65 years old, an age range associated with peak economic productivity (11). The increased life expectancy in this region has been associated with the rising incidence of NCDs (12). This matter has led to changes in health expenditure, not only for healthcare systems but also for patients and their families. Latin America is a region where health spending relies heavily on out-of-pocket expenditures, with a lack of universal coverage (10), and reactive healthcare systems rather than preventive ones (13).

While communicable diseases continue to be significant contributors to mortality and hospitalizations in Ecuador, the past decades have witnessed a growing importance of NCDs (14). As of 2022, diabetes was the leading cause of mortality in the general population. Its impact is even more pronounced among women, where it ranks as the second leading cause of death. Furthermore, diabetes stands among the top ten causes of hospitalization in the country (15). It is crucial to emphasize that these statistics do not account for the health complications associated

with diabetes. NCDs not only impose a significant burden on health but also create economic challenges for the healthcare system, patients, and their families. This complexity is heightened in a setting marked by increased out-of-pocket expenditure (16), where individuals in need of healthcare and at risk of diabetes are compelled to allocate a portion of their income to meet their health needs.

In Ecuador, tobacco use remains a significant public health problem. The Fourth National Survey on Drug Use among Students aged 12 to 17, conducted in 2012, reported higher tobacco consumption among those over 16 years old, with 8 out of 10 smoking more than five days a month for over two years (17). Among adults, 10.7% identified as current cigarette smokers. On average, daily smokers consumed 5 cigarettes per day. Within this group, 60% reported smoking fewer than five cigarettes per day, 25% smoked between five and nine, 11% between ten and fourteen, and 4% indicated smoking fifteen or more cigarettes per day (18).

Tobacco use not only affects population health but also imposes an important economic burden on individuals, families and the healthcare system. In terms of direct costs, total spending on treating diseases caused by tobacco use and exposure to second-hand smoke, the Tobacco Atlas' Cost Recovery and Revenue Estimator (CORRE) estimates an annual financial cost of 0.1% of Ecuador's GDP. However, this figure only represents a portion of the total economic cost borne by the Ecuadorian society (19). The productivity loss resulting from illness and premature deaths linked to tobacco use is significantly higher, exceeding the direct costs by more than threefold. It is estimated that Ecuador loses, on average, 0.2% of their GDP annually due to these productivity losses (19).

However, these estimates are considered conservative. Broader assessments suggest that tobacco use generates more than 1% of their GDP annually in direct medical costs, over 0.3% of

the GDP, and an additional 0.3% of GDP in informal care costs (20). Combined, these losses represent more than 1.3% of the country's GDP (20).

In Ecuador, out-of-pocket payments (OOP) represent, on average in 2022, 33% of total health expenditure (16). This means that, given the heavy reliance on OOPs for financing health care in Ecuador, in addition to the indirect economic costs of tobacco use, individuals and their families must pay approximately one-third of the cost of treating tobacco-related diseases from their own resources. This places a disproportionate financial burden on low-income households, reducing their ability to meet other essential needs. In a context marked by high levels of underemployment, inequality, and rising poverty (21). The impact of this burden falls most heavily on the country's most vulnerable populations.

Like many countries, Ecuador faces a persistent challenge related to the illicit trade of tobacco products, with an estimated 51% of the tobacco market consisting of illicit cigarettes (22). This problem is exacerbated by both the strategic behaviour of the tobacco industry and weaknesses in the design and enforcement of mitigation efforts (22). Illicit cigarettes pose a serious threat to tobacco control, as they reduce the price of products, increasing their affordability and accessibility (23). In addition, illicit products often lack the mandated health warning and packaging regulations, which undermines the public health messaging and contributes to lost government revenue (24).

In light of the health and economic challenges posed by diabetes and tobacco use in Ecuador, this dissertation aims to examine how individual behaviours, and systemic factors interact to influence health outcomes and policy effectiveness. It is structured into three empirical chapters, each addressing a specific dimension of this broader research question. Together, these chapters

provide a comprehensive analysis of how socioeconomic inequality, individual decision-making and policy design interact to influence health outcomes in Ecuador and comparable LMICs.

Objectives of the Three Chapters

Similar to other LMIC regions, Latin America has been understudied in terms of the state of diabetes management, as well as the impact of cigarette packaging, prices and labelling policies on the behaviour of smokers and nonsmokers. Therefore, the objectives for each study are:

1. To study how the prevalence and management of diabetes vary with socio-economic characteristics such as sex, age, education, employment, income, ethnicity and marital status across the Ecuadorian population.
2. To understand the potential impact of plain packaging, stick health warnings, price changes and illicit cigarette availability in the adult population of Ecuador, using DCE as a method to understand the consumer preferences on intention to purchase and risk perception.
3. To examine the consumer preferences in four different countries (Ontario-Canada, Ecuador, Chile and Colombia), this study uses the Becker-DeGroot-Marschak (BDM) auction mechanism to elicit participants' willingness to pay (WTP) for various cigarette pack attributes, including plain packaging, stick warnings, branded packs, and illicit products.

While each chapter addresses a distinct research question, they are unified by a shared focus on non-communicable diseases and the behavioural and systemic factors that shape health outcomes. Tobacco use, a major modifiable risk factor for NCDs such as type 2 diabetes, is explored through consumer responses to potential policy interventions, while diabetes management is analyzed through the lens of inequality in access to care.

Dissertation contributions

This dissertation provides important insights through the findings of all three empirical chapters. Chapter 2 begins by examining socioeconomic inequalities in diabetes management using data from the 2018 STEPS survey, a nationally representative database that has rarely been used in academic publications and, to date, has not been applied to the study of diabetes in Ecuador. Understanding how socio-economic status influences the quality of diabetes management across different population groups is critical for designing effective health policies aiming to reduce the prevalence and overall burden of the disease.

It applies multinomial probit models and the Wagstaff concentration index to identify the extent and drivers of inequality among the different groups. The findings in Chapter 2 will inform health policy and program development, not only within Ecuador but also in other Latin American countries with similar socio-economic landscapes, thereby promoting broader regional health equity and improved diabetes management.

Chapter 3 uses a Discrete Choice Experiment (DCE) to explore how plain packaging, stick health warning, price and illicit cigarettes influence tobacco product appeal (measured by the willingness to buy for smokers and willingness to try for nonsmokers) and perceived health risks among Ecuadorian adults. This chapter complements the regional DCE publications by providing evidence from Ecuador, a country with a unique combination of high cigarette prices, strong warning label policies and a large illicit cigarette market. However, this is the first DCE performed in Ecuador and the first analysis on the effect of these policies on smokers and nonsmokers in a pre-implementation context.

A conditional logistic regression was used to model both choice behaviour and risk perception, with attributes (price, branded packaging, plain packaging, health warning on a stick and illicit pack) that were combined to identify the attractiveness of the different pack types (branded pack with no stick warning, branded pack with stick warning, plain pack with no stick warning, plain pack with stick warning and the illicit pack). Marginal effects and WTP were calculated for willingness to buy/try and perceived risk. Additionally, a latent class analysis (LCA) was conducted to identify unobserved subgroups with similar preference patterns, accounting for heterogeneity in responses.

Lastly, Chapter 4 applies the BDM auction mechanism to measure the WTP for legal (branded packs with no stick warning, branded pack with stick warning, plain pack with no stick warning, and plain pack with stick warning) and illicit cigarettes (only for Design 1) across Ecuador, Chile, Colombia and Ontario-Canada.

The four countries were selected due to their diverse levels of implementation of tobacco control policy, offering valuable insight into how consumers respond to tobacco control regulations and illicit market dynamics. This study contributes to filling a critical gap in the literature by including illicit cigarette packs in the analysis and enabling cross-country comparisons.

All three chapters provide results that are an important input to developing evidence-based health policies in Ecuador. This dissertation not only provides novel methods in each chapter but also uses either original data or secondary data that has not previously been analyzed. In particular, Chapters 3 and 4 are based on primary data collected as part of a multi-country research project in which I participated. Together, these studies offer new empirical evidence that is relevant not only for Ecuador but for similar low and middle-income countries.

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Chapter 2. Socioeconomic inequalities in the management of diabetes in Ecuador

Abstract

Background:

As in many Latin American countries, the prevalence and mortality of diabetes in Ecuador have increased over the years. The economic burden of diabetes is not only due to the high cost of treating the disease but also because the out-of-pocket expenditure is a barrier to accessing timely diagnosis and treatment. Therefore, this chapter aims to study how the prevalence and management of diabetes vary in relation to the socio-economic characteristics within the Ecuadorian population.

Methods

This study used the STEPS survey conducted in Ecuador in 2018. Based on the data from STEP 1 and STEP 3, six groups were created using three criteria: a) whether the individual had their blood sugar measured by a health professional; if yes, b) whether they had been diagnosed with diabetes; and c) the results of their fasting glucose levels measured by STEPS. A multinomial probit model was used to identify the association between the diabetes status and socio-economic characteristics. A second analysis was performed to estimate the degree of income-related inequality for diabetes using the Wagstaff concentration index.

Results

Age is an important factor that determines the likelihood of being diagnosed with diabetes or having high glucose level. Low education levels were associated with poorer diabetes outcomes. Income levels have an impact on diabetes management and prevalence. Income inequality plays a key role when accessing healthcare in Ecuador.

Conclusion

By detailing the socio-economic inequalities in diabetes management and prevalence in Ecuador, this study contributes valuable evidence that can inform targeted health policies and interventions in Latin America**.** The findings highlight a substantial proportion of undiagnosed and misdiagnosed individuals who require urgent attention. Designing policies that prioritize the population groups identified in this study can help prevent future health complications.

Introduction

Most low- and middle-income countries, including those in the Latin America region, have experienced an increase in prevalence and mortality due to uncontrolled diabetes (1). According to the 2021 Diabetes Atlas, whose projections are based on the population estimates from the United Nations Population Division (UNDP), 1 in 11 adults in South and Central America have diabetes, and 1 in 3 people with diabetes are undiagnosed. Moreover, the region is expected to see a 48% increase in people with diabetes by 2045 (2). This means that the number of people with diabetes in this subregion is estimated to be 33 million by 2030 and 55 million by 2045 (2).

The burden of diabetes is larger than the number of individuals living with the disease. It also impacts the economic stability of healthcare systems and the financial well-being of patients and their families. In many countries of Latin America, moreover, a substantial financial burden falls on patients and their families because out-of-pocket (OOP) payments play an essential role in the financing of the health care system (3,4). These OOP (all payments related to health care use that are borne by patients or families themselves at the point of use (5)) are increasing and represent a disproportionately higher share of income for people with lower income (6) (7), thus deepening the already large socioeconomic inequalities in the region (8). Also, because OOP costs represent a disproportionately large part of a low budget, individuals living in low-income households tend to forgo health care services that are seen as not urgent, such as screening and managing asymptomatic health issues, like the case of pre-diabetes or mild forms of diabetes. OOP payments generate large socio-economic inequalities in access to care since individuals from lower socio-economic status have a hard time accessing diagnosis services on time, and, even when they do, they do not have the means to manage their condition correctly, before it becomes symptomatic and generates functional impairment and drops in health-related quality of life (9). This study will

document what socio-economic factors explain the detection (and lack thereof) and management (or poor management) of pre-diabetes and diabetes in Ecuador.

Ecuador offers a compelling case study of the role of socio-economic factors on the prevalence and management of diabetes across populations. As in the rest of the Latin America region, the prevalence and mortality related to diabetes in this country have increased throughout the years (10). Although Ecuador is not one of the top countries in Latin America for prevalence, its expenditure related to treating a person with diabetes is among the highest, as of 2021 according to the International Diabetes Federation (IDF) (2). The importance of this economic burden was corroborated by Ferrana et al. (11), who estimated that for the 2020 to 2050 period, the total cost (direct and indirect costs) of diabetes and kidney diseases in Ecuador is projected to result in a GDP loss of $16 billion international dollars[1] (0.30% of the GDP). This forecasted loss is similar to that in Bolivia (0.30% of GDP), Brazil (0.29% of GDP), and Uruguay (0.29% of GDP), and higher than Peru (0.25% of GDP) (11).

Most importantly, Ecuador stands out for its high reliance on OOP expenditures, significantly exceeding the regional average. In 2021, Ecuador's OOP was 33% of current health expenditures[2] (as high as 63% in the early 2000s and as low as 30% in 2018 (7)), which is above the Latin American average of 26% and the average for the South American subregion of 24%. Ecuador is second only to Paraguay's 36% with Chile and Venezuela in the third and fourth place at 30 % and 28% respectively, followed by Peru at 27%, Bolivia and Brazil at 23%, Argentina at 22%, Uruguay at 15%, and Colombia at 14% (3). The high OOP represents a critical impediment

[1] US dollars using Parity Purchase Power (PPP) to be able to compare across countries
[2] Current health expenditure (CHE) corresponds to "the total final consumption expenditure on health care goods and services"(33)

to healthcare access, particularly for people with chronic diseases such as diabetes, given how costly their management and treatment are in the long term (13,14).

In addition, according to World Bank data, Ecuador's income inequality, measured by the Gini coefficient, is the third highest in South America, with 46 points (in 2022) and twenty-first in the world. Only Brazil and Colombia have a higher Gini coefficient in the region, with 53 and 52 points respectively. Peru is the regional country with the lowest score, 40 in 2021 (15).

These statistics not only highlight the socio-economic inequalities within Ecuador but also illustrate the country's barriers that hinder healthcare access. This challenge gets worse when considering poverty rates. As of December 2023, Ecuador's national absolute poverty rate was 26.0%, and the rate of extreme poverty was 9.8% (A person is considered poor if their per capita family income is less than USD 89.29 per month, and extremely poor if it is less than USD 50.32) (16). The urban areas reported lower levels of poverty at 18.4% and extreme poverty at 3.3%. However, the situation is different in rural areas for they face higher poverty rates at 42.2% and extreme poverty at 23.7%. In addition to this, the multidimensional poverty index, which reflects what deprivations a person experiences at the household level across four dimensions (1. Education, 2. Work and social insurance, 3. Health, water and food, 4. Housing and a healthy environment), was 37.3% nationally but varied dramatically between urban (23.0%) and rural areas (67.9%) (17). For regional comparison, according to 2021 World Bank data, 3.6% of Ecuador's population lives below the international poverty line of $2.15 a day (2017 PPP), ranking it third highest in the South American region, exceeded only by Brazil at 5.8% and Colombia at 7.3%, with no available data for Venezuela (18).

Understanding how socio-economic status influences the quality of diabetes management across different population groups is essential for designing effective health policies aimed at

reducing the prevalence and overall burden of the disease. Therefore, the objective of this research is to study how the prevalence and management of diabetes vary with socio-economic characteristics such as sex, age, education, employment, income, ethnicity and marital status across the Ecuadorian population. The findings will inform health policy and program development, not only within Ecuador but also in other Latin American countries with similar socio-economic landscapes, thereby promoting broader regional health equity and improved diabetes management.

Data and methods

To determine such association, this study applies econometric tools to understand who (based on socio-economic and demographic characteristics) is more likely to have undiagnosed diabetes or diagnosed but poorly managed diabetes. The section below will explain the data and methods used to achieve the research objective.

Data:

The study uses a data set known as STEPS, specifically designed by the World Health Organization (WHO) to study how non-communicable diseases (NCDs) in middle- and low-income countries are diagnosed and controlled. The data utilized in this study is derived from the 2018 STEPS survey, a collaborative effort by the Ministry of Health (MSP) and the Instituto Nacional de Estadisticas y Censos (INEC), in coordination with the Pan American Health Organization (PAHO). The PAHO/WHO STEPwise (STEPS) survey is administered to a sample representative of the national population of each country (136 STEPS surveys have been conducted to date, with eight of them specifically within the Region of the Americas (19)) and follows a standardized methodology for the collection, analysis, and dissemination of data pertaining to the

primary risk factors associated with NCDs (20). In Ecuador, the data was collected in May and June 2018.

Aligned with the Global Monitoring Framework for NCDs, this survey adopts an approach based on 25 key indicators designed to monitor progress in NCD prevention. Comprising three distinct "steps" (20), the survey serves as a comprehensive tool for assessing and understanding NCD risk factors:

In Step 1, information on demographic, health status and NCD risk factors is collected through self-reports, including data on tobacco use, alcohol consumption, diet, physical activity, cervical cancer screening, body mass, blood pressure, blood glucose, and blood lipids.

Step 2 involves the collection of physical measurements, including height, weight, waist circumference, and blood pressure.

In Step 3, the survey incorporates biochemical measurements, specifically fasting blood glucose, total cholesterol levels, and urinary sodium (21) .

In the Ecuadorian context, the population sampled comprised adults between 18 and 69 years living everywhere in the country except in the Galapagos Island region, which represents 0.2% of the Ecuadorian population (22). The sampling methodology employed a three-stage probabilistic sampling approach (23):

1. Selection of 448 primary sampling units (PSU) in each of the 25 strata (24).
2. Selection of 16 occupied dwellings within each primary sampling unit selected in the first stage, giving a total of 6,680 dwellings for data collection[3].

[3] It was 12 dwellings at the beginning of the survey but due to the high rates of occupancy change in the country, it increased to 16.

3. Selection of one person between 18 and 69 years of age per dwelling at random.

Information could not be collected due to: the dwelling being unoccupied (438 or 6.6% of selected dwellings) or temporarily occupied (259 or 3.9%), inhabitants could not be reached (237 or 3.6%), occupants refused to take the survey (293 or 4.4%) or a host of minor different reasons (12.2% that included: destroyed housing, housing converted into business, housing under construction and other reasons). To summarize, 30% of the overall dwellings were non-responsive, but reasons linked to occupants of the dwellings represented only 8% of the initial sample.

At the end, information was collected from 4,641 households. Post-randomization weights were calculated by the Ministry of Public Health and the INEC to align the resulting sample at the margins on sex and age with the population projections for 2018 (based on the 2010 population census).

Figure 1 and Figure 2, illustrates the relative weights (the ratio of each observation's weight to the mean weight), which demonstrate substantial variation among them (25). For instance, the relative weights in the case of STEP 1 ranged from 0.07 to 6.82, while for STEP 3, it varied from 0.07 to 8.81. The high relative weights could cause some observations to have disproportionate influence in the results, potentially introducing bias to the estimations. Therefore, the decision was made not to use weights for this study, allowing me to present the analysis in terms of the STEPs survey participants.

Figure 1. Distribution of relative weight corresponding to STEP 1

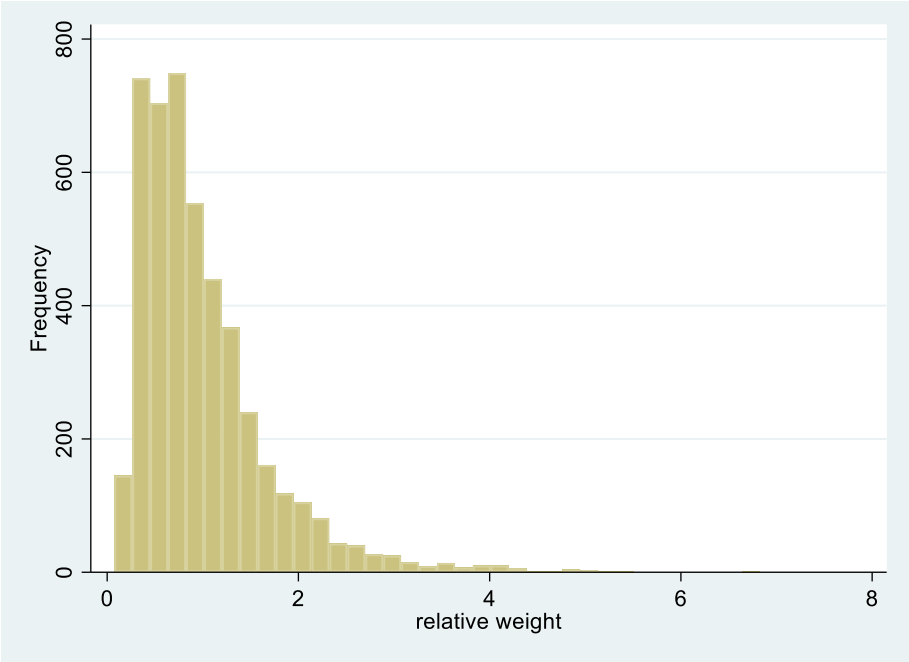
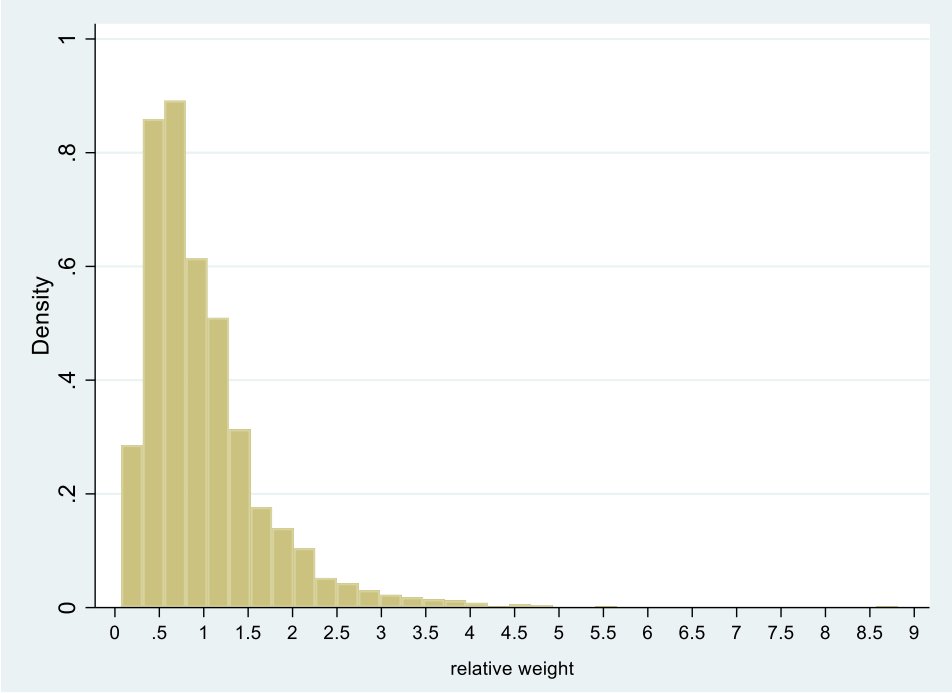


Figure 2. Distribution of relative weight corresponding to STEP 3



Variables:

Based on the data from STEP 1 and STEP 3, I categorized the sample into six groups using three criteria: a) whether the individual had their blood sugar measured by a health professional; if yes, b) whether they had been diagnosed with diabetes; and c) the results of their fasting glucose levels measured by STEPS. Those who did not take the glucose test in STEP 3 (528 cases), are excluded from the study. The six groups are defined as follows (see **Error! Reference source not found.**):

1. Controlled diabetics: People who have been told by a doctor or other healthcare professional that they have diabetes or raised blood sugar levels and blood test in STEPS indicates that they have low fasting glucose levels.
2. Uncontrolled diabetics: People who have been told by a doctor or other healthcare professional that they have diabetes or raised blood sugar levels and blood test in STEPS indicates that they have intermediate or high fasting glucose levels.
3. Undiagnosed high-risk: People who have never had their blood sugar levels tested before and the blood test in STEPS indicates that they have intermediate or high fasting blood glucose levels.
4. Undiagnosed normal: People who have never had their blood sugar levels tested before and the blood test in STEPS indicates that they have normal fasting blood glucose levels.
5. Misdiagnosed high-risk: People who have been told by a doctor or other healthcare professional that they do not have diabetes but a blood test in STEPS indicates that they have intermediate or high fasting blood glucose levels.

6. Confirmed non-diabetic: People who have been told by a doctor or other healthcare professional that they do not have diabetes and whose blood tests in STEPS indicate that they have normal fasting blood glucose levels.

Table 1 Definition of the six groups

				Results of measured fasting glucose levels	
				Normal	High
Blood sugar measured by a health professional	Yes	Have been told they have diabetes	Yes	1) Controlled diabetics	2) Uncontrolled diabetics
			No	6) Confirmed non-diabetic	5) Misdiagnosed high-risk
	No			4) Undiagnosed normal	3) Undiagnosed high-risk

Controlled diabetics and uncontrolled diabetics are those who had previously accessed the healthcare system and received a diabetes diagnosis. The distinction between them lies in their glucose levels; controlled diabetics maintain controlled glucose levels, in contrast to uncontrolled diabetics, where glucose levels remain high. According to the Ecuadorian Clinical Practice Guideline for Diabetes, individuals with fasting glucose levels equal to or exceeding 126mg/dl are classified as diabetic, while those with levels between 110mg/dl and 125mg/dl fall into the pre-diabetic category (26). Based on this biomedical cut-points the individuals considered high-risk were those whose fasting glucose levels were greater or equal to 110mg/dl.

Undiagnosed high-risk and undiagnosed normal have not accessed a healthcare professional and/or test to diagnose diabetes. Nevertheless, they participated in the STEPS survey's

blood test to determine their fasting blood glucose levels. Individuals in the undiagnosed high-risk exhibited intermediate to high glucose levels, indicating possible pre-diabetes or diabetes.

Lastly, misdiagnosed high-risk and confirmed non-diabetics are individuals who accessed the healthcare system and were informed by healthcare professionals that they did not have diabetes. However, during the STEPS survey, blood tests for misdiagnosed high-risk individuals revealed intermediate or high fasting glucose levels, suggesting potential undiagnosed conditions. Conversely, confirmed non-diabetic test results were within the normal range. The number of observations per group can be found in Table 2.

Table 2 Number of observations per group

Group	Number of observations
1) Controlled diabetics	136
2) Uncontrolled diabetics	130
3) Undiagnosed high-risk	251
4) Undiagnosed normal	1,784
5) Misdiagnosed high-risk	242
6) Confirmed non-diabetic	1,487
Total	4,030

The following variables were identified as key Socio-economic status (SES) factors in explaining the diverse scenarios related to diabetes management and prevalence:

In the case of age, it was recorded as a continuous variable in the survey. While I used age in its continuous form for all estimations, I categorized it into two groups for the descriptive analysis: 18 to 44 years and 45 to 69 years. These age groups were defined by the Ministry of Public Health in their report.

The education variable was generated based on the information from question C5, related to the highest level of education completed. There were originally 10 categories in question C5, to make analysis easier, I reduced them to five categories according to the level of education, as follows:

- No formal schooling: no education level completed.
- Primary school: from 1 to 6 years of elementary school education completed.
- High school: individuals that completed elementary and secondary school education.
- College/University/Graduate Degree: people who completed at least a college or university undergraduate education.
- Refused to answer

For self-reported ethnicity, the survey originally identified six ethnic groups in question C6. These were consolidated into three categories for the analysis, based on the definition of each ethnicity that INEC uses for all surveys:

- Indigenous: An important percentage of the population identifies as such.
- Afro-descendent: A group comprised of afro-Ecuadorian, black, *mulato* (mix of white and black) and *montubio* (mix of indigenous and black).
- Mestizos and whites: A group comprised of mestizos (mix of white and indigenous, the vast majority of Ecuadorians) and whites.
- Refused to answer

In the case of employment, the information from the 10 categories in question C8, was transformed into 6 categories for the analysis. These new categories were created based on the status of employment (formal or informal), and different reasons for not working (housewife, students and retired, unemployed):

- Formally employed: People who have a formal contract in the private or public sector.
- Employed in the informal sector: Individuals employed by companies that have not been formally registered in accordance with national regulations.
- Housewife
- Students and retired
- Unemployed: This category includes those who are not working but actively seeking a job, and those that cannot work for some reason.
- Refused to answer

To classify marital status, I used the information from question C7. I differentiated those who live alone and those who have a partner:

- Single, separated, divorced and widow
- Married, cohabiting
- Refused to answer

Income information was collected using two questions, C10 and X1. C10 collected information on annual income in a continuous manner. For those who refused to provide that continuous information on income, question X1 suggested categories within which respondents could indicate their monthly income. I used the mid-point of each category to calculate a monthly

and then yearly income for respondents to X1, making their responses comparable to those of C10. I then calculated the deciles of the distribution of income and used the income decile of each respondent as the variable describing income.

Detailed information for these variables can be found in Table 3:

Table 3. Recoding and grouping of variables.

Variable	New Variable	Original Variables Used
Education		
1	No formal schooling	Without official schooling, literacy center
2	Primary school	Primary education, basic education
3	High school	Secondary education, middle school/ high school
4	College/University/ Graduate degree	Non-university higher education, university higher education, graduate studies
88	Refused to answer	
Ethnicity		
1	Indigenous	Indigenous
2	Afro-descendent	Afroecuatorianos, Negros, Mulatos, Montubios
3	Mestizo, White	Mestizos, White, Others
88	Refused to answer	
Employment		
1	Formally employed	Employed public sector, employed private sector
2	Employed in the informal sector	Self employed, works with no payment
3	Housewife	Housewife
4	Student and retired	Student, retired
5	Unemployed	Unemployed but cannot work, unemployed and willing to work
88	Refused to answer	
Marstat		
1	Single, separated, divorced, widow	Single, separated, divorced, widow
2	married, cohabiting	Married, cohabiting
88	Refused to answer	
Income decile	Total annual income grouped in deciles	Taking the past year, can you tell me what the average income of the house hold have been? Can you give an estimate of the annual household income if I present some options to you?

Methods:

The analysis to identify the association between diabetes status and SES characteristics used two models: binary probit and multinomial probit. These two models were used for they deal with categorical dependent variables, estimating the probability of belonging to a specific group relative to a baseline, considering multiple explanatory variables, such as: sex, age (continuous), education, ethnicity, marital status, employment status, and income deciles.

The first model collapsed the full set of six diabetes categories to only two: at-risk and controlled populations. At-risk included: uncontrolled diabetics, undiagnosed high-risk, undiagnosed normal and misdiagnosed high-risk. The reason for including the high-risk groups in this category is that they require attention to their health condition due to high glucose levels. The undiagnosed normal are included here because they did not know their health status since they have not accessed the healthcare system prior to participating in the STEPS survey. Those in the controlled group are controlled diabetics and confirmed non-diabetic. Since the dependent variable was a dichotomous and categorical variable, a binary probit model was chosen.

The second model used a multinomial probit with all six categories as the dependent variable, using the confirmed non-diabetic as the reference category. Confirmed non-diabetics represent an optimal scenario where an individual got access to healthcare professionals who indicated that the person does not have diabetes, and the fasting glucose test in the STEPS survey confirmed this diagnosis. Since there were different categories in the dependent variable, and the aim of the model was to understand the influence of the SES, a multinomial probit model was appropriate.

The explanatory variables were categorized into dummy variables having the following as reference categories: male, with university-level education, mestizo, single, formally employed, and in the highest income decile (decile 10). Additionally, age was included as a continuous variable. This standardization allowed a comparison of how the dynamics of diabetes differed across socio-economic statuses and demographics.

The second analysis performed estimated the degree of income-related inequality for diabetes. This analysis used the Wagstaff concentration index to identify the income-related inequality level and the contributing factors. For this study, the Wagstaff index was calculated for

each of the six groups, representing different categories of glucose control and awareness. These groups are composed of different populations that vary in terms of their socio-economic status, access to healthcare, and health behaviours (27) (28).

Given that the analysis involves a bounded, dichotomous variable (i.e., whether an individual belongs to a specific diabetes group), the choice between the Erreygers and Wagstaff indexes had to be made. The Wagstaff index was selected because I prefers it properties (e.g., of it "answers the question of how far the society is, given its overall level of health, from a state where only the individuals at the top of the income distribution are healthy" (29). It is also a mixture of a relative and absolute measure (27), considering information on both the relative distribution of the groups across income and the absolute differences linked to the overall prevalence of the outcome

Each group's index was then decomposed to provide a deeper understanding of the dynamics that underlie the income-related inequality (30). The decomposition included the following variables: demographic (female, age group), behavioural (tobacco consumer, alcohol consumer, fruit and vegetable consumption as well as physical activity levels according to the recommendations by WHO (31) and socioeconomic (no school, primary, high school, indigenous, afro-descendent, informal worker, housewife, student or retired, unemployed, married). Performing this decomposition helped identify the variables that correlate with income-related inequality within each group, aligning to uncover the underlying factors that intensify health disparities.

The methods previously explained provide an analysis from both a macro (population-wide) and micro (within each group) perspective to understand how inequities influence the

prevalence and management of diabetic patients in the Ecuadorian context, offering important details for the development of health policies.

Results

Description of the sample:

Table 4 shows the distribution of the sample across the various categories of the dependent and independent variables.

A total of 4,628 people participated in the survey, of which 58% were women and 60% were between the ages of 18 and 44 years old, with a mean age of 41 years.

The level of education among participants was low, since 53% of the population had no formal schooling or attended primary school only. This resembles the education context in the country, according to the 2010 census, 51% of the population indicated that they have the previously mentioned schooling levels (22).

Ecuador is a country with an important percentage of indigenous and afro descendant population, and an overall majority of mestizos. In the survey, 8% of the participants reported being indigenous and 12% afro-descendant (22).

The greatest proportion of the participants work in the informal sector, which means that they are not covered by public social insurance, including health coverage. Only 30% of the interviewed have formal employment, which resembles the reality of the country as estimated by the Employment, Unemployment, and Underemployment Survey (17).

Table 4 also lists the distribution of the sample across the six diabetes categories. The undiagnosed normal group is the largest group in the sample. Younger individuals are

predominantly in the undiagnosed normal group, while older age is more common in the uncontrolled diabetics. While higher educational levels are observed among the controlled diabetics, lower levels of education are a characteristic of the undiagnosed high-risk group. Diabetics (controlled and uncontrolled) show higher percentages of informal employment and housewives, aligning with their older demographics. Income variability is notable across groups, with lower income deciles more prevalent in the controlled diabetics, undiagnosed high-risk and misdiagnosed high-risk.

Table 4 Description of the same population in each group

Description of population in each group

Variable	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
	Total population in the survey		Controlled diabetics		Uncontrolled diabetics		Undiagnosed high-risk		Undiagnosed normal		Misdiagnosed high-risk		Confirmed non-diabetic	
Sex														
Men	1,939	41.9%	53	39.0%	55	42.3%	105	41.8%	797	44.7%	91	37.6%	567	38.1%
Women	2,689	58.1%	83	61.0%	75	57.7%	146	58.2%	987	55.3%	151	62.4%	920	61.9%
Age group														
18-44	2,798	60.5%	63	46.3%	29	22.3%	125	49.8%	1,266	71.0%	102	42.1%	842	56.6%
45-69	1,830	39.5%	73	53.7%	101	77.7%	126	50.2%	518	29.0%	140	57.9%	645	43.4%
Education														
No formal schooling	511	11.0%	10	7.4%	18	13.8%	45	17.9%	214	12.0%	29	12.0%	132	8.9%
Primary school	1,934	41.8%	56	41.2%	61	46.9%	134	53.4%	837	46.9%	119	49.2%	521	35.0%
High school	1,536	33.2%	41	30.1%	28	21.5%	59	23.5%	595	33.4%	49	20.2%	550	37.0%
College/University/ Graduate degree	643	13.9%	29	21.3%	23	17.7%	13	5.2%	137	7.7%	45	18.6%	281	18.9%
Refused to answer	4	0.1%							1	0.1%			3	0.2%
Ethnicity														
Indigenous	378	8.2%	3	2.2%	2	1.5%	28	11.2%	172	9.6%	9	3.7%	55	3.7%
Afro-descendent	560	12.1%	17	12.5%	27	20.8%	31	12.4%	234	13.1%	25	10.3%	182	12.2%
Mestizo, White	3,688	79.7%	116	85.3%	101	77.7%	192	76.5%	1,377	77.2%	208	86.0%	1,249	84.0%
Refused to answer	2	0.0%							1	0.1%			1	0.1%
Marital Status														
Single, separated, divorced, widow	2,113	45.7%	59	43.4%	54	41.5%	111	44.2%	828	46.4%	106	43.8%	659	44.3%
married, cohabiting	2,510	54.2%	77	56.6%	74	56.9%	140	55.8%	954	53.5%	135	55.8%	828	55.7%
Refused to answer	5	0.1%			2	1.5%			2	0.1%	1	0.4%		
Employment														
Formally employed	1,373	29.7%	43	31.6%	32	24.6%	58	23.1%	500	28.0%	75	31.0%	472	31.7%
Employed in the informal sector	1,625	35.1%	45	33.1%	52	40.0%	115	45.8%	626	35.1%	90	37.2%	477	32.1%
Housewife	1,022	22.1%	28	20.6%	31	23.8%	63	25.1%	397	22.3%	57	23.6%	340	22.9%
Student and retired	334	7.2%	11	8.1%	6	4.6%	8	3.2%	138	7.7%	14	5.8%	103	6.9%
Unemployed	270	5.8%	9	6.6%	9	6.9%	7	2.8%	122	6.8%	6	2.5%	93	6.3%
Refused to answer	4	0.1%							1	0.1%		0.0%	2	0.1%
Income deciles														
1	456	10.2%	12	9.0%	12	9.4%	46	18.5%	199	11.5%	19	8.2%	120	8.3%
2	578	12.9%	15	11.2%	16	12.5%	32	12.9%	224	12.9%	26	11.2%	146	10.1%
3	343	7.7%	8	6.0%	14	10.9%	27	10.9%	155	8.9%	13	5.6%	105	7.3%
4	426	9.5%	10	7.5%	12	9.4%	28	11.3%	194	11.2%	27	11.6%	128	8.9%
5	462	10.3%	16	11.9%	10	7.8%	14	5.6%	165	9.5%	20	8.6%	175	12.2%
6	483	10.8%	13	9.7%	11	8.6%	24	9.7%	214	12.3%	22	9.4%	153	10.6%
7	390	8.7%	14	10.4%	11	8.6%	22	8.9%	152	8.8%	23	9.9%	114	7.9%
8	448	10.0%	12	9.0%	15	11.7%	19	7.7%	175	10.1%	28	12.0%	134	9.3%
9	533	11.9%	20	14.9%	16	12.5%	27	10.9%	171	9.9%	27	11.6%	207	14.4%
10	363	8.1%	14	10.4%	11	8.6%	9	3.6%	84	4.8%	28	12.0%	158	11.0%
Total in group	4,628		136	2.9%	130	2.8%	251	5.4%	1,784	38.5%	242	5.2%	1,487	32.1%

First analysis: multinomial probit (influence of each socio-economic factor)

When comparing the likelihood of being in the at-risk group versus the low-risk group, factors such as low education levels, being indigenous and being in the first, second, fourth, seventh or eighth deciles were associated with a higher likelihood of being in the at-risk group (misdiagnosed, undiagnosed (uncontrolled or normal) or uncontrolled diabetic). Being a female and being young are associated with a lower likelihood of being in the at-risk group. Please refer to Appendix 1 for detailed results.

Results for the multinomial probit analysis using all six diabetes groups are presented in Table 5, which lists the marginal effects of the different socio-economic factors (The underlying coefficient estimates for the multinomial probit regression can be found in Appendix 2 and Appendix 3.) For instance, age is the only variable that was statistically significant for five of the six groups. Despite this, the probability associated with an increase in age of 10 years related to each group is small, except for the undiagnosed normal. This group has a 10% decrease in the probability of being undiagnosed with normal glucose levels with an increase in age of 10 years.

Being a female decreases the probability of not accessing the healthcare system and having normal glucose levels by 8 percentage points compared to men (undiagnosed normal). However, the probability of a female being confirmed non-diabetic is 6% higher than a male.

Regarding education, statistical significance with positive coefficients was found for the undiagnosed high-risk and the undiagnosed normal groups. The results reveal a consistent pattern where individuals with less than a university education have a higher probability of not accessing the healthcare system and thus being undiagnosed. For instance, those with no formal education have a 5% increase in the probability of being undiagnosed high-risk compared to those who have

a university-level education. Additionally, lower education decreases the probability of being a controlled diabetic or a confirmed non-diabetic.

Ethnicity plays an important role in the opportunity of accessing the healthcare system and overall health outcomes. Being indigenous increases the probability of being undiagnosed normal by 16%, while decreasing the chances of being confirmed non-diabetic by 11%, when compared with the mestizo population.

Employment categories as well as marital status did not show statistically significant differences across most groups compared to formally employed individuals and single.

For both controlled and uncontrolled diabetics, no income decile was statistically significant. However, coefficients were positive and significant for those undiagnosed and negative for misdiagnosed. For instance, having low income (decile 1) increases the probability of being undiagnosed high-risk by 4% and undiagnosed with normal glucose levels by 11%, compared to the richest decile. The second income decile has an 12% higher likelihood of being part of the undiagnosed normal group, and a 10% less probability of being a confirmed non-diabetic. Higher-income deciles were associated with greater probabilities of pertaining to the undiagnosed normal group and negative probabilities of being confirmed non-diabetic.

Table 5 Average marginal effects based on the multinomial probit results

	Average marginal effects (Delta-method)					
	Controlled diabetics (n=136)	Uncontrolled diabetics (n=130)	Undiagnosed high-risk (n= 251)	Undiagnosed normal (n=1784)	Misdiagnosed high-risk (n=242)	Confirmed non-diabetic (n=1487)
Female	0.01	0.00	0.00	-0.08**	0.01	0.06**
No school	-0.04**	-0.02	0.05**	0.22**	-0.02	-0.20**
Primary	-0.02	-0.01	0.05**	0.17**	0.00	-0.18**
High school	-0.01	-0.01	0.03**	0.09**	-0.03**	-0.06**
Indigenous	-0.02	-0.03	0.02	0.16**	-0.02	-0.11**
Afro-descendent	0.00	0.02**	-0.01	0.01	-0.01	0.00
Married, cohabiting	0.00	0.00	0.00	-0.01	0.00	0.01
Employed in the informal sector	-0.01	0.00	0.01	0.02	0.00	-0.02
Housewife	-0.01	0.00	0.01	0.03	-0.01	-0.01
Student and retired	0.01	-0.01	-0.02	0.01	0.00	0.01
Unemployed	0.01	0.01	-0.04	0.03	-0.04	0.02
Age[a]	0.01**	0.02**	0.00	-0.09**	0.02**	0.04**
Decile 1	0.00	-0.01	0.04*	0.11*	-0.04	-0.10**
Decile 2	0.00	0.00	0.01	0.12**	-0.03	-0.10**
Decile 3	-0.01	0.01	0.02	0. 09**	-0.05**	-0.07
Decile 4	-0.01	0.00	0.02	0.10**	-0.01	-0.10**
Decile 5	0.01	0.00	-0.02	0.04	-0.03	0.00
Decile 6	0.00	0.00	0.01	0.10**	-0.03	-0.07**
Decile 7	0.01	0.01	0.02	0.09**	-0.01	-0.11**
Decile 8	0.00	0.01	0.00	0.10**	-0.01	-0.10**
Decile 9	0.00	0.00	0.02	0.04	-0.02	-0.05

*** p<0.05, *p<0.10; a: the coefficients were multiplied by 10, so that the average marginal effect shows two decimals.*

Second analysis: Estimation of the Wagstaff Index

As Table 6 shows, the Wagstaff Index of income-related inequality is statistically significant for all groups except uncontrolled diabetics. In the case of controlled diabetics, the positive value suggests a moderate concentration of this group among higher-income individuals. On the other hand, the significant positive index value ($p<0.01$) of the misdiagnosed high-risk group and confirmed non-diabetics are more concentrated in higher-income deciles.

In contrast, the negative index value, which is statistically significant ($p<0.01$), suggests a concentration of the undiagnosed high-risk and undiagnosed normal group among lower-income individuals. This highlights a disparity where lower-income individuals are more likely to face barriers that prevent them from accessing health care to determine their diabetes status.

Undiagnosed high-risk and misdiagnosed high-risk have the highest absolute values of the Wagstaff index. Both groups have high glucose levels, although the first one did not access the healthcare system, and the second one did. In the case of undiagnosed high-risk, this means that the lower one's income, the more likely they are to belong to this group of individuals who have not been tested for diabetes despite possibly having higher risk levels of glucose. On the other hand, having a 0.16 Wagstaff index for misdiagnosed high-risk shows individuals with higher incomes, despite having access to healthcare and receiving professional reassurance about not having diabetes, might still experience undetected or mismanaged glucose levels.

Table 6 Wagstaff concentration index for each of the groups

Group	Wagstaff Index Value	Robust std. Error	p-value
Controlled diabetics (n=136)	0.08	0.05	0.08
Uncontrolled diabetics (n=130)	0.04	0.05	0.39
Undiagnosed high-risk (n=251)	-0.17	0.04	0.00
Undiagnosed normal (n=1784)	-0.10	0.02	0.00
Misdiagnosed high-risk (n=242)	0.16	0.04	0.00
Confirmed non-diabetic (n=1487)	0.11	0.02	0.00

Decomposing the concentration index using the different demographic and socioeconomic variables indicated the role of these factors in explaining the income-related inequality for those in a particular diabetes group. Lower education levels generally increase the likelihood of being in less favourable diabetes groups (undetected or mismanaged diabetes conditions). This pattern is also observed among minority ethnic groups, particularly Indigenous and Afro-descendant communities. On the other hand, higher education level tends to be protective against being in adverse health groups (details can be found in Appendix 4).

Discussion

Research consistently links socioeconomic characteristics with the prevalence of NCDs, including diabetes (32–35). However, most studies on this topic have been carried-out in high income countries (HIC), with a scarce number of studies conducted for low-and middle income settings (LMIC), and even less for the Latin American region (32–35). While in HIC a lower diabetes prevalence was associated with higher education and income, that was not always the case in LMIC (32,36,37). Current research shows that in LMICs, diabetes prevalence tends to increase with higher income and, to a lesser degree, with better educational levels (34). Although many studies highlight the need for further analysis on this topic, the situation in Latin America presents

a complex picture. On one hand, there has been a notable increase in overweight and obesity, particularly among higher-income populations. On the other hand, undernutrition and hunger remain persistent challenges, disproportionately affecting those in the lowest income groups (38).

Contributing to closing the evidence gap in the Latin American context, this study provides a comprehensive analysis of how socioeconomic factors influence the prevalence and management of diabetes across different populations in Ecuador, revealing significant insights into health inequalities. The findings confirm the importance of age as a factor that determines the likelihood of being diagnosed with diabetes or having a high glucose level, consistent with findings in previous studies (32) . In addition, education emerges as a crucial socio-economic factor, with lower educational attainment strongly linked to poorer diabetes outcomes. Individuals with no or primary education only are significantly more likely to belong to groups with poor diabetes control or who have never undergone testing, underscoring the role of educational disparities in health equity.

Consistent with other studies, income levels profoundly impact diabetes management and prevalence, with findings indicating that lower-income deciles are more likely to be associated with worse diabetes outcomes (except the misdiagnosed high-risk group, which is associated with higher income deciles). Conversely, higher-income individuals tend to have better diabetes-related health outcomes (35,36,39–42).

In the multinomial probit model, the categories “controlled diabetic” and “uncontrolled diabetic” did not show statistically significant coefficients across income deciles, which is consistent with the results of the Wagstaff Index; for both groups, the WI had a *p*-value greater than 0.05. For the “undiagnosed high-risk” group, individuals in the poorest income decile had a coefficient of 0.04, indicating a higher probability of belonging to this group compared to those in

the richest decile. This finding aligns with the Wagstaff Index of –0.17, suggesting that this group is disproportionately concentrated among the lower-income population.

Similarly, for the "undiagnosed normal" group, several lower-income deciles had positive coefficients, implying a greater likelihood of being in this group compared to higher-income deciles. The corresponding Wagstaff Index of –0.10 further confirms that this group is more concentrated among the poorer segments of the population. In contrast, for the "misdiagnosed high-risk" group, income decile 3 showed a statistically significant negative coefficient (–0.05), indicating a reduced probability of misdiagnosis in this income group. The positive Wagstaff Index of 0.16 suggests that individuals in this category are more concentrated in the higher-income deciles.

For the "confirmed non-diabetic" group, the results were mixed. Most income deciles exhibited negative coefficients with no clear trend, suggesting that, except for deciles 3, 5, and 9, the probability of belonging to this group was lower compared to decile 10. However, the Wagstaff Index for this group was positive, indicating that those accurately identified as non-diabetic are more concentrated in higher-income groups.

Additionally, factors such as sex, ethnicity, and employment status show statistically significant associations with diabetes in specific instances, suggesting that these variables also contribute to the health disparities, which coincide with prior work, although the results related to the prevalence of diabetes and sex vary between studies (33,35,37,41).

The outcomes of this study align with those regarding health inequalities, showing that in the Ecuadorian setting, socioeconomic inequalities play a key role when accessing healthcare (43). Income is a well-studied social determinant of health, referred to as a barrier to accessing

healthcare services, but it is not the only one (14). However, a deeper understanding of how socio-economic factors affect an individual's likelihood of obtaining a diabetes diagnosis, receiving an accurate diagnosis, and achieving controlled glucose levels is crucial. To this end, it is essential to develop further research that examines these socioeconomic factors using the available data in LMICs, which remain underutilized. Such insights are essential for analyzing health inequalities and generating targeted interventions to mitigate these disparities, information that is provided in this research, considering Ecuador as a case study.

One limitation of this study is the cross-sectional nature of the data, which only provides insights from 2018 with no comparable recent data collected in Ecuador. The country has not conducted any survey or study to collect data related to NCDs. More recent information is important, especially when prevalence estimations for Ecuador, done by the International Diabetes Federation, show a significant increase since 2021, and estimations show that this trend will continue (44). This restricts the ability to conduct a more extensive analysis of inequalities that could determine the changes in the results presented or infer causality. Unfortunately, the quest to access this information was long and not easy, as there were technical details that could not be answered for the technical teams in charge of the survey were no longer working in the Ministry of Public Health and there were no technical memoirs of the process besides the documents found in the organization’s webpage.

Like many in the region, the Ecuadorian healthcare system comprises both public and private health services. Access to private services typically depends on the ability to pay, and these services are often associated with higher-quality care (45). Therefore, this links to the high percentage of OOP because in order to access the private health care delivery, the individual would only be able to do so, if they have the income resources to pay for them.

On the other hand, although there have been improvements in the infrastructure of the public health system (46), it still faces challenges such as long waiting lists and shortages of technology and medications. These facilities are predominantly located in poorer areas; therefore, when individuals manage to access a public healthcare unit, they often must purchase essential supplies or seek private diagnostic tests and pay out of pocket (47,48). The findings of this study highlight a marked socio-economic gradient in health, demonstrating that lower socio-economic status is associated with increased health risks and less effective diabetes management.

Research in LMICs has consistently suggested the importance of developing health policies to manage diabetes, that address socioeconomic inequalities (34,35,49–51). Although prevention is highly recommended to manage and control this condition, these policies rarely included socioeconomic factors for their design and implementation, even though targeted policies to disadvantaged populations are likely to be cost-effective (52).

By detailing the socio-economic inequalities in diabetes management and prevalence in Ecuador, this study contributes valuable evidence that can inform targeted health policies and interventions in Latin America. For instance, implementing diabetes screening campaigns in indigenous communities and offering free diabetes screening tests to women and individuals with low education levels in public hospitals and the Primary Healthcare Network can help those at higher risk identify if they have diabetes or become aware of potential risk factors.

This approach not only aligns with global health equity objectives but also addresses the specific challenges faced by Latin American countries in their pursuit of sustainable health improvements. Developing targeted health policies that leverage insights into how socio-economic factors and health inequalities will affect the prevalence and management of non-communicable chronic diseases such as diabetes will not only meet the specific needs of certain populations but

also generate future savings for families and the healthcare system by preventing health complications in these individuals, such as diabetic retinopathy and diabetic foot, two of the most common medical conditions suffered by diabetics in Ecuador (53,54). A way to start would be to implement the recommended interventions for diabetes management considered as effective as a result of a cost-effectiveness analysis by WHO, which include: screening and glycaemic control, control of blood pressure, statin use, foot care, and diabetic retinopathy screening (55).

The substantial proportion of the undiagnosed population that has diabetes needs to be addressed. The financial burden of income that the patients and their families need to allocate to access the healthcare system results in people being diagnosed only after health complications have appeared. Health financing policies to decrease OOP expenditures need to be included in diabetes management policies. As previously mentioned, Ecuador significantly reduced out-of-pocket health expenditures due to a substantial increase in government health spending, which rose from 28% of total health expenditure in 2000 to 64% in 2018 (56). This major shift was driven by political decisions beginning in 2008 that prioritized the health and education sectors, including a constitutional reform that mandated increased funding for these areas (57). Unfortunately, government allocations to the health sector have declined over time, except in 2020 due to the COVID-19 pandemic, leading to a resurgence in out-of-pocket expenditures. Additionally, focalized management and control strategies considering the risk of having or developing this health condition, based on the results presented here and in other studies, are key to understanding the needs of the population. Primary health policies that reach the risk groups and closely follow up on their health status will prevent the health system from an increased need for resources for the diabetic population. Lastly, regular data collection related to diabetes risk factors will provide

national and local authorities the ability to make informed decisions and develop the research needed in the country and in the region.

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Appendix

The appendix section includes the detailed results in which the tables presented in the analysis above were based on.

Appendix 1: Probit analysis considering individuals with controlled diabetes (low-risk group) as the reference group.

	Coefficient	St. Error	z	P>|z|	[95% conf.	interval]
		At risk group				
Female	-0.26	0.08	-3.18	0.00	-0.42	-0.10
No school	0.87	0.14	6.23	0.00	0.60	1.15
Primary school	0.75	0.10	7.31	0.00	0.55	0.95
High school	0.26	0.11	2.46	0.01	0.05	0.47
Indigenous	0.57	0.13	4.37	0.00	0.31	0.82
afro-descendent	0.02	0.09	0.27	0.79	-0.15	0.20
Married, cohabiting	-0.05	0.06	-0.76	0.45	-0.17	0.08
Employed in the informal sector	0.11	0.07	1.53	0.13	-0.03	0.24
Housewife	0.09	0.10	0.89	0.37	-0.10	0.27
Student or retired	0.02	0.10	0.24	0.81	-0.17	0.22
Unemployed	-0.09	0.12	-0.78	0.44	-0.33	0.14
Age	-0.02	0.00	-8.04	0.00	-0.02	-0.01
decile 1	0.40	0.19	2.14	0.03	0.03	0.76
decile 2	0.35	0.14	2.46	0.01	0.07	0.63
decile 3	0.28	0.19	1.48	0.14	-0.09	0.65
decile 4	0.38	0.16	2.42	0.02	0.07	0.68
decile 5	-0.04	0.16	-0.24	0.81	-0.34	0.27
decile 6	0.26	0.15	1.74	0.08	-0.03	0.55
decile 7	0.36	0.15	2.45	0.01	0.07	0.65
decile 8	0.38	0.13	2.98	0.00	0.13	0.63
decile 9	0.13	0.14	0.93	0.35	-0.15	0.42
constant	0.48	0.18	2.64	0.01	0.12	0.83

Appendix 2: Multinomial probit considering the confirmed non-diabetic group as a baseline reference for the analysis

	Coefficient	St. Error	z	P>|z|	[95% conf. interval]	
Controlled diabetics						
female	0.03	0.12	0.24	0.81	-0.20	0.25
no school	-0.15	0.23	-0.64	0.52	-0.60	0.31
primary	0.11	0.15	0.76	0.45	-0.18	0.41
high school	-0.06	0.16	-0.41	0.68	-0.37	0.25
indigenous	-0.13	0.30	-0.43	0.67	-0.73	0.47
afro-descendent	0.00	0.15	-0.03	0.98	-0.29	0.28
married	0.00	0.13	0.03	0.97	-0.25	0.26
Employed in the informal sector	-0.05	0.12	-0.44	0.66	-0.28	0.18
housewife	-0.13	0.15	-0.92	0.36	-0.42	0.15
student or retired	0.10	0.18	0.55	0.59	-0.25	0.44
unemployed	0.04	0.19	0.20	0.84	-0.34	0.41
age*	0.01	0.00	4.13	0.00	0.01	0.02
decile 1	0.17	0.25	0.69	0.49	-0.32	0.67
decile 2	0.21	0.23	0.92	0.36	-0.23	0.65
decile 3	0.03	0.24	0.14	0.89	-0.44	0.51
decile 4	0.07	0.24	0.30	0.77	-0.39	0.53
decile 5	0.11	0.21	0.53	0.60	-0.31	0.53
decile 6	0.12	0.23	0.53	0.60	-0.32	0.56
decile 7	0.34	0.24	1.42	0.16	-0.13	0.81

decile 8	0.16	0.22	0.71	0.48	-0.28	0.59
decile 9	0.12	0.18	0.66	0.51	-0.24	0.48
constant	-2.28	0.20	-11.32	0.00	-2.68	-1.89
Uncontrolled diabetics						
female	-0.05	0.13	-0.34	0.73	-0.30	0.21
no school	0.01	0.23	0.06	0.96	-0.44	0.47
primary	0.12	0.16	0.79	0.43	-0.18	0.43
high school	-0.15	0.16	-0.95	0.34	-0.46	0.16
indigenous	-0.36	0.35	-1.02	0.31	-1.05	0.33
Afro-descendent*	0.29	0.14	2.09	0.04	0.02	0.56
married	0.03	0.11	0.25	0.80	-0.19	0.25
Employed in the informal sector	0.09	0.12	0.72	0.47	-0.15	0.32
housewife	-0.04	0.18	-0.20	0.84	-0.39	0.32
student or retired	-0.27	0.24	-1.12	0.26	-0.75	0.20
unemployed	0.18	0.24	0.78	0.44	-0.28	0.65
age*	0.03	0.00	7.57	0.00	0.02	0.04
decile 1	0.04	0.29	0.15	0.88	-0.52	0.61
decile 2	0.14	0.25	0.56	0.57	-0.35	0.63
decile 3	0.31	0.28	1.13	0.26	-0.23	0.85
decile 4	0.16	0.24	0.66	0.51	-0.31	0.62
decile 5	-0.06	0.26	-0.23	0.82	-0.56	0.44
decile 6	0.11	0.26	0.40	0.69	-0.41	0.63
decile 7	0.36	0.26	1.41	0.16	-0.14	0.86

decile 8	0.35	0.23	1.53	0.13	-0.10	0.79
decile 9	0.14	0.25	0.56	0.57	-0.35	0.63
constant	-3.37	0.34	-9.87	0.00	-4.04	-2.70
Undiagnosed high-risk						
female	-0.18	0.12	-1.62	0.11	-0.40	0.04
no school*	0.99	0.20	5.04	0.00	0.61	1.38
primary*	0.90	0.15	5.96	0.00	0.61	1.20
high school*	0.42	0.15	2.74	0.01	0.12	0.72
indigenous	0.41	0.23	1.80	0.07	-0.04	0.86
afro-descendent	-0.05	0.12	-0.42	0.68	-0.29	0.19
married	-0.03	0.10	-0.29	0.77	-0.23	0.17
Employed in the informal sector	0.15	0.12	1.29	0.20	-0.08	0.38
housewife	0.10	0.17	0.57	0.57	-0.24	0.43
student or retired	-0.20	0.18	-1.15	0.25	-0.55	0.14
unemployed*	-0.40	0.23	-1.74	0.08	-0.86	0.05
age	0.00	0.00	-1.10	0.27	-0.01	0.00
decile 1*	0.62	0.22	2.74	0.01	0.18	1.06
decile 2	0.35	0.19	1.85	0.06	-0.02	0.73
decile 3	0.39	0.22	1.80	0.07	-0.03	0.82
decile 4*	0.39	0.20	1.98	0.05	0.00	0.77
decile 5	-0.16	0.24	-0.68	0.50	-0.63	0.31
decile 6	0.22	0.20	1.10	0.27	-0.17	0.62
decile 7*	0.45	0.19	2.39	0.02	0.08	0.81
decile 8	0.26	0.23	1.12	0.26	-0.20	0.72

decile 9	0.33	0.19	1.78	0.07	-0.03	0.69
constant	-1.92	0.27	-7.08	0.00	-2.46	-1.39
Undiagnosed normal						
female*	-0.30	0.07	-4.19	0.00	-0.44	-0.16
no school*	0.95	0.15	6.28	0.00	0.65	1.25
primary*	0.78	0.11	6.98	0.00	0.56	1.00
high school*	0.33	0.12	2.86	0.00	0.11	0.56
indigenous*	0.61	0.12	4.95	0.00	0.37	0.85
afro-descendent	0.02	0.10	0.21	0.84	-0.18	0.22
married	-0.03	0.06	-0.51	0.61	-0.15	0.09
Employed in the informal sector	0.09	0.07	1.31	0.19	-0.05	0.23
housewife	0.08	0.09	0.89	0.38	-0.10	0.26
student or retired	-0.01	0.11	-0.05	0.96	-0.22	0.21
unemployed	0.00	0.13	0.01	0.99	-0.25	0.25
age*	-0.03	0.00	-10.89	0.00	-0.03	-0.02
decile 1*	0.48	0.16	2.97	0.00	0.16	0.79
decile 2*	0.47	0.14	3.43	0.00	0.20	0.74
decile 3*	0.37	0.18	2.06	0.04	0.02	0.71
decile 4*	0.44	0.15	2.88	0.00	0.14	0.73
decile 5	0.10	0.15	0.64	0.52	-0.20	0.40
decile 6*	0.39	0.14	2.70	0.01	0.11	0.67
decile 7*	0.43	0.13	3.22	0.00	0.17	0.70
decile 8*	0.44	0.13	3.35	0.00	0.18	0.70
decile 9	0.20	0.13	1.52	0.13	-0.06	0.45

constant	0.54	0.17	3.27	0.00	0.22	0.86
Misdiagnosed high-risk						
female	0.02	0.11	0.21	0.83	-0.19	0.24
no school	0.26	0.20	1.30	0.19	-0.13	0.65
primary*	0.37	0.15	2.42	0.02	0.07	0.66
high school	-0.18	0.16	-1.13	0.26	-0.48	0.13
indigenous	0.04	0.22	0.18	0.86	-0.38	0.46
afro-descendent	-0.10	0.14	-0.72	0.47	-0.36	0.17
married	-0.06	0.09	-0.68	0.50	-0.24	0.12
Employed in the informal sector	0.01	0.11	0.12	0.91	-0.20	0.22
housewife	-0.12	0.14	-0.84	0.40	-0.41	0.16
student or retired	-0.01	0.18	-0.06	0.96	-0.36	0.34
unemployed	-0.41	0.24	-1.67	0.10	-0.89	0.07
age*	0.01	0.00	3.60	0.00	0.01	0.02
decile 1	-0.21	0.28	-0.73	0.47	-0.76	0.35
decile 2	-0.10	0.22	-0.46	0.64	-0.53	0.33
decile 3	-0.33	0.28	-1.20	0.23	-0.87	0.21
decile 4	0.07	0.23	0.29	0.77	-0.38	0.52
decile 5	-0.29	0.24	-1.23	0.22	-0.75	0.17
decile 6	-0.17	0.24	-0.70	0.49	-0.64	0.30
decile 7	0.13	0.26	0.49	0.62	-0.38	0.64
decile 8	0.14	0.18	0.76	0.45	-0.22	0.49
decile 9	-0.11	0.20	-0.55	0.58	-0.49	0.28
constant	-1.79	0.32	-5.60	0.00	-2.42	-1.16

Confirmed non-diabetic (base outcome)

Appendix 3: Average marginal effects for each variable per group

	dy/dx	Delta-method std. err.	z	P>z	[95% conf.	interval]
Sex: female						
Controlled diabetics	0.01	0.01	1.24	0.22	-0.01	0.02
Uncontrolled diabetics	0.00	0.01	0.54	0.59	-0.01	0.02
Undiagnosed high-risk	0.00	0.01	-0.52	0.60	-0.02	0.01
Undiagnosed normal	-0.08	0.02	-4.54	0.00	-0.11	-0.05
Misdiagnosed high-risk	0.01	0.01	1.56	0.12	0.00	0.03
Confirmed non-diabetic	0.06	0.02	3.06	0.00	0.02	0.09
Education: no school						
Controlled diabetics	-0.04	0.01	-2.83	0.01	-0.06	-0.01
Uncontrolled diabetics	-0.02	0.01	-1.83	0.07	-0.05	0.00
Undiagnosed high-risk	0.05	0.02	3.10	0.00	0.02	0.09
Undiagnosed normal	0.22	0.04	5.97	0.00	0.15	0.30
Misdiagnosed high-risk	-0.02	0.02	-1.04	0.30	-0.05	0.01
Confirmed non-diabetic	-0.20	0.04	-5.73	0.00	-0.27	-0.13
Education: primary						
Controlled diabetics	-0.02	0.01	-2.08	0.04	-0.03	0.00
Uncontrolled diabetics	-0.01	0.01	-1.71	0.09	-0.03	0.00
Undiagnosed high-risk	0.05	0.01	3.63	0.00	0.02	0.08
Undiagnosed normal	0.17	0.03	6.00	0.00	0.11	0.22
Misdiagnosed high-risk	0.00	0.01	-0.24	0.81	-0.03	0.02
Confirmed non-diabetic	-0.18	0.03	-7.14	0.00	-0.23	-0.13
Education: High school						
Controlled diabetics	-0.01	0.01	-1.26	0.21	-0.03	0.01
Uncontrolled diabetics	-0.01	0.01	-1.76	0.08	-0.03	0.00
Undiagnosed high-risk	0.03	0.01	2.06	0.04	0.00	0.06
Undiagnosed normal	0.09	0.03	2.91	0.00	0.03	0.15
Misdiagnosed high-risk	-0.03	0.01	-2.43	0.02	-0.05	-0.01
Confirmed non-diabetic	-0.06	0.03	-2.27	0.02	-0.11	-0.01

Ethnicity: indigenous						
Controlled diabetics	-0.02	0.02	-1.26	0.21	-0.06	0.01
Uncontrolled diabetics	-0.03	0.02	-1.73	0.08	-0.07	0.00
Undiagnosed high-risk	0.02	0.02	0.86	0.39	-0.02	0.05
Undiagnosed normal	0.16	0.03	5.56	0.00	0.11	0.22
Misdiagnosed high-risk	-0.02	0.02	-1.04	0.30	-0.05	0.02
Confirmed non-diabetic	-0.11	0.04	-3.05	0.00	-0.18	-0.04
Ethnicity: afro-descendent						
Controlled diabetics	0.00	0.01	-0.12	0.91	-0.02	0.02
Uncontrolled diabetics	0.02	0.01	2.20	0.03	0.00	0.03
Undiagnosed high-risk	-0.01	0.01	-0.58	0.57	-0.03	0.02
Undiagnosed normal	0.01	0.03	0.25	0.80	-0.04	0.06
Misdiagnosed high-risk	-0.01	0.01	-0.93	0.35	-0.03	0.01
Confirmed non-diabetic	0.00	0.02	-0.18	0.86	-0.05	0.04
Marital status: married						
Controlled diabetics	0.00	0.01	0.18	0.86	-0.01	0.02
Uncontrolled diabetics	0.00	0.01	0.46	0.65	-0.01	0.01
Undiagnosed high-risk	0.00	0.01	-0.13	0.90	-0.02	0.02
Undiagnosed normal	-0.01	0.02	-0.42	0.67	-0.04	0.02
Misdiagnosed high-risk	0.00	0.01	-0.57	0.57	-0.02	0.01
Confirmed non-diabetic	0.01	0.02	0.49	0.62	-0.02	0.04
Employment: informal						
Controlled diabetics	-0.01	0.01	-0.93	0.35	-0.02	0.01
Uncontrolled diabetics	0.00	0.01	0.37	0.71	-0.01	0.01
Undiagnosed high-risk	0.01	0.01	0.97	0.33	-0.01	0.03
Undiagnosed normal	0.02	0.02	1.05	0.30	-0.02	0.06
Misdiagnosed high-risk	0.00	0.01	-0.41	0.68	-0.02	0.01
Confirmed non-diabetic	-0.02	0.02	-1.27	0.20	-0.06	0.01
Employment: Housewife						
Controlled diabetics	-0.01	0.01	-1.11	0.27	-0.03	0.01
Uncontrolled diabetics	0.00	0.01	-0.27	0.79	-0.02	0.02
Undiagnosed high-risk	0.01	0.02	0.53	0.60	-0.02	0.04
Undiagnosed normal	0.03	0.02	1.12	0.26	-0.02	0.07

Misdiagnosed high-risk	-0.01	0.01	-1.18	0.24	-0.04	0.01
Confirmed non-diabetic	-0.01	0.02	-0.38	0.70	-0.06	0.04
Employment: Student or Retired						
Controlled diabetics	0.01	0.01	0.82	0.41	-0.01	0.03
Uncontrolled diabetics	-0.01	0.01	-1.04	0.30	-0.04	0.01
Undiagnosed high-risk	-0.02	0.02	-1.10	0.27	-0.05	0.01
Undiagnosed normal	0.01	0.03	0.35	0.73	-0.05	0.07
Misdiagnosed high-risk	0.00	0.02	0.14	0.89	-0.03	0.03
Confirmed non-diabetic	0.01	0.03	0.45	0.66	-0.04	0.06
Employment: Unemployed						
Controlled diabetics	0.01	0.01	0.62	0.53	-0.01	0.03
Uncontrolled diabetics	0.01	0.01	1.10	0.27	-0.01	0.04
Undiagnosed high-risk	-0.04	0.02	-1.69	0.09	-0.08	0.01
Undiagnosed normal	0.03	0.03	0.85	0.40	-0.04	0.09
Misdiagnosed high-risk	-0.04	0.02	-1.60	0.11	-0.08	0.01
Confirmed non-diabetic	0.02	0.03	0.74	0.46	-0.04	0.09
Age						
Controlled diabetics	0.00	0.00	6.43	0.00	0.00	0.00
Uncontrolled diabetics	0.00	0.00	6.51	0.00	0.00	0.00
Undiagnosed high-risk	0.00	0.00	1.67	0.10	0.00	0.00
Undiagnosed normal	-0.01	0.00	-15.33	0.00	-0.01	-0.01
Misdiagnosed high-risk	0.00	0.00	6.95	0.00	0.00	0.00
Confirmed non-diabetic	0.00	0.00	6.39	0.00	0.00	0.00
Income: decile 1						
Controlled diabetics	0.00	0.02	-0.11	0.92	-0.03	0.03
Uncontrolled diabetics	-0.01	0.01	-0.61	0.54	-0.04	0.02
Undiagnosed high-risk	0.04	0.02	1.92	0.05	0.00	0.08
Undiagnosed normal	0.11	0.04	3.00	0.00	0.04	0.19
Misdiagnosed high-risk	-0.04	0.02	-1.70	0.09	-0.09	0.01
Confirmed non-diabetic	-0.10	0.04	-2.40	0.02	-0.18	-0.02
Income: decile 2						
Controlled diabetics	0.00	0.01	0.07	0.95	-0.02	0.03
Uncontrolled diabetics	0.00	0.01	-0.21	0.83	-0.03	0.02

Undiagnosed high-risk	0.01	0.02	0.77	0.44	-0.02	0.05
Undiagnosed normal	0.12	0.03	3.42	0.00	0.05	0.18
Misdiagnosed high-risk	-0.03	0.02	-1.56	0.12	-0.07	0.01
Confirmed non-diabetic	-0.10	0.03	-2.84	0.01	-0.16	-0.03
Income: decile 3						
Controlled diabetics	-0.01	0.01	-0.51	0.61	-0.03	0.02
Uncontrolled diabetics	0.01	0.01	0.78	0.43	-0.02	0.04
Undiagnosed high-risk	0.02	0.02	1.20	0.23	-0.02	0.06
Undiagnosed normal	0.09	0.04	2.28	0.02	0.01	0.17
Misdiagnosed high-risk	-0.05	0.02	-2.07	0.04	-0.10	0.00
Confirmed non-diabetic	-0.07	0.05	-1.57	0.12	-0.16	0.02
Income: decile 4						
Controlled diabetics	-0.01	0.01	-0.58	0.56	-0.04	0.02
Uncontrolled diabetics	0.00	0.01	-0.16	0.87	-0.03	0.02
Undiagnosed high-risk	0.02	0.02	0.94	0.35	-0.02	0.05
Undiagnosed normal	0.10	0.04	2.67	0.01	0.03	0.18
Misdiagnosed high-risk	-0.01	0.02	-0.69	0.49	-0.05	0.03
Confirmed non-diabetic	-0.10	0.04	-2.61	0.01	-0.17	-0.02
Income: decile 5						
Controlled diabetics	0.01	0.01	0.67	0.50	-0.02	0.03
Uncontrolled diabetics	0.00	0.01	-0.19	0.85	-0.03	0.02
Undiagnosed high-risk	-0.02	0.02	-0.76	0.45	-0.06	0.03
Undiagnosed normal	0.04	0.04	1.16	0.25	-0.03	0.12
Misdiagnosed high-risk	-0.03	0.02	-1.43	0.15	-0.07	0.01
Confirmed non-diabetic	0.00	0.04	-0.06	0.96	-0.08	0.07
Income: decile 6						
Controlled diabetics	0.00	0.01	-0.12	0.91	-0.03	0.02
Uncontrolled diabetics	0.00	0.01	-0.12	0.91	-0.03	0.03
Undiagnosed high-risk	0.01	0.02	0.30	0.77	-0.03	0.04
Undiagnosed normal	0.10	0.03	2.94	0.00	0.03	0.17
Misdiagnosed high-risk	-0.03	0.02	-1.49	0.14	-0.07	0.01
Confirmed non-diabetic	-0.07	0.04	-2.00	0.05	-0.14	0.00
Income: decile 7						
Controlled diabetics	0.01	0.01	0.47	0.64	-0.02	0.03
Uncontrolled diabetics	0.01	0.01	0.53	0.60	-0.02	0.03

Undiagnosed high-risk	0.02	0.02	1.07	0.28	-0.02	0.06
Undiagnosed normal	0.09	0.03	2.52	0.01	0.02	0.15
Misdiagnosed high-risk	-0.01	0.02	-0.50	0.62	-0.06	0.03
Confirmed non-diabetic	-0.11	0.03	-3.35	0.00	-0.17	-0.05
Income: decile 8						
Controlled diabetics	0.00	0.01	-0.28	0.78	-0.03	0.02
Uncontrolled diabetics	0.01	0.01	0.67	0.50	-0.02	0.03
Undiagnosed high-risk	0.00	0.02	0.12	0.90	-0.04	0.04
Undiagnosed normal	0.10	0.03	3.04	0.00	0.04	0.17
Misdiagnosed high-risk	-0.01	0.02	-0.50	0.62	-0.04	0.02
Confirmed non-diabetic	-0.10	0.03	-3.14	0.00	-0.16	-0.04
Income: decile 9						
Controlled diabetics	0.00	0.01	0.13	0.90	-0.02	0.02
Uncontrolled diabetics	0.00	0.01	0.21	0.83	-0.02	0.03
Undiagnosed high-risk	0.02	0.02	1.38	0.17	-0.01	0.06
Undiagnosed normal	0.04	0.03	1.26	0.21	-0.02	0.10
Misdiagnosed high-risk	-0.02	0.02	-1.25	0.21	-0.05	0.01
Confirmed non-diabetic	-0.05	0.03	-1.47	0.14	-0.11	0.02

Appendix 4: Decomposition of Wagstaff index for each group

The following table indicates how do the different demographic and socioeconomic variables contribute to the overall Wagstaff index. It is important to analyze the Relative and Relative grouped columns in this case.

	Controlled diabetics					Uncontrolled diabetics				
	Coefficient	Wagstaff	Absolute	Relative	Relative grouped	Coefficient	Wagstaff	Absolute	Relative	Relative grouped
female	0.01	-0.14	0.00	-0.01	.	0.00	-0.14	0.00	0.00	.
age group	0.02	-0.09	0.00	-0.02	.	0.05	-0.09	0.00	-0.11	.
no school	-0.03	-0.44	0.01	0.14	0.15	0.05	-0.44	-0.02	-0.53	-0.66
primary	-0.01	-0.30	0.00	0.05	.	0.06	-0.30	-0.02	-0.41	.
high school	-0.01	0.21	0.00	-0.04	.	0.06	0.21	0.01	0.28	.
indigenous	-0.02	-0.38	0.01	0.09	0.09	0.01	-0.38	0.00	-0.11	-0.27
afro-descendent	0.00	-0.14	0.00	0.00	.	0.05	-0.14	-0.01	-0.17	.
Employed in the informal sector	0.00	-0.15	0.00	0.00	0.00	0.05	-0.15	-0.01	-0.17	-0.01
housewife	-0.01	-0.20	0.00	0.02	.	0.05	-0.20	-0.01	-0.22	.

student or retired	0.00	0.21	0.00	0.01	.	0.05	0.21	0.01	0.24	.
unemployed	0.01	-0.13	0.00	-0.01	.	0.06	-0.13	-0.01	-0.16	.
married	0.00	0.16	0.00	0.01	.	-0.37	0.16	-0.06	-1.36	.
residual	.	.	0.06	0.76	0.76	.	.	0.03	0.81	0.81
Wagstaff	.	.	0.98	0.98	0.98	.	.	-1.61	-1.61	-1.61

	Undiagnosed high-risk					Undiagnosed normal				
	Coefficient	Wagstaff	Absolute	Relative	Relative grouped	Coefficient	Wagstaff	Absolute	Relative	Relative grouped
female	-0.03	-0.14	0.00	-0.02	.	-0.06	-0.14	0.01	-0.08	.
age group	-0.02	-0.09	0.00	-0.01	.	-0.19	-0.09	0.02	-0.17	.
no school	0.14	-0.44	-0.06	0.36	0.46	0.08	-0.44	-0.04	0.36	0.56
primary	0.11	-0.30	-0.03	0.20	.	0.05	-0.30	-0.01	0.14	.
high school	0.08	0.21	0.02	-0.10	.	-0.03	0.21	-0.01	0.07	.

indigenous	0.29	-0.38	-0.11	0.67	0.74	-0.03	-0.38	0.01	-0.12	-0.18
afro-descendent	0.09	-0.14	-0.01	0.07	.	-0.04	-0.14	0.01	-0.05	.
Employed in the informal sector	0.15	-0.15	-0.02	0.14	-0.04	0.15	-0.15	-0.02	0.22	-0.04
housewife	0.14	-0.20	-0.03	0.17	.	0.16	-0.20	-0.03	0.31	.
student or retired	0.14	0.21	0.03	-0.17	.	0.17	0.21	0.04	-0.34	.
unemployed	0.10	-0.13	-0.01	0.08	.	0.19	-0.13	-0.02	0.23	.
married	0.14	0.16	0.02	-0.13	.	0.02	0.16	0.00	-0.02	.
residual	.	.	-0.04	0.22	0.22	.	.	0.03	-0.30	-0.30
Wagstaff	.	.	1.23	1.23	1.23	.	.	-0.23	-0.23	-0.23

	Misdiagnosed high-risk					Confirmed non-diabetic				
	Coefficient	Wagstaff	Absolute	Relative	Relative grouped	Coefficient	Wagstaff	Absolute	Relative	Relative grouped
female	0.01	-0.14	0.00	-0.01	.	0.06	-0.14	-0.01	-0.08	.
age group	0.07	-0.09	-0.01	-0.04	.	0.07	-0.09	-0.01	-0.06	.

no school	0.12	-0.44	-0.05	-0.34	-0.40	-0.43	-0.44	0.19	1.70	2.22
primary	0.16	-0.30	-0.05	-0.29	.	-0.41	-0.30	0.12	1.13	.
high school	0.17	0.21	0.04	0.23	.	-0.32	0.21	-0.07	-0.61	.
indigenous	0.05	-0.38	-0.02	-0.13	-0.17	-0.33	-0.38	0.13	1.16	1.38
afro-descendent	0.05	-0.14	-0.01	-0.04	.	-0.18	-0.14	0.02	0.22	.
Employed in the informal sector	-0.16	-0.15	0.02	0.15	0.05	-0.21	-0.15	0.03	0.29	0.05
housewife	-0.16	-0.20	0.03	0.19	.	-0.21	-0.20	0.04	0.39	.
student or retired	-0.16	0.21	-0.03	-0.20	.	-0.23	0.21	-0.05	-0.44	.
unemployed	-0.21	-0.13	0.03	0.16	.	-0.17	-0.13	0.02	0.20	.
married	-0.11	0.16	-0.02	-0.11	.	0.30	0.16	0.05	0.42	.
residual	.	.	0.10	0.60	0.60	.	.	-0.07	-0.60	-0.60
Wagstaff	.	.	-0.08	-0.08	-0.08	.	.	3.33	3.33	3.33

Chapter 3: Consumers' preferences in Ecuador: a Discrete Choice Experiment on tobacco packaging, stick warnings, prices and illicit cigarettes.

Abstract

Background

The Framework Convention on Tobacco Control (FCTC) provides a comprehensive policy package known as MPOWER, which includes guidelines on tobacco packaging, health warning labels, and prices, among others. Ecuador, as a Party of the FCTC, has partially implemented these policies. However, the current prevalence of tobacco consumption remains at 10% of the adult population. This study focuses on understanding the potential impact of plain packaging, stick health warnings, price changes and illicit cigarette availability in the adult population of Ecuador, using Discrete Choice Experiment (DCE) as a method to understand the consumer preferences on intention to purchase and risk perception.

Methods

A DCE where the following attributes were considered: packaging, warning on the cigarette sticks, prices and illicit pack. The data was collected for adult population from Ecuador. The information was analyzed using conditional logistic regression to estimate marginal effects for intention to purchase and risk perception as outcomes. Afterwards, a latent class analysis (LCA) was used to account for unobserved heterogeneity.

Results

The main findings indicate that plain packaging may be effective in reducing the intention to purchase by smokers and the willingness to try by nonsmokers. Another result shows that price increases also appear effective in reducing tobacco consumption. Finally, smokers and nonsmokers demonstrated a preference for avoiding illicit packs. The LCA revealed substantial heterogeneity in preferences across individuals. The Class with slightly younger members, who have higher education and higher income than the other Class 2, clearly avoided illicit packs. By contrast, in Class 2, the coefficient for illicit packs was not statistically significant, indicating little concern over whether a pack was illicit.

Conclusions

The findings support potential reforms to tobacco control legislation, such as implementing plain packaging, warning on the stick and increasing the price of tobacco products. These measures can help prevent smoking initiation and reduce the appeal of cigarette purchases among current smokers. However, it is crucial to control de illicit market.

Introduction

Even though seventeen countries (out of 21) in Latin America are part of the WHO Framework Convention on Tobacco Control (FCTC), the region as a whole is implementing the mandated measures at a slow but steady pace (1). This policy framework, known as MPOWER, is considered to be effective in reducing tobacco consumption and includes the following elements: Monitor tobacco use and prevention policies (M), Protect people from tobacco smoke (P), Offer help to quit smoking (O), Warn about the dangers of tobacco (W), Enforce bans on tobacco advertising, promotion and sponsorship (E) and Raise taxes on tobacco (R) (2).

This study focuses on actions under the umbrellas of W and R, which try to dissuade individuals from smoking by increasing the price of the product (R) or warning about the consequences of the habit (W). The MPOWER measures are briefly explained below.

Monitoring tobacco uses and prevention policies (M) involves the periodic collection of nationally representative data on tobacco use among youth and adults, and with this data, surveillance, monitoring, and evaluation systems are established. The aim of this cross-cutting policy is to provide reliable information to assess the evolving status of tobacco consumption and accurately plan tobacco control policies and strategies (2).

In addition, Article 8 of the FCTC refers to the "Protection from exposure to tobacco smoke" (P) (3), which instructs that each Party should implement national laws and promote effective measures to protect individuals from tobacco smoke exposure in indoor workplaces, public transportation, indoor public spaces, and other relevant areas (3). It is a governmental duty to protect people from second-hand smoke, thus, the importance of mandating smoke-free indoor and public spaces, for there are no safe levels of exposure (4).

The "Offer help to quit smoking" (O) intervention focuses on facilitating access to medical services for individuals seeking to quit smoking. This means that the healthcare system should include clinical treatments, other medical care, and low-cost pharmacotherapy to support cessation efforts effectively (2).

To provide the population with information on the health consequences and addictive nature of tobacco, the FCTC includes "Warn about the dangers of tobacco" (W) as part of the MPOWER. The adequate implementation of effective packaging and labelling measures is established by technical guidelines from WHO, which include (5):

- Each Party[4] is required to adopt measures to ensure that all tobacco products carry health warnings and messages with the following characteristics:
    - Location: health warnings must be on both the front and back of each package, and the message must be highly visible in the bottom area. Further warnings and messages should also be considered in addition to the development of innovation measures regarding location.
    - Size: health warnings and messages should be 50% or more but no less than 30% of the principal display area. They should be printed in bold, legible font size.
    - Pictorials: health warnings and messages should include pictures or pictograms in both principal display areas.
    - Colour: Health warnings and messages should be printed in full colour.
    - Rotation: Evidence suggests that repeated health warnings and messages decrease their impact over time; therefore, rotating them after 12 – 36 months is important.

[4] A Party refers to a State that has ratified, accepted or approved the WHO FCTC and, as such, is legally bound by its obligations under international law (83).

  - Message content: messages should address different issues related to tobacco use, such as addiction, economic outcomes, health problems, and advice on cessation. They should be short and clear.
  - Language: one or two languages should be used, depending on the jurisdiction.
  - Source attribution: the country decides to include the source of information, depending on whether it will increase the effectiveness of the health warning and message.

- Beside warnings, W actions also include plain packaging; this means "to restrict or prohibit the use of logos, colours, brand images or promotional information on packaging other than brand names and product names displayed in a standard colour and font style"(5). The goal is to limit the attractiveness of cigarettes through packaging and marketing.

The (E) intervention focuses on enacting comprehensive legislation prohibiting all tobacco advertising, promotion and sponsorship (2). According to Article 13 of the FCTC, this includes all advertising that is false, misleading, or deceptive. The FCTC requires: health warnings in advertising, restrictions on incentives to purchase tobacco, and the disclosure of tobacco industry spending on non-banned promotional activities (3).

Finally, Article 6 of the FCTC refers to interventions that raise taxes on tobacco products (R) in order to reduce tobacco demand (7). The WHO's best practices for tobacco tax policies recommend adopting a relatively simple tax system that applies a specific excise tax across all tobacco products. In addition, it is advised that the total tax burden should account for more than 75% of the retail price (total tax share threshold), with specific excise taxes making up at least 70% of the final retail price (specific tax share threshold) (8).

Five of these interventions are considered cost-effective and feasible in addressing non-communicable diseases (9). Among them are W and R, for both measures proved to be effective policies with an average cost-effectiveness ratio of less than $100 international dollars[5] per DALY, a threshold established by WHO for economic evaluations (10). Additionally, in the past 10 years, the evidence on the efficiency of plain packaging, health warnings and the impact of tobacco taxes has grown consistently (11). However, the evidence has been developed in high-income countries, and much is based on observational and quasi-experimental studies. These studies have not included illicit tobacco and stick health warnings in the analysis (12,13).

By 2022, of the 21 Latin American countries, only Brazil had implemented all MPOWER measures. 15 other countries in this region included mandatory health warnings on packages in their legislation, but only Uruguay implemented plain packaging, where promotional elements are eliminated and all surfaces have the required dull colouring (14). In terms of taxes, Argentina, Brazil, Chile and Nicaragua (1) are the only countries that have achieved the total tax share threshold established as a best practice level for this intervention (8).

All measures outlined in the FCTC consider legal cigarettes. However, a major issue in many countries, especially LMIC, is the prevalence of illicit tobacco products[6]. That is why, as a product of the FCTC, the Protocol to Eliminate Illicit Trade in Tobacco Products was created as an international treaty to "eliminate all forms of illicit trade in tobacco products, in accordance with the terms of Article 15 of the WHO Framework Convention on Tobacco Control" (15). This treaty outlines several measures to secure the tobacco supply chain, including the implementation of track and trace systems, regulation of the supply chain, and legal measures to address offences

[5] US dollars using Parity Purchase Power (PPP) to be able to compare across countries
[6] This refers to "any practice or conduct prohibited by law and which relates to the production, shipment, receipt, possession, distribution, sale or purchase" (91) that usually do not pay taxes as a result.

related to illicit trade. Additionally, it emphasizes international cooperation for information sharing and mutual assistance (15).

Reducing illicit trade is critical for tobacco control because illicit trade undermines national efforts in several ways. First, because illicit tobacco is not subject to either the excise tax or the value added taxes (VAT), it is usually cheaper than official tobacco (keep in mind taxes represent 60% of the price of official tobacco), thus increasing affordability to tobacco products and leading to more consumption and potentially earlier initiation. Additionally, illicit tobacco products often do not include mandated large health warnings, bypassing national regulations aiming to provide information about the harmful effects of tobacco consumption (16,17).

The tobacco industry has a vested interest in overstating the size of the black market: their claim is that too much regulation of the official market will lead to more unofficial trade, thus defeating the public health purpose (18). In a sense, they use the black market to lobby against public health measures. Unfortunately, not all countries in the Latin American region have independent studies (not financed or influenced by the industry) to measure the illicit tobacco market. All industry-related research has estimated a higher illicit market level than academic/independent studies. For instance, in Ecuador, the tobacco industry estimates suggest an 80% market share for illicit cigarettes compared to 51% from an independent study (23). Similar differences are observed in Colombia (18% versus 6%) (20) , Chile (24% versus 11%) (21), Mexico (17% versus 8.8%) (22), and Peru (48% versus 13%) (19).

Evidence on packaging, warning and taxes

Evidence has shown that packaging characteristics can influence consumers' perception of reduced harm (24). Firstly, plain packaging may reduce the attractiveness of tobacco products and

the appeal of smoking, especially among target groups such as young people and women (11). Additionally, research has observed that large pictorial warnings may reduce the attractiveness of the product; removing colours and brand images reduces the false beliefs related to relative risk, particularly among the youth, younger adults (25–30) and daily smokers (31). A growing body of literature highlights the importance of packaging for the tobacco industry and suggests that pack design can have an important influence on perceptions, especially among younger individuals (24,32).

Global evidence suggests that higher tobacco taxes may be effective in reducing consumption by increasing prices and making these products less affordable (33). Research indicates that lower-income groups are particularly sensitive to such tax increases, leading to a reduction in their tobacco consumption compared to higher-income groups. This effect contributes to a decrease in tobacco-related illnesses, reducing healthcare expenses, and preventing premature deaths (8,33). However, it is important to note that these empirical findings depend on the context and timing of the policy implementation. In many cases, it is difficult to isolate the individual effects of plain packaging or price increases alone.

For instance, many LMICs lack national evidence to determine the potential impact that changes in tobacco packaging, health warnings, and price can have on their population. In this context, Discrete Choice Experiments (DCEs) have emerged as a valuable tool for understanding such effects. Based on Random Utility Theory (34,35), a DCE is an "elicitation technique that provides stated-preference data for analysis"(35). This method presents respondents with choice sets where each option includes the attributes being analyzed. These attributes determine the utility of the alternatives (36) and provide information to estimate how changes in the attributes affect choices, generating information to inform policy decisions (37,38). In health economics, the

number of DCEs has increased since the 1990s, with the UK, US, Australia, Netherlands and Canada being the countries with the greatest number of studies using this methodology. The number of DCEs performed in LMICs has increased radically, reaching 102 studies between 2013 and 2017 (39).

In line with these trends, DCEs in high-income countries have also grown significantly in tobacco control, establishing them as a valuable tool for evaluating the potential impact of policies before implementation. However, their use in LMICs has progressed more slowly, especially in the past 5 years (35,40). DCEs in tobacco control have focused mostly on smoking cessation, smoking behaviour, electronic cigarette consumption, water-pipe tobacco use, and tobacco packaging. These studies have analyzed a range of attributes, with price having dominant effects on tobacco policies and behaviour (35).

Evidence from Latin America on this topic remains limited, with only seven DCEs conducted in the region examining cigarette packaging, health warnings, stick warnings and pricing[7]. Two of these studies aimed to evaluate the effect of two attributes: cigarette packaging and health warnings size. A DCE conducted in Colombia among adult smokers and nonsmokers found that individuals were less likely to select packs featuring larger health warnings (70% coverage compared to 30%). In addition, that study showed that plain packaging reduced the appeal to try, lowered taste preference and increased harm perception, regardless of the warning size. Also, plain packaging diminished brand distinction (41). Similar results were observed in a DCE conducted among young individuals (12 to 14 years old) in Mexico, where, besides packaging and health warnings,

[7] Please find in Appendix 1 the details related to the literature research done for this section. It is important to indicate that DCEs included here refer only to those conducted in Latin American countries, which examined the packaging, health warnings, stick warnings and pricing only of cigarettes. All DCEs that analyzed novel products were not included.

attributes such as brand, tobacco flavour, flavour capsule and presence of descriptive terms (e.g. mild smell) were considered. Researchers found that participants found packs less appealing, were less interested to try, and perceived smoking as more harmful if packages included plain packaging or larger health warnings; this impact was greater when a plain pack included larger health warnings (38).

Other studies in this region have examined the impact of packaging on the brand appeal and health risk perception. In Brazil, both smoking and nonsmoking young women (aged 16 to 26) perceived branded packs, particularly those that have female-oriented colour schemes and descriptors (i.e. slim or vanilla flavour) or designs resembling thin or lipstick-shaped packs, to be more appealing and less harmful than plain packs. Even when presented in plain packs, attractive brand names and descriptors influenced young women's preferences (42). Similarly, a study in Uruguay found that adult smokers considered a pack more harmful when it lacked distinctive branding elements and colour. Moreover, when the pack eliminated only one of these features, participants tended to view the pack as less harmful (43).

When measuring the effects of changing attributes of pictorial health warnings, a DCE conducted among adult smokers in Mexico showed that increasing the size of the health warning and adding a pictorial image to the back of the pack were each independently associated with lower willingness to purchase and greater perception of the health warning as informative. These findings highlight the importance of including pictorial health warnings on both sides of cigarette packs (44).

Recent research from Colombia and Chile studied the effects of plain packaging, stick health warnings, and price level. The DCE included two designs: the first featured an option for an illicit cigarette pack, while the second included only licit pack options. In the case of Colombia, the

study found that plain packaging was more effective in reducing attractiveness, even when illicit packs were available. However, a warning on a stick did not affect the health risk perception of smokers and nonsmokers, and the influence on their willingness to buy/try was very small (45). The study in Chile showed that when prices rise, plain packaging and/or warnings on cigarette sticks are introduced, the likelihood of smokers opting out increases. Smokers prefer not to purchase illicit cigarettes. A latent class analysis indicated that there are two types of smokers, one class that is influenced by visual attributes and a second class that is price driven. In the case of nonsmokers, a group of them resist smoking, independent of the pack features (46). The present study complements these findings by providing evidence from Ecuador, a country with a unique combination of high cigarette prices, strong warning label policies and a large illicit cigarette market.

Background

The present document reports the findings of a DCE investigating the effects of plain packaging, stick health warnings, and price level in Ecuador. It is one of the case studies included in the multi-country study noted above that also included Colombia and Chile. Ecuador, a middle-income South American country, ratified the FCTC in 2006, and, in 2015, adhered to the Protocol to Eliminate Illicit Trade in Tobacco Products (47). In July 2011, Ecuador approved the Law for the Regulation and Control of Tobacco (Ley Organica de Regulacion y Control de Tabaco). This national legislation aims to protect the population from the harmful consequences of tobacco consumption (48). Among different sections, this law includes guidelines on packaging, labelling, warnings, and presentation requirements for tobacco products. Meanwhile, the Internal Tax Law regulates the cigarette-specific excise tax (Ley de Regimen Tributario Interno) (49).

With respect to health warnings and packaging, the Ministry of Public Health, through the Tobacco Control Program and the Health Promotion Unit, issues annual updates on health warnings by March 15, according to Article 18 of the respective law. These warnings must be equally and randomly distributed across 60% of the main surfaces designated for this purpose on the external packaging, labels, and containers of all brands and product lines of tobacco products. In addition, the health information must cover 70% of the side panels of each cigarette pack or other packaging or containers. All health warnings must be directly printed on the material's surface in a manner that is sufficiently visible and distinguishable (48,50,51). Although there have been attempts to implement plain packaging, a proposed law to do so has been stalled in the National Assembly since 2016 (52).

Article 82 of the Internal Tax Law establishes a specific excise tax rate set at $0.16 USD per cigarette in 2022 and adjusted annually for inflation based on the Consumer Price Index (49). For 2022, the most-sold 20-cigarette pack was priced at $6.00 USD, of which $3.20 USD corresponded to the specific excise tax and $0.64 USD to VAT (which is not an excise tax but ad-valorem, meaning proportional to the price of the product). This means that the specific excise tax share was 53.3% of the sales price, while the total tax share reached 64%. (1). Despite the current law's annual inflation adjustment (49), between 2018 and 2022, the country's inflation level was not high enough to trigger an adjustment, leaving cigarette prices unchanged (53).

These health policies, combined with the implementation of other MPOWER policies outlined in different national regulations (48), have contributed to a continuous decline in tobacco consumption. According to estimations by WHO, the age-standardized current tobacco use prevalence (percentage of population that currently consumes tobacco products) among persons aged 15 years or older, dropped from 14.5% (CI: 9.9-19.2) in 2000 to 12.2% (CI: 9.4-15.1) in 2010

and 10.2% (CI: 6.4-14) in 2022 (54). However, this low prevalence overall masks stark gender differences: among adults (aged 18 and older), men's prevalence was 23.8% as of 2018, while women's was 4% (55). Also, age at initiation is low: According to the Global Youth Tobacco Survey, in 2016 the prevalence of current tobacco use among individuals aged 13 to 15 was 13%, with a 5-percentage point difference between men and women (15% versus 10%) (56).

Philip Morris International (PMI) has held a de facto monopoly in the licit cigarette market in Ecuador since 2017, when the British American Tobacco company exited the country (57). As in other Latin American countries, Ecuador faces ongoing challenges regarding tobacco illicit trade. A local academic study (23) indicates that 51% of the tobacco market volume in the three largest cities in Ecuador is illicit. Notably, this percentage is significantly lower than the 80% publicly stated and promoted by the tobacco industry. Among the illicit packs, 25% originate from China, 20% from Colombia, 20% from Korea, 17% from Mexico, 13% lack an identifiable country of origin, and 5% were from other countries. Illicit packages of Marlboro (imported illegally from outside Ecuador) were the most prevalent illicit brand (34%), followed by Carnival (19%), Elephant (17%), Ultima (9%), and Modern (8%) (23).

The aforementioned study (23) also reveals that 68% of Ecuadorian smokers purchase single cigarettes, while only 30% buy full packs. This purchasing pattern is closely linked to the point of sale: 56% of smokers obtain their cigarettes from retail shops, while 36% buy from informal street vendors, who commonly sell both single sticks and illicit products. Among respondents who were presented cigarette packs (from different brands), 90% of legal packs were priced between $2.25 for a 10-stick pack and $6.00 USD for a 20-stick pack, whereas 78% of illicit packs ranged from $0.50 for a 10-stick pack to $2.00 USD for a 20-stick pack (23).

Under this context, this study focuses on understanding the potential impact of plain packaging, stick health warnings, price changes and illicit cigarette availability in the adult population of Ecuador, using DCE as a method to understand the consumer preferences on intention to purchase and risk perception. The sections below will provide detailed information on the development of the DCE, the results after model estimation, and finally how these results provide valuable input for health policy. The present study builds on the DCE conducted in Ontario, Canada, Colombia, Chile, South Africa and Vietnam as part of the multi-country study noted above. The interest in being part of this project was to provide evidence to national authorities and decrease the gaps in knowledge happening not only in the Latin American region but also in LMICs. In addition, comparing the results with fellow LMIC countries provides a perspective on Ecuador's current situation and the steps to take moving forward in health policies.

Methods

This multi-country DCE was funded through a grant from the Canadian International Development Research Centre (IDRC). The original design was led by McMaster University and approved by the Hamilton Integrated Research Ethics Board (HiREB) (13,45). The protocol was customized to the Ecuadorian context and then approved by the Pontificia Universidad Catolica del Ecuador's Human Research Ethics Committee (CEI-122-2021).

Outcomes

The outcomes examined in this DCE were intention to purchase tobacco and risk perception for smokers, and intention to try smoking and risk perception for nonsmokers. Each respondent was presented with a question and four options. The wording of the question depended on whether the person was a smoker or not. For smokers, the question was: *If you had only these*

options to choose from, which one would you be most likely to buy? In the case of nonsmokers, the question was changed to: *If these were the only options available, which one would most encourage someone like you to smoke?*

Each of the first three options for the question corresponded to a pack and a price, while the fourth was "none of the above", in which the person decided not to choose one of the presented cigarette packs. The participants were to keep in mind that selecting 'none of the above' means you would choose not to smoke. For example, if you smoke a pack of 20 cigarettes per day, selecting 'none of the above' means you would prefer not to smoke for a day rather than buy any of the three packs shown. Similarly, if you smoke a pack of 20 cigarettes per week, choosing 'none of the above' implies that you would choose not to smoke for a week. For this DCE, "none of the above" will be referred as the "opt-out" option.

Additionally, each respondent was asked: *Which of these options do you believe would represent the least risk to your health?* The participant had to pick one of the options previously explained and the opt-out option was "don't know".

Figure 3 shows an example of the questions for Design 1 (licit & illicit alternatives) [8].

[8] English translation: "If you had these options to choose from, which would you be most likely to purchase? Please select one of the following: Pack 1, Pack 2, Pack 3, None of the above."

"Which of these options do you believe would represent the lowest risk to your health? Please select one of the following: Pack 1, Pack 2, Pack 3, None of the above."

Figure 3 Example of a question for Design 1

Cajetilla 1	Cajetilla 2	Cajetilla 3
		
$4,60	$7,00	$1,00

(Esta pregunta es obligatoria)
Si usted tuviera solo estas opciones para elegir, ¿cuál sería más probable que comprara?

Elija una de las siguientes opciones.

- ○ Cajetilla 1
- ○ Cajetilla 2
- ○ Cajetilla 3
- ○ Ninguna de las anteriores

(Esta pregunta es obligatoria)
¿Cuál de estas opciones cree usted que representaría el menor riesgo para su salud?

Elija una de las siguientes opciones.

- ○ Cajetilla 1
- ○ Cajetilla 2
- ○ Cajetilla 3
- ○ No sabría - Otro ¿Cuál?

Attributes

The DCE included packaging, warnings on cigarette sticks, and prices as attributes to be analyzed. Although these attributes followed the initial DCE design developed by Guindon, Mentzakis and Buckley (13), the levels and their characteristics were adapted to the Ecuadorian reality. The following paragraphs elaborate on each of the attributes:

Packaging: The standard Ecuadorian package follows national health warnings and tax stamp regulations (pack a in Figure 4). The plain package is a hypothetical pack (nowhere to be found in Ecuador) that follows the characteristics stated in Article 11 of the WHO's Framework Convention on Tobacco Control (FCTC) (3,11) (pack b in Figure 4). The standard licit pack brand, Lark (produced by Phillip Morris), was selected based on a national study and the information reported by the country to WHO, as the most sold brand (1,23). The best-selling illicit brand in Ecuador is Marlboro, imported illegally from Mexico and Colombia. However, it was not chosen as the illicit brand to include in the study because it is a PMI brand that previously was being produced in Ecuador, which could potentially confuse participants (23). Instead, we chose Carnival, the second most-sold illicit brand in Ecuador (as estimated by a local, independent academic study) (23). In the instructions section of the questionnaire, participants were informed that Carnival was an illicit cigarette brand (pack c in Figure 4).

Figure 4 Packs presented in the DCE

a. Standard licit pack b. Plain packaging c.Illicit pack

Warning on cigarette sticks: The stick without warning was the standard cigarette sold that included the brand name on the stick. Meanwhile, the stick with warning is a hypothetical case, with the phrase "Fumar causa cancer" (smoking causes cancer) printed on it.

Prices: In the year 2020, the price for a pack of 20 Lark cigarettes in Ecuador was $5.30 (58). This provided a basis for specifying both higher prices (for Design 1 (licit & illicit alternatives): $7.70, $7.00; for Design 2 (only licit alternatives): $7.70, $7.00, $6.40, $5.80) and lower prices (for Design 1 (licit & illicit alternatives) and Design 2 (only licit alternatives): $4.60) in each design. The average price of an illicit cigarette pack was $1.00 (23). Design 1 included two prices for illicit cigarettes: $4.30 and $1.00.

Figure 5 Cigarette sticks presented in the DCE

Stick without health warning

Stick with health warning

Experimental design

Two separate experiments (Design 1 and Design 2) with similar structures were developed. The reason for developing two designs was to assess whether consumer preferences changed when an illicit pack was included as a choice option, given the significant role illicit tobacco plays in the market. Design 1 presented two licit alternatives (Lark standard pack and Lark plain pack), one illicit alternative (Carnival), and an opt-out option (none of the above). Design 2 presented two licit alternatives (Lark standard pack and Lark plain pack) and an opt-out (none of the above). The attributes description for each design is detailed in Table 7.

Table 7 Attributes and levels per design

	Design 1 (licit & illicit alternatives)	Design 2 (only licit alternatives)
Packaging	Standard Ecuadorian package Plain package Illicit pack	Standard Ecuadorian package Plain package
Warning on stick	Without warning With warning	Without warning With warning
Prices USD$		
Licit cigarette packs	$7.70 $7.00 $5.30 $4.60	$7.70 $7.00 $6.40 $5.80 $5.30 $4.60
Illicit cigarette packs	$4.30 $1.00	
No choice/Opt-out	None of the above	None of the above

Design 1 (licit & illicit alternatives) was divided into two blocks to diminish the burden and respondent fatigue. Respondents faced 12 choice sets split into two blocks (block 1 and block 2). Each block had six choice sets and a dominant choice set (seven choice tasks in total). Meanwhile, Design 2 (only licit alternatives) resulted in one block (block 3) with six choice sets and a dominant choice set. Each participant was randomly assigned to one of the three blocks.

A dominant choice set occurs when one option in the set is superior in all attributes to all other alternatives, and it is expected for participants to always choose it (59). The dominant choice sets are not intended to provide information regarding preferences, but they were included to test the respondents' attention and comprehension of the attributes. Their inclusion enables one to identify low-quality respondents. For both Designs, a dominant choice set corresponded to the fifth-choice set. In Design 1 (licit & illicit alternatives), the dominant alternative corresponds to the branded package, which was cheaper than the plain package with stick warning, and the illicit option at its highest price (but still cheaper than the licit alternative)[9]. In the case of Design 2 (only licit alternatives), the dominant option was the branded pack without a stick warning, which was less expensive than the plain pack without a stick warning at a medium price and the plain pack with a stick warning at its highest price (see Appendix 2 for all options).

Restrictions were imposed on the design so that there would be no dominant option in the other choice sets, following the lead of the Ontario DCE (13). For the licit options (branded pack

[9] The branded option is not absolutely dominant, since the price of the illicit pack is lower, but it can be seen as being reasonably dominant (i.e., dominant for most participants) because it follows all the legal aspects to be sold in the country whereas Carnival, the illicit option, is a Korean brand that is not legally imported to Ecuador. By dropping respondents who failed to select the dominant option when presented, we exclude those who did not pay attention (taking the DCE without effort) but also some outliers with very low aversion to buying illicit cigarettes.

and plain packaging), the restrictions were: a) attributes cannot differ in price only; b) plain packaging with stick warning cannot be the most expensive licit option; c) branded packs with no stick warning cannot be the cheapest licit option; d) all attributes cannot be identical. No restrictions were imposed on the illicit option.

Data collection

Following the experience of the Colombian team (45), Ecuador hired Netquest, a private company that specializes in online survey services, to run the online panel. The information for 1,383 participants was collected between May and June 2022 (921 in Design 1 (licit & illicit alternatives) and 462 in Design 2 (only licit alternatives). It included smokers and nonsmokers from the country's four regions between the ages of 18 and 65.

Analysis

The information was analyzed using the following groups: smokers Design 1, smokers Design 2, nonsmokers Design 1, nonsmokers Design 2. This was done to understand the differences between both designs and between smokers and nonsmokers.

To ensure data quality, two criteria were used to identify and exclude low quality respondents: (1) failure to select the dominant alternative in choice set 5, which was interpreted as a lack of attention to the discrete choice experiment—494 participants (36% of the total sample) fell into this category; and (2) completion of the full questionnaire in less than five minutes—16 participants (1% of the total) met this criterion. In total, 500 respondents were excluded: 494 who failed the dominant choice task and an additional 6 who passed it but completed the survey too quickly. After applying these quality control measures, the final analytic sample consisted of 883

participants, representing 64% of the original dataset (results for the original dataset are included in Appendix 3[10]). Stata 17 was used to run all the analyses.

Following standard analysis for DCEs (18,22,23), a conditional logistic regression (clogit) was used with choice as a dependent variable. The independent variables were the attributes: price, plain package, warning on stick, illicit pack (only for Design 1 (licit & illicit alternatives) and opt-out. A similar regression was run to estimate risk perception, where the dependent variable was "safe", the option perceived as the least risky to a person's health.

In both cases, the reference values for the packs were as follows: branded pack with no stick warning and a price of $5.30. The coefficients from the clogit models were used to derive estimates of the marginal effects, predicted probabilities (results are reported in Appendix 4), and willingness to pay (WTP). To calculate marginal effects, a combination of attributes was created to generate pack types: branded pack with no stick warning, branded pack with stick warning, plain pack with no stick warning, plain pack with stick warning, and the illicit pack. Marginal effects provide information on the preferences of smokers and nonsmokers; when negative, individuals avoid the combination of attributes. The greater the negative value, the more they dislike it. When the value is positive, this shows that they prefer to choose that combination of attributes. The WTP provides the monetary value respondents place on a specific attribute value compared to the baseline reference value (36).

A latent class analysis (LCA) was used to account for unobserved heterogeneity in preferences by identifying subgroups (or classes) of individuals with similar choice patterns. LCA

[10] As can be seen when comparing the analysis presented in the results section and those in Appendix 3, the results have the same statistical significance and positive/negative effect. However, when removing low-quality respondents the magnitude of the marginal effects considerably increases.

is important because clogit does not account for preference heterogeneity, since it assumes that all respondents have the same preferences. The LCA assigns individuals probabilistically to latent classes, each representing distinct patterns of preferences (13,36,60). Separate LCA were run for smokers and nonsmokers and for the question asked (intention to purchase and perception of risk on health), a clogit was used in each class. The resulting two latent classes were then described based on the following characteristics: age, sex, education (high school, technical college, undergraduate degree), and income (low: those earning less than $USD 800.00 a month and high: those earning more than $USD 800.00 a month).

In the case of intention to try, the LCA for nonsmokers in both Designs did not converge, and thus no results are reported. A similar issue happened for smokers and nonsmokers in Design 2 when modelling risk perception.

For smokers, the model assessing the intention to purchase in Designs 1 and 2 achieved the best fit with two latent classes, as indicated by the lowest Bayesian Information Criterion (BIC) (13). The same result was observed in the risk perception models for smokers and nonsmokers in Design 1.

Results

In general terms, the participants' demographics in each of the DCE designs are similar. The average age in the smoker population is 32, with a higher female representation. Compared to smokers, nonsmokers are younger (average age of 27 versus 32), more often female (56% versus 50), with a lower level of education (44% of nonsmokers have an undergraduate degree versus 60% of smokers with that education level) and are more likely to have lower income (68% versus 50%).

When comparing nonsmokers in Design 1 (licit & illicit alternatives) with those in Design 2 (only licit alternatives), their sociodemographic characteristics are almost identical: the average age is 27 years of age, 44% male, 41% have undergraduate education, and 32% fall into the high-income category. In contrast, slight differences are observed among smokers between the two designs. While the average age of smokers is 32 years across both designs, there are fewer women (50%) in Design 1 (licit & illicit alternatives) compared to Design 2 (56%). Additionally, 62% of smokers in Design 1 (licit & illicit alternatives) have an undergraduate education, compared to 60% in Design 2 (only licit alternatives). High-income representation is slightly lower in Design 1 smokers (48%) relative to Design 2 smokers (52%).

Smoking habits of the sample population

As seen in Table 8, in Design 1 (licit & illicit alternatives) 26% of the smokers reported smoking daily, while in Design 2 (only licit alternatives) this figure increases to 28%. Additionally, the same proportion of smokers tried to quit smoking in both designs (73%). Among nonsmokers, Design 1 (licit & illicit alternatives) had a higher proportion of people who had never smoked compared to those who used to smoke.

In response to the question, *"In the last 30 days, have you used an electronic cigarette, also known as an e-cig (e.g. vape, mod, e-hookah, JUUL, IQOS, AIO)?"*, the results showed that, on average, 9% of nonsmokers used an e-cigarette in both designs. In the case of smokers, 20% of smokers in Design 1 (licit & illicit alternatives) also used e-cigarettes, compared to 24% in Design 2 (only licit alternatives).

Table 8 Descriptive statistics per design of the DCE

	Design 1	Design 2

	(licit & illicit alternatives)		(only licit alternatives)	
	Smoker (n=409)	Nonsmoker (n=154)	Smoker (n=198)	Nonsmoker (n=122)
	Mean or %			
Age	31.9	27.2	32.0	28.0
Male	50%	44%	44%	43%
Female	50%	56%	56%	56%
Other	0%	0%	0	0%
Highschool	23%	47%	23%	40%
Technical college	14%	10%	16%	10%
Undergraduate degree	62%	42%	60%	46%
Low income	50%	66%	47%	68%
High income	50%	34%	52%	31%
Never smoked	-	62%	-	60%
Used to Smoke	-	37%	-	38%
Smokes occasionally	74%	-	72%	-
Smokes daily	26%	-	28%	-
Tried to stop smoking	73%	-	73%	-
Used e-cigarettes	20%	9%	24%	10%

Table 9 shows the same information for adult (more than 25 years of age) smokers and nonsmokers, and young (less than 25 years of age) smokers and nonsmokers, for each design. When comparing adult smokers and adult nonsmokers in Design 1 (licit & illicit alternatives), both have the same average age of 36 years. However, adult smokers have more male population (49%) compared to nonsmokers (38%). In terms of education, 14% adult smokers have a technical college degree versus 11% of nonsmokers, 72% of smokers have an undergraduate education level versus 69% of nonsmokers. In Design 1 (licit & illicit alternatives), 55% of adult smokers are in the high-income category, while 52% of nonsmokers are in that income category.

In Design 2 (only licit alternatives), the average age of adult smokers is 37, and the average age of nonsmokers is 35. For both adult smokers and nonsmokers males make up 45% of the sample. Among adult smokers, 16% hold a technical college degree, and 73% have an undergraduate degree. In comparison, 9% of adult nonsmokers hold a technical college degree, and 68% have completed an undergraduate degree. Regarding income, 59% of adult smokers fall into the high-income category, compared to 46% of adult nonsmokers.

Young smokers and nonsmokers in Design 1 (licit & illicit alternatives) have the same average age of 22. Among young smokers, 51% are male, compared to 47% among young nonsmokers. 40% of young smokers hold an undergraduate degree, while only 24% of young nonsmokers have completed the same level of education. Additionally, 33% of young smokers are in the high-income category, compared to 15% of young nonsmokers.

Similar to Design 1, young smokers and nonsmokers in Design 2 (only licit alternatives) have an average age of 22. There is a slightly larger female participation of young smokers (57%) versus young nonsmokers (56%). Regarding educational attainment, 36% of young smokers have an undergraduate degree compared to 27% of young nonsmokers. In terms of income, there is a

larger percentage of young smokers (37%) in the high-income category than young nonsmokers (15%).

In terms of smoking habits, in both Designs, there is a larger proportion of adult smokers who reported smoking occasionally (71% in Design 1, 65% in Design 2) than daily (29% in Design 1, 35% in Design 2). In the case of young smokers, 82% in Design 1 (licit & illicit alternatives) and 84% in Design 2 (only licit alternatives) smoke occasionally, while 18% in Design 1 and 16% in Design 2 smoke daily.

Among adult nonsmokers, 56% in Design 1 (licit & illicit alternatives) and 45% in Design 2 (only licit alternatives) are former smokers. This proportion is lower among young nonsmokers, with 25% in Design 1 and 32% in Design 2 indicating they had previously smoked.

Table 9 Descriptive statistics by age and smoking groups

	Design 1 (licit & illicit alternatives)				Design 2 (only licit alternatives)			
	Adult smoker (n=285)	Adult nonsmoker (n=61)	Young smoker (n=124)	Young nonsmoker (n=93)	Adult smoker (n=128)	Adult nonsmoker (n=56)	Young smoker (n=70)	Young nonsmoker (n=66)
	Mean or %							
Age	36.0	35.8	22.4	21.5	37.3	35.4	22.3	21.7
Male	49%	38%	51%	47%	45%	45%	43%	42%
Female	50%	62%	49%	53%	55%	55%	57%	56%
Other	0%	0%	0%	0%	0%	0%	0%	0%
Highschool	13%	18%	46%	67%	12%	21%	44%	56%
Technical college	14%	11%	13%	10%	16%	9%	17%	11%
Undergraduate degree	72%	69%	40%	24%	73%	68%	36%	27%
Low income	43%	39%	61%	69%	38%	52%	61%	74%
High income	55%	52%	33%	15%	59%	46%	37%	15%
Never smoked	-	44%	-	73%	-	54%	-	65%
Used to Smoke	-	56%	-	25%	-	45%	-	32%
Smokes occasionally	71%	-	82%	-	65%	-	84%	-
Smokes daily	29%	-	18%	-	35%	-	16%	-
Tried to stop smoking	71%	-	77%	-	77%	-	67%	-
Used e-cigarettes	17%	10%	28%	9%	19%	7%	34%	12%

Marginal effects

Intention to purchase/try

As shown in the upper panel of Table 10[11], the marginal effects of the attributes among the smokers in Design 1 (licit & illicit alternatives) are statistically significant. When the price increased by 10%, the likelihood of purchasing a branded pack with no stick warning decreased by 3% (ME: -0.03, CI: -0.03,-0.02). In addition, both illicit packs (ME: -0.28, CI: -0.30,-0.25) and plain packaging with no stick warning (ME: -0.21, CI: -0.24,-0.18) significantly reduced the probability that a smoker chose these options. However, adding a stick warning to the cigarettes in branded packs (ME: 0.11, CI: 0.07,0.15) or a plain pack (ME: 0.04, CI: 0.02,0.05) increased the chance that a smoker in Design 1 selected one of these alternatives.

In Design 2 (only licit alternatives), when smokers did not have the option of choosing an illicit pack, the average effects of price (ME: -0.03, CI: -0.04,-0.02) and plain packaging with no stick warning (ME: -0.15, CI: -0.20,-0.09) were negative, similar to those observed among smokers in Design 1 (licit & illicit alternatives), although the marginal effect for plain packaging is smaller than in design 1. differed. Branded packs with a stick warning (ME: 0.14, CI: 0.07,0.20) and plain packaging with a stick warning (ME: 0.06, CI: 0.03,0.10) increased smokers' likelihood of choosing these options.

In the case of nonsmokers in Design 1 (licit & illicit alternatives), only price, plain packaging with no stick warning, and illicit cigarettes were statistically significant. A 10% price increase lowers the probability of a nonsmoker's intention to try by 2% (ME: -0.02, CI: -0.03,0.00).

[11] Predicted probabilities are reported in Appendix 3 of this document.

Plain packaging with no stick warning decreases the intention to try by 26 percentage points (ME: -0.26, CI: -0.31,-0.21).

For nonsmokers in Design 2 (only licit alternatives), the marginal effect of all attributes was statistically significant and showed a negative impact on the intent to try. Plain packaging with no stick warning was the attribute combination with the largest effect, reducing the probability of trying by 28 percentage points (ME: -0.28, CI: -0.36,-0.19). This was followed by branded pack with stick warning (ME: -0.12, CI: -0.22,-0.02), plain packaging with stick warning (ME: -0.04, CI: -0.08, -0.01) and price (ME: -0.03, CI: -0.06,-0.01).

Risk perception

This section presents the marginal effects of attribute combination on the probability of being perceived as the least risky, shown in the lower panel of Table 10. For smokers in Design 1 (licit & illicit alternatives), price did not have a statistically significant effect. However, branded packs with stick warning (ME: 0.05, CI: 0.02,0.09) and plain packaging with a stick warning (ME: 0.02, CI: 0.01,0.03) had a positive effect in the likelihood of being perceived as low risk. On the other hand, illicit packs (ME: -0.22, CI: -0.25,-0.18) were significantly less likely to be considered low risk. Surprisingly, this was also the case for plain packs with no stick warning (ME: -0.19, CI: -0.22,-0.16). For smokers in Design 2, plain packaging with no stick warning was the only attribute that significantly reduced perceived safety (ME: -0.12, CI: -0.16,-0.07).

For nonsmokers in Design 1 (licit & illicit alternatives), the marginal effect of plain packaging with no stick warning (ME: -0.20, CI: -0.25,-0.15) and illicit packs (ME: -0.23, CI: -0.29,-0.16) were statistically significant and negative, indicating that they are perceived as riskier. The effect of price was statistically significant with a marginal effect of 0.01 (CI: 0.00,0.02). On

the other hand, for nonsmokers in Design 2, only the plain packaging with no stick warning had an effect in the risk perception, decreasing the likelihood to be perceived as low risk (ME: -0.09, CI: -0.15,-0.03)

Table 10 Marginal effects

Product, attributes	Design 1 (licit & illicit alternatives)				Design 2 (only licit alternatives)			
	Smokers (n=409)		Nonsmokers (n=154)		Smokers (n=198)		Nonsmokers (n=122)	
	Mg. Eff.	95% CI	Mg. Eff.	95% CI	Mg. Eff.	95% CI	Mg. Eff.	95% CI
Intention to purchase								
Price	-0.03***	(-0.03,-0.02)	-0.02***	(-0.03,0.00)	-0.03***	(-0.04,-0.02)	-0.03***	(-0.06,-0.01)
Plain packaging with no stick warning	-0.21***	(-0.24,-0.18)	-0.26***	(-0.31,-0.21)	-0.15***	(-0.20,-0.09)	-0.28***	(-0.36,-0.19)
Branded with stick warning	0.11***	(0.07,0.15)	0.01	(-0.06,0.08)	0.14***	(0.07,0.20)	-0.12***	(-0.22,-0.02)
Plain packaging with stick warning	0.04***	(0.02,0.05)	0.00	(-0.02,0.02)	0.06***	(0.03,0.10)	-0.04***	(-0.08,-0.01)
Illicit	-0.28***	(-0.30,-0.25)	-0.28***	(-0.34,-0.22)	-	-	-	-
Risk perception (least risky)								
Price	0.00	(-0.01,0.00)	0.01***	(0.00,0.02)	0.00***	(-0.02,0.00)	-0.01	(-0.02,0.00)
Plain packaging with no stick warning	-0.19***	(-0.22,-0.16)	-0.20***	(-0.25,-0.15)	-0.12***	(-0.16,-0.07)	-0.09***	(-0.15,-0.03)
Branded with stick warning	0.05***	(0.02,0.09)	0.03	(-0.04,0.09)	0.05	(-0.01,0.10)	-0.01	(-0.08,0.06)
Plain packaging with stick warning	0.02***	(0.01,0.03)	0.01	(-0.01,0.03)	0.02	(-0.01,0.06)	-0.01	(-0.06,0.04)
Illicit	-0.22***	(-0.25,-0.18)	-0.23***	(-0.29,-0.16)	-	-	-	-

**** p<0.05; the marginal effects of the opt-out option are not displayed in the output. Branded pack with no stick warning (standard pack) is the reference category. To estimate the marginal effect of price, I used $5.30 USD as the price of the reference pack.*

Willingness to pay

Intention to purchase/ try

Table 11 provides the WTP for intention to purchase and risk for both designs. When the values are negative, they indicate that the person would not even want the pack with those attributes if it were free; indeed, they would be willing to pay to avoid the attribute. One would have to pay the person to take such a pack.

Regarding intention to purchase, smokers in Design 1 (licit & illicit alternatives) had a WTP of $6.07 USD to avoid plain packaging, and an even higher WTP of $12.26 USD to avoid illicit cigarettes. However, they were also willing to pay $1.67 USD more for a pack that featured a health warning on the stick. Meanwhile, in Design 2, where the illicit option was not available, smokers were willing to pay $3.08 USD to avoid plain packaging.

In Design 1 (licit & illicit alternatives), nonsmokers were willing to pay an additional $14.60 USD to avoid plain packaging, however, the result was not statistically significant in the case of stick warning. While nonsmokers in Design 2 (only licit alternatives), presented a WTP of $6.58 USD to avoid plain packaging and $2.14 USD to avoid warning on a stick. Note that none of the WTP estimates related to risk perception were statistically significant.

Table 11 Willingness to Pay-WTP

Product, attributes	Design 1 (licit & illicit alternatives)		Design 2 (only licit alternatives)	
	Smokers (n=409) WTP	Nonsmokers (n=154) WTP	Smokers (n=198) WTP	Nonsmokers (n=122) WTP
plain packaging	-6.07***	-14.60***	-3.08***	-6.58***
warning on stick	1.67***	-0.35	1.62***	-2.14***
illicit	-12.26***	-17.60***	-	-

**** p<0.05; WTP of the opt-out option are not displayed in the output. Branded pack with no stick warning (standard pack) is the reference category. To estimate the WTP, I used $5.30 USD as the price of the reference pack.*

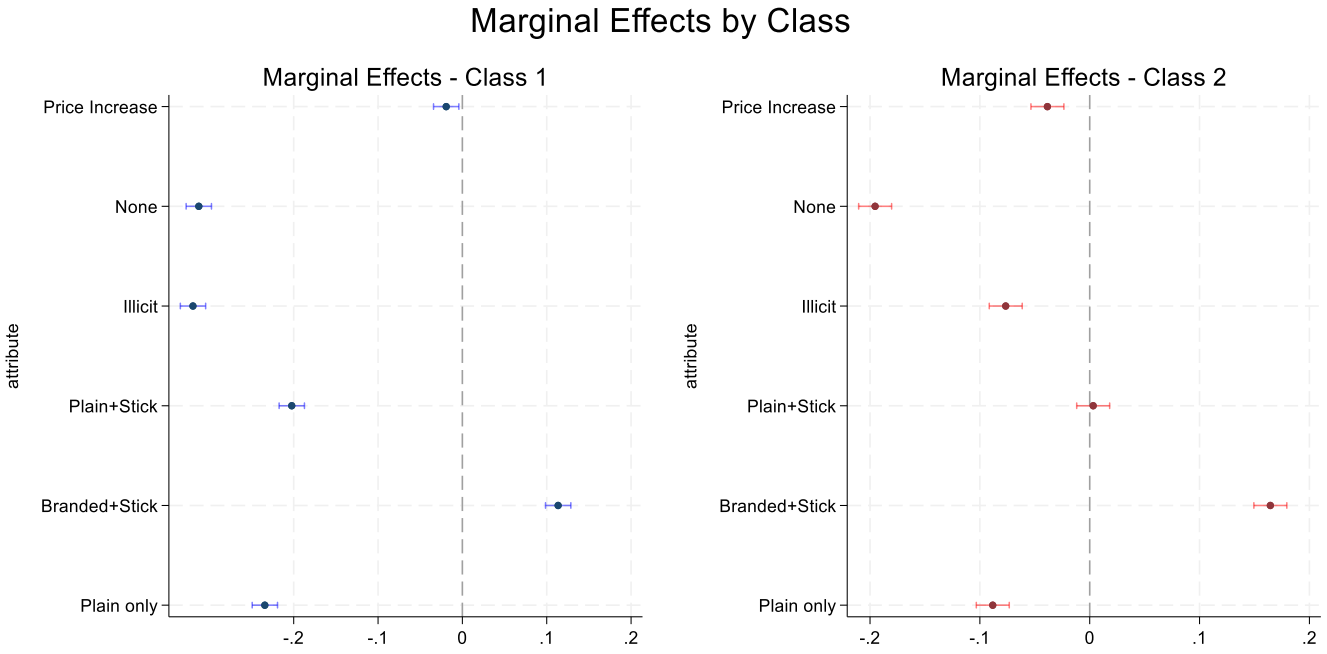
Latent class analysis

The results from the LCA model indicate heterogeneity in preferences among participants. Table 12 and Figure 6 present the LCA results for the intention to purchase marginal effects and risk perception.

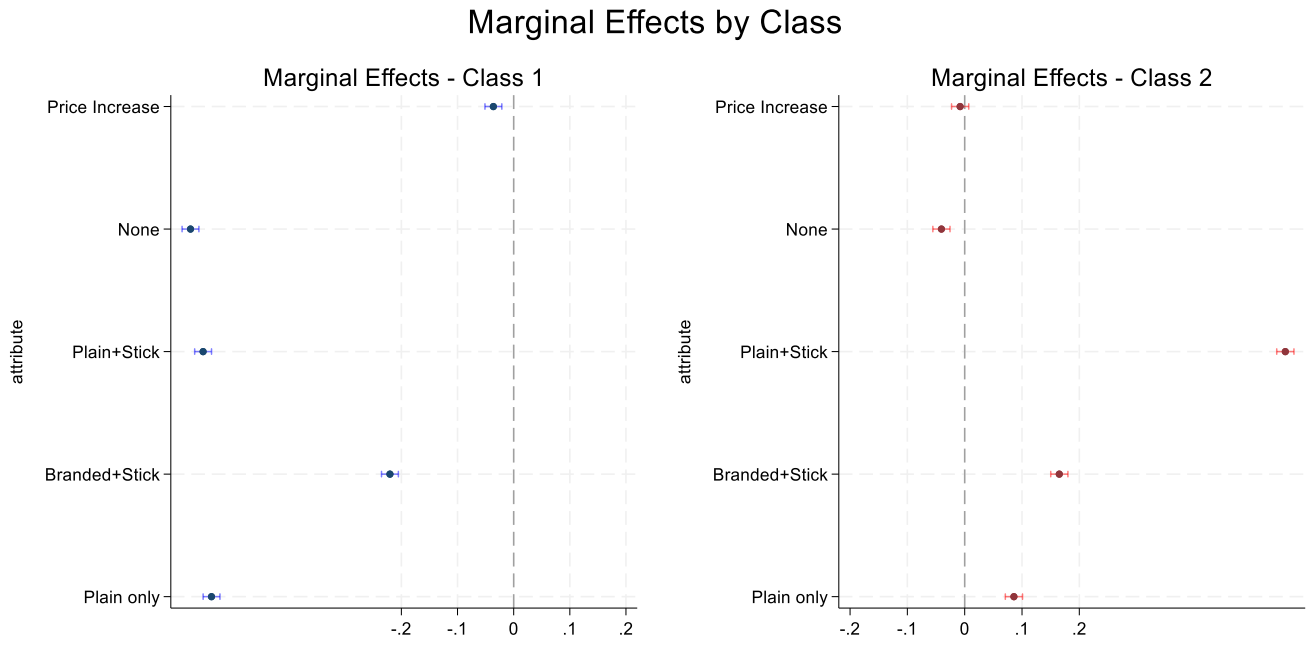
Figure 6 LCA, Design 1 (licit & illicit alternatives) and Design 2 (only licit alternatives) per smoking habits, results marginal effects

Intention to purchase:

Smokers Design 1 (licit & illicit alternatives). Class 1 share = 0.78, Class 2 share=0.22

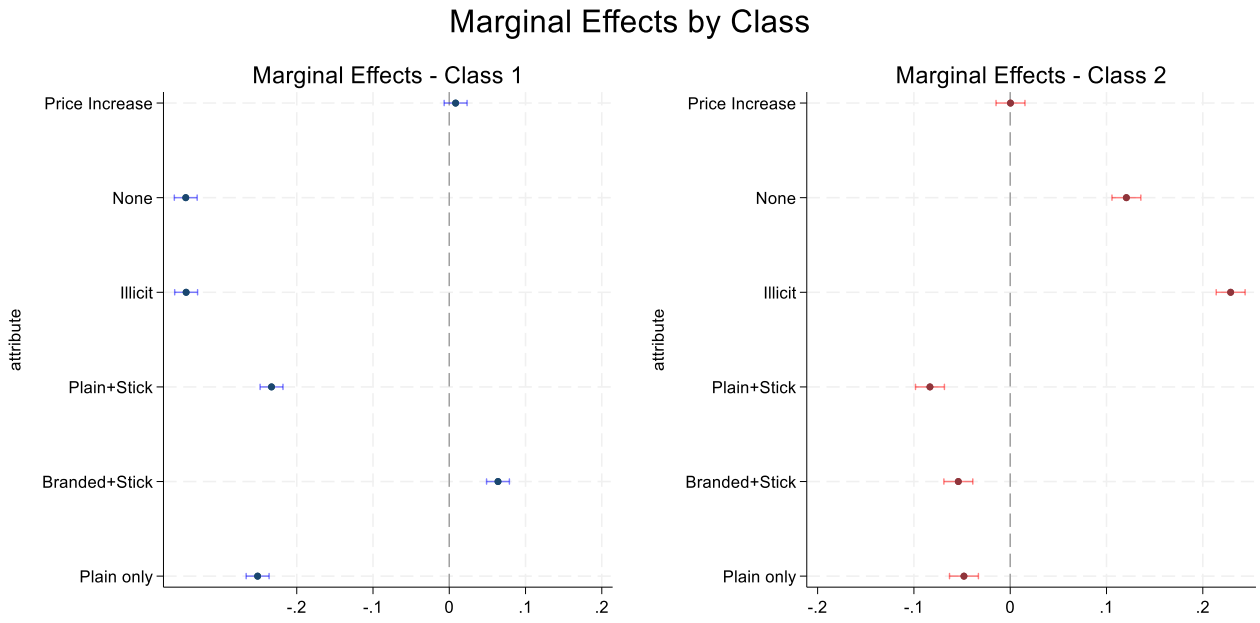


Smokers Design 2 (only licit alternatives). Class 1 share = 0.55, Class 2 share=0.45



Risk perception

Smokers Design 1 (licit & illicit alternatives). Class 1 share = 0.74, Class 2 share=0.26



Nonsmokers Design 1 (licit & illicit alternatives). Class 1 share = 0.73, Class 2 share=0.27

Table 13 shows the class assignment. Across all groups of smokers and nonsmokers, study designs, and evaluated outcomes, only high school education, technical education, and the low- and high-income categories among smokers in Design 1 showed statistically significant associations when assessing risk perception.

The LCA shows that in the case of smokers in Design 1 (licit & illicit alternatives), the individuals in Class 1 (share=78%) are slightly younger, with a higher education and higher income than those in Class 2 (reference group). Those in Class 1 prefer the branded pack with stick warning (ME: 0.11) but prefer to avoid illicit packs (ME:-0.32) and plain packaging (ME of plain pack without stick warning: -0.23, and ME plain pack with stick warning: -0.20). For Class 1, a 10% increase in price reduces the likelihood of purchasing a branded pack with no stick warning by 2%. However, the effect of price doubles for Class 2 (4%). Individuals in Class 2 preferred to buy a branded pack with stick warning (ME: 0.16), but the marginal effect of the illicit pack is statistically not significant.

For smokers in Design 2, Class 1 (share=55%) has slightly older participants compared to Class 2 (share=45%), with a larger female representation; they are more likely to be less educated but have more participants from higher and lower income groups than the reference group (Class 2). In Class 1, participants do not like plain packaging (ME plain pack with stick warning: -0.55, ME plain pack with no stick warning:-0.54). The negative effect of branded pack with stick warning is less strong (ME:-0.22), and the price has an ME of -0.04. With the exception of price (ME:-0.04) all the licit options attract the likelihood to purchase by smoker in Class 2 (ME plain pack with no stick warning: 0.09, ME branded pack with stick warning: 0.17, ME plain pack with stick warning 0.56).

The results for risk perception for smokers in Design 1 present important differences between Class 1 (share=74%) and Class 2 (share=26%). Class 1 has younger participants with higher income and education than Class 2. For smokers in Class 1, the illicit pack (ME:-0.34) is strongly perceived as having more risk to health, followed by the plain packs with (ME:-0.24) and without (ME: -0.26) stick warning. The branded pack with stick warning is the only one with a positive marginal effect of 0.06. Price had a small effect for Class 1 (ME:0.01). The results were different for Class 2, for which the illicit pack is associated with being considered low risk (ME:0.35), it is the only pack option that was statistically significant.

Nonsmokers in Design 1 had a Class 1 (share=73%) where participants are younger than Class 2 (share=27%), with a high percentage of females, low education and low income. The illicit packs (ME:-0.35), plain packs (ME plain pack with no stick warning: -0.25, ME plain pack with stick warning: -0.23) are considered riskier for individuals in Class 1. Those in Class 2 believe the illicit pack is a safer option (ME:0.23), the other pack types were statistically not significant.

Table 12 Latent class analysis (LCA), results marginal effects

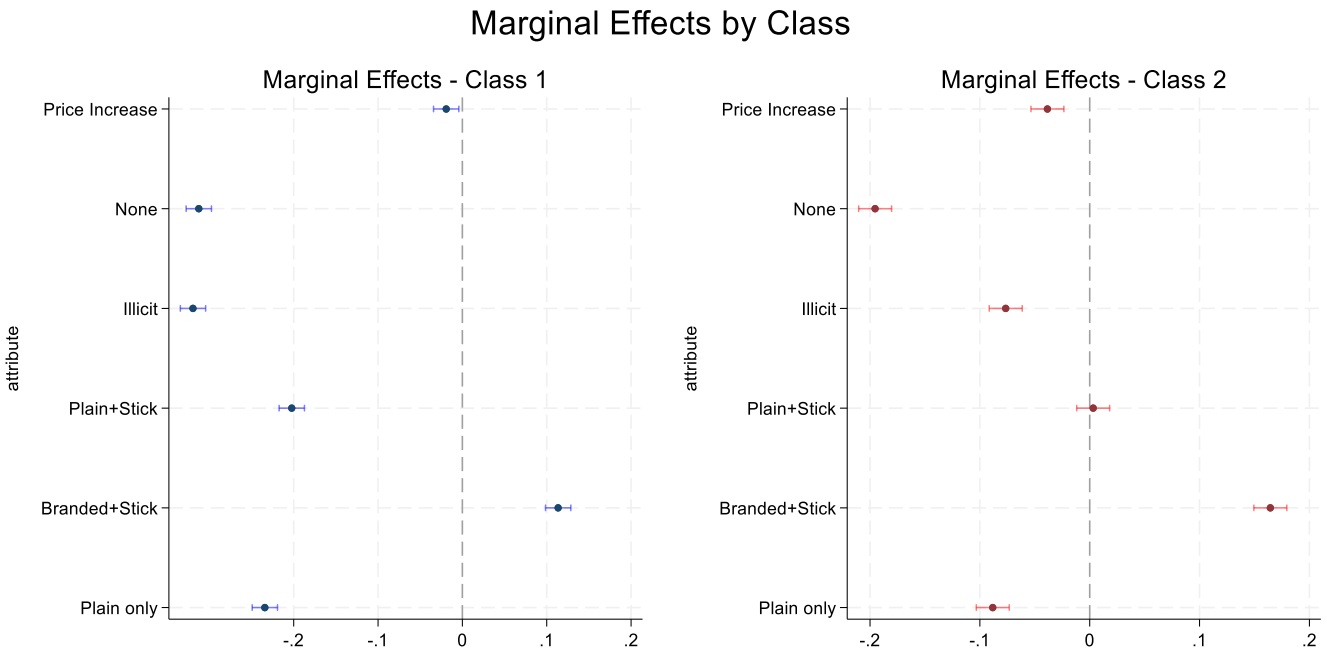
Product, product attributes	Design 1 nonsmokers* (licit & illicit alternatives)				Design 1 smokers (n=409) (licit & illicit alternatives)				Design 2 smokers (n=198) (only licit alternatives)			
	Class 1, share=		Class 2, share=		Class 1, share= 0.78		Class 2, share= 0.22		Class 1, share=0.55		Class 2, share=0.45	
	Pr	95% CI	Pr	95% CI	Pr	95% CI	Pr	95% CI	Pr	95% CI	Pr	95% CI
Intention to purchase												
Price	-	-	-	-	-0.02**	(-0.03,0.00)	-0.04**	(-0.05,-0.02)	-0.04**	(-0.05,-0.02)	-0.01**	(-0.02,0.01)
Plain pack no stick warning	-	-	-	-	-0.23**	(-0.25,-0.22)	-0.09**	(-0.10,-0.07)	-0.54**	(-0.55,-0.52)	0.09**	(0.07,0.10)
Branded with stick warning	-	-	-	-	0.11**	(0.10,0.13)	0.16**	(0.15,0.18)	-0.22**	(-0.24,-0.21)	0.17**	(0.15,0.18)
Plain pack with stick warning	-	-	-	-	-0.20**	(-0.22,-0.19)	0.00**	(-0.01,0.02)	-0.55**	(-0.57,-0.54)	0.56**	(0.54,0.57)
Illicit	-	-	-	-	-0.32**	(-0.33,-0.30)	-0.08	(-0.09,-0.06)	-	-	-	-
Opt-out	-	-	-	-	-0.31**	(-0.33,-0.30)	-0.20**	(-0.21,-0.18)	-0.58**	(-0.59,-0.56)	-0.04**	(-0.06,-0.03)
	Design 1 nonsmokers (n=154) (licit & illicit alternatives)				Design 1 smokers (n=409) (licit & illicit alternatives)				Design 2 smokers* (only licit alternatives)			
	Class 1, share=0.73		Class 2, share=0.27		Class 1, share=0.74		Class 2, share=0.26		Class 1, share=		Class 2, share=	
	Pr	95% CI	Pr	95% CI	Pr	95% CI	Pr	95% CI	Pr	95% CI	Pr	95% CI
Risk perception (least risk to health)									-	-	-	-
Price	0.01	(-0.01,0.02)	0.00	(-0.01,0.02)	-0.01**	(-0.03,0.00)	0.00	(-0.02,0.01)	-	-	-	-
Plain pack no stick warning	-0.25**	(-0.27,-0.24)	-0.05	(-0.06,-0.03)	-0.26**	(-0.27,-0.24)	0.00	(-0.02,0.01)	-	-	-	-
Branded with stick warning	0.06	(0.05,0.08)	-0.05	(-0.07,-0.04)	0.06**	(0.04,0.07)	0.00	(-0.02,0.01)	-	-	-	-
Plain pack with stick warning	-0.23**	(-0.25,-0.22)	-0.08	(-0.10,-0.07)	-0.24**	(-0.26,-0.23)	-0.01	(-0.02,0.01)	-	-	-	-
Illicit	-0.35**	(-0.36,-0.33)	0.23**	(0.21,0.24)	-0.34**	(-0.34,-0.36)	0.35**	(0.33,0.36)	-	-	-	-
Opt-out	-0.35**	(-0.36,-0.33)	0.12	(0.11,0.14)	-0.34**	(-0.34,-0.36)	0.31**	(0.30,0.33)	-	-	-	-

* results no presented since no convergence was achieved, this includes nonsmokers from Design 2. *** p<0.05*

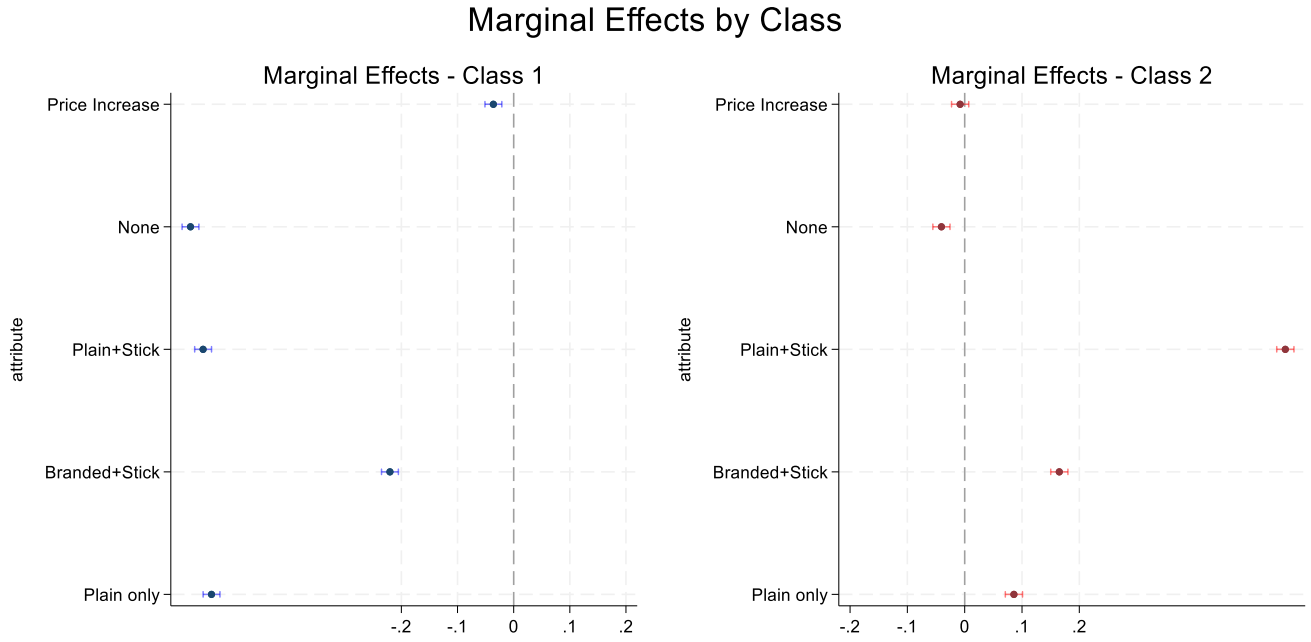
Figure 6 LCA, Design 1 (licit & illicit alternatives) and Design 2 (only licit alternatives) per smoking habits, results marginal effects

Intention to purchase:

Smokers Design 1 (licit & illicit alternatives). Class 1 share = 0.78, Class 2 share=0.22

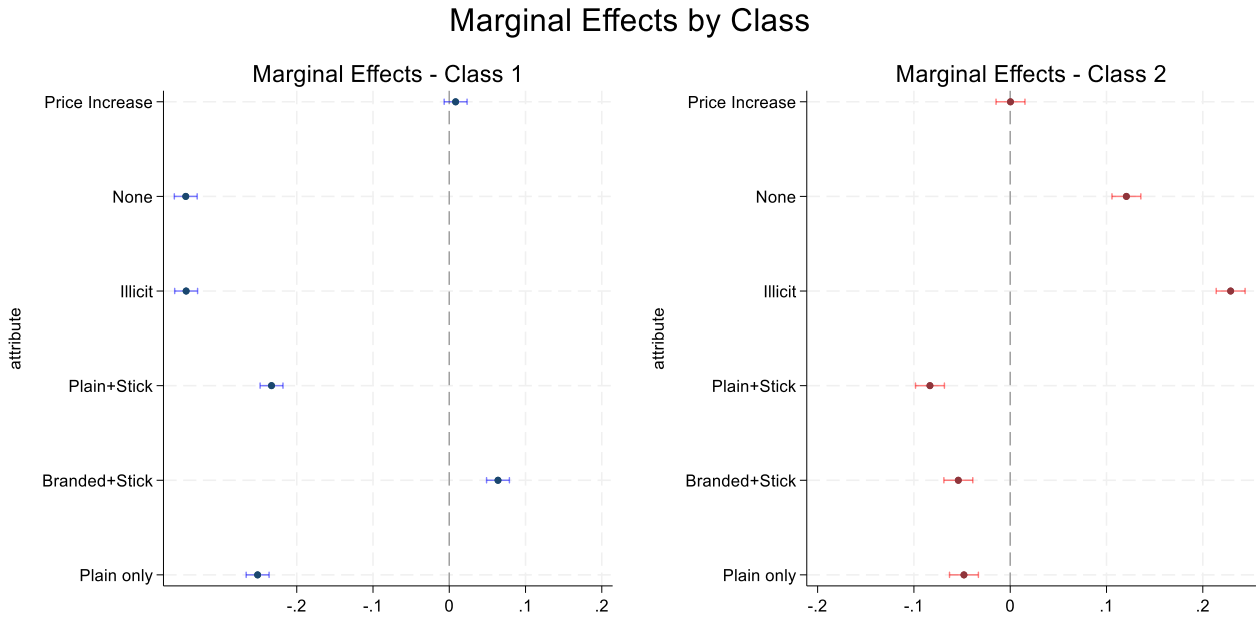


Smokers Design 2 (only licit alternatives). Class 1 share = 0.55, Class 2 share=0.45



Risk perception

Smokers Design 1 (licit & illicit alternatives). Class 1 share = 0.74, Class 2 share=0.26



Nonsmokers Design 1 (licit & illicit alternatives). Class 1 share = 0.73, Class 2 share=0.27

Table 13 Class characteristics - class 2 is the reference

Variable coefficient	Intention to purchase Smokers Design 1	Intention to purchase Smokers Design 2	Risk Smokers Design 1	Risk Nonsmokers Design 2
			Class 1	
Age	-0.01	0.03	-0.02	-0.03
Male	0.01	-0.23	-0.05	-0.55
High school education	1.36	-0.46	2.43**	-13.01
Technical education	1.33	-0.20	2.30**	-11.64
Undergraduate education	1.22	-0.56	2.16	-12.87
Low income	0.43	1.31	1.39**	-0.27
High income	0.09	1.27	1.68**	0.73
Constant	0.07	-1.30	-1.83	14.96
Share	78%	55%	74%	73%

Design 1 smokers: n=409, nonsmokers: n=154. Design 2 smokers: n=198, nonsmokers: n=122

Comparing results to Colombia's DCE

To compare our results with those of the DCE conducted in Colombia, it is essential to contextualize the status of tobacco control policies in Colombia. Colombia implemented smoke-free policies in 2008 and banned tobacco advertising, promotion and sponsorship interventions in 2009. It has not implemented plain package and although health warnings are mandatory, the size covers only 30% of each surface (1). Although Colombia has a slightly larger tax share (65.2%) compared to Ecuador (64%), as of 2022, cigarettes are much cheaper in Colombia than in Ecuador: the retail price for the most sold brand of 20 cigarettes in Ecuador was $ 5.30 USD, while Colombia's was $1.63USD (61). Illicit trade in the Colombian market accounts for 6.4% (academic figure, versus 18% according to the tobacco industry) only as of 2018, versus 51% in Ecuador (independent estimate) (20) (23).

Smokers and nonsmokers in the two neighbouring countries are exposed to notable differences in prices, health warnings and packaging and the presence of illicit cigarettes. These differences are important to consider when comparing the results of the two DCEs. Also, although both studies employed the same methodology and data collection strategy, the questionnaires featured differences that should be acknowledged for accurate comparison.

As shown in

Table 14, there is a significant negative effect of plain packaging in both countries. For Ecuadorian and Colombian smokers in both Designs, plain packaging is one of the most important attributes that decreases the likelihood of purchasing.

Illicit cigarettes have a stronger effect in Ecuador than in Colombia. The marginal effect for Ecuadorian smokers is -0.28 versus -0.05 for Colombians. In the case of nonsmokers, the difference is even greater for Ecuadorians, since the marginal effect of the illicit pack in Ecuador is -0.28, while Colombians have a positive 0.51, this being the attribute with the largest effect for Colombian nonsmokers. These results could be due to the difference in the size of illicit cigarette market in both countries. There are mixed results for health warning on a cigarette stick among smokers and nonsmokers in both Designs.

In the case of risk perception, plain packaging stands as the attribute with the highest negative marginal effect, a result that is consistent in both countries, and that strengthens the conclusions that were found in the intention to purchase section.

Table 14 Marginal effects on intention to purchase and risk perception in Ecuador and Colombia

Product, attributes	Licit and illicit alternatives		Only licit alternatives		Licit and illicit alternatives		Only licit alternatives	
	Smokers	Nonsmokers	Smokers	Nonsmokers	Smokers	Nonsmokers	Smokers	Nonsmokers
	Marginal Effects in Ecuador				Marginal Effects in Colombia			
Intention to purchase								
Price	-0.03***	-0.02***	-0.03***	-0.03***	-0.09***	-0.02***	-0.02***	-0.08***
Plain packaging	-0.21***	-0.26***	-0.15***	-0.28***	-0.21***	-0.09***	-0.25***	-0.31***
Branded with stick warning	0.11***	0.01	0.14***	-0.12***	-0.03*	-0.01*	0.09***	-0.09**
Plain packaging with stick warning	0.04***	0.00	0.06***	-0.04***				
Illicit	-0.28***	-0.28***			-0.05*	0.51***		
Risk perception (least risky)								
Price	0.00	0.01***	0.00***	-0.01	-0.02***	0.00	-0.01	0.03
Plain packaging	-0.19***	-0.20***	-0.12***	-0.09***	-0.10***	-0.08***	-0.10***	-0.16***
Branded with stick warning	0.05***	0.03	0.05	-0.01	0.01	0.01	0.00	-0.05*
Plain packaging with stick warning	0.02***	0.01	0.02	-0.01	-0.043**	0.12***		
Illicit	-0.22***	-0.23***						

A previous DCE in Colombia, different from the one conducted as part of the multi-country study of which this is part, where plain packaging and large health warnings were analyzed as attributes, supported the results shown in Table 14. Researchers concluded that these two attributes impact the intention to try, taste and harm perception, thus decreasing the demand for cigarettes (41).

Discussion

The objective of this study is to use a DCE to evaluate the potential effect of plain packaging, health warnings on cigarette sticks, price changes and illicit cigarette availability on the intention to purchase and the tobacco-related risk perception of the adult population of Ecuador. This is the first time a DCE on this topic has been conducted in Ecuador. (62).

The results indicate that plain packaging is an effective attribute in reducing the intention to purchase by smokers and the willingness to try by nonsmokers, mostly because both groups consider cigarettes riskier when packed in these packs.

This aligns with global and regional evidence that plain packaging diminishes the attractiveness of cigarettes (28,40). Although the region of the Americas has made important progress in tobacco control, implementing plain packaging has been left behind (32). Only Canada and Uruguay have implemented plain packages. Greater efforts are needed in the region to make plain packages mandatory (14). Countries should implement large health pictorial warnings and plain packages to prevent the youth from starting and continuing smoking (40). Ecuador is one of the six countries in the region that attempted to adopt plain packaging (in 2016), however, the bill submitted to the Health Committee of the National Assembly has had no hearings or debates in Parliament as the time the DCE was conducted (14).

According to this study, price increases would be effective in reducing tobacco consumption in Ecuador, consistent with other studies internationally (35,40). Although the tobacco industry has used illicit trade as a reason to fight tobacco control policies, especially excise taxes, there is evidence that this effect may not be as strong as claimed by the tobacco industry (22). In the case of Ecuador, this study shows that, other things equal, smokers prefer to stay away from illicit packs. In addition, when a smoker and a nonsmoker have an illicit pack as an option, their preferences change from when they do not have it. For instance, when they have both licit and illicit alternatives, smokers' WTP increases to stay away from plain packs and increases for warning on a stick compared to when there is no illicit option.

Regarding risk perception, it was striking to see that 20% of smokers think an illicit pack is less risky to their health than other packs. This is more understandable in the case of nonsmokers, because of the lack of knowledge (Class 3 in Design 1 (licit & illicit alternatives)). However, one important thing to consider is that in Ecuador, it is hard to differentiate between licit and illicit packs. In 2010, Ecuador implemented mandatory pictorial and text health warnings on cigarette packs following the approval of the National Tobacco Control Law (16). Since then, the Ministry of Public Health has annually issued six rotating health warnings, which must be printed on all cigarette packs, covering 60% of both the front and back display areas. The illicit packs found in the local study indicated that the illicit Marlboro packs did not have the legal Ecuadorian health warnings and tax stamps. However, this information is not easily identified by smokers and nonsmokers for two reasons: 1) the high prevalence of smokers that buy single sticks instead of a pack, 2) illicit Marlboro packs are produced legally in Mexico and imported by Colombia but then illegally entering Ecuador, so when someone sees the pack they could think it is licit if they don't know the packaging and labelling characteristics that it should have to be legal in Ecuador.

The results from the LCA indicate substantial heterogeneity in preferences across segments of the population. This confirms the need for a set of policies that address different aspects of packaging, pricing and stick warning. For example, in Design 1 (which included both licit and illicit alternatives), smokers in Class 1 clearly avoided illicit packs, whereas those in Class 2 showed little concern for whether a pack was licit or illicit, indicating that the presence of illicit products is not a decisive factor for all smokers. However, when the illicit pack was removed as an option (Design 2), the combined effect of plain packaging, stick warnings, and higher prices had a stronger influence on intention to purchase, suggesting that regulatory measures are more effective when the illicit market is controlled.

The findings from this study highlight that, other things equal, smokers prefer to avoid illicit cigarettes, emphasizing the need to control the availability of these products. Although smokers and nonsmokers want to avoid them, the price difference is an important factor that allows these cigarettes to be more affordable. The government will have to re-introduce a track and tracing system that is not run by the tobacco industry and that is applied to nationally produced and imported tobacco products (23). Additionally, the population need to understand the difference between licit and illicit cigarettes in terms of their characteristics and be aware of the health implications of both types of tobacco products. Unfortunately, people in the country are only listening to the narrative of the tobacco industry, where they state that a high price is increasing the size of the illicit market, a claim that has been dismantled by ample evidence (8). However, in Ecuador this issue is further complicated because 35% of the illicit packs were manufactured by Philip Morris in Colombia and Mexico, which entered the country illegally, bypassing tax obligations and national packaging and health warning regulations.

This comparison between Ecuador and Colombia offers important inputs to tighten existent tobacco control policies and implement new ones to avoid the economic and health burden attributable to smoking. Smokers and nonsmokers do not like plain packaging, thus implementing this policy, could potentially move smokers away from purchasing cigarette packs, and reduce the chances nonsmokers would try to smoke.

Limitations

Although this study carefully followed the research protocol and inputs developed for a multi-country project, some limitations should be considered when interpreting the estimated results. Although considerable effort was made to present clear instructions detailing the different types of cigarette packs included in the study, including clear examples, some participants may still have had points of confusion that could not be clarified because due to COVID the DCE was conducted with an online panel rather than in-person as originally planned.

Secondly, having an online panel introduced a sampling bias toward urban setting, even though participants were recruited from all provinces in Ecuador, including the Galapagos Islands. As of 2020, while 70% of Ecuadorian households had internet access, 77% of the urban population and only 56% of the rural population (63) had such access. Therefore, the results are not representative of the entire national population (64).

Thirdly, all participants were told which pack was illicit. The exact words in the questionnaire were: *"Finally, below you will find an illicit pack of cigarettes. In Ecuador, illicit cigarettes are usually cigarettes that are sold through clandestine networks without the collection of national taxes. Illicit cigarettes also usually do not adhere to any health regulations, such as health warning labels or ingredient disclosure. In addition, the composition of the ingredients may*

differ". Therefore, smokers and nonsmokers may have anticipated the negative connotation of illicit cigarettes, and their responses might be influenced by confirmation bias. This could be different in a usual setting where, as previously mentioned, both licit and illicit cigarettes of the same brand can be found and appear identical.

Additionally, although the study presented information on packs of cigarettes, both smokers and nonsmokers might not know the official price and health warning characteristics of a legal pack of cigarettes. This is because in Ecuador an important percentage of cigarettes are bought per cigarette and not per pack (23). Unfortunately, the current legislation does not prohibit single-stick sales, limiting the population's full exposure to the full price, health warnings and packaging effects. There is an important number of informal street vendors commonly selling cigarettes for 15 to 25 USD cents per unit (23). As a result, even regular smokers may be unfamiliar with the actual price of a cigarette pack, potentially influencing their responses in the DCE.

Policy implications

The results of this study emphasize the need to develop tobacco control policies that diminish the likelihood of purchasing cigarettes by smokers and decrease the willingness to try by nonsmokers. Plain packaging has shown a consistent important effect in both groups, aligning not only with international evidence, but also the recommendations by WHO. Ecuador, as well as other countries in the region, ought to introduce plain packaging, including the graphic health warnings that the country currently mandates. It is essential to strengthen the law proposal to mandate plain packaging in the country and provide national authorities with the information and evidence on the importance of this attribute in the preferences of smokers and nonsmokers. However, given that results showed that smokers and nonsmokers liked the health stick warning, it would be

important to implement this as part of the law, especially in Ecuador, where a high percentage of smokers buy single sticks and are not exposed to the packaging

In terms of illicit cigarettes, this study has shown that, other things equal a large percentage of smokers and nonsmokers prefer licit cigarettes, even to the point of having a significantly negative WTP for illicit cigarettes. But the nature of the illicit market in Ecuador makes it difficult for individuals to distinguish illicit from licit cigarettes. Ecuador must address the illicit cigarette trade through best-practice strategies to control cigarette production, import, marketing and consumption, all of which are protected in the Protocol to Eliminate Illicit Trade in Tobacco Products(15). However, progress has been hindered by changes in the track and tracing system (SIMAR). In 2022, the Servicio de Rentas Internas (SRI), National Tax Authority, established that the tobacco industry should self-regulate: that is, should hire, implement and manage the track and tracing system, and share the information with SRI. Previously, this system was managed by SRI, with publicly available information updated on its website. Since April 2022, no further updates were published, raising concerns about the potential tobacco industry intervention in the information provided and the type of system that will be used.

There are several ways to strengthen the SIMAR tracking system. While the current system provides important information on national production and marketing, it does not cover the market that is outside SIMAR. There should be information regarding what occurs with cigarettes produced in the country and exported, as well as those that are imported to Ecuador.

This study provides Ecuador and other countries in the region with local evidence to inform effective public policy design. The findings support potential reforms to tobacco control legislation, such as implementing plain packaging, warning on the stick and increasing the price of tobacco products. These measures can help prevent smoking initiation and reduce the appeal of

cigarette purchases among current smokers. However, for these policies to achieve their objectives, it is crucial to control the illicit market.

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64. Instituto Nacional de Estadisticas y Censos. Encuesta de Condiciones de Vida. Quito, Ecuador: INEC; 2014.

Appendix

Appendix 1: Literature search strategy

PUBMED

Search number	Query	Filters	Search Details	Results
11	((discrete choice experiment) AND (cigarettes))	in the last 10 years	(("discrete"[All Fields] OR "discretely"[All Fields] OR "discreteness"[All Fields] OR "discretization"[All Fields] OR "discretizations"[All Fields] OR "discretize"[All Fields] OR "discretized"[All Fields] OR "discretizes"[All Fields] OR "discretizing"[All Fields]) AND ("choice behavior"[MeSH Terms] OR ("choice"[All Fields] AND "behavior"[All Fields]) OR "choice behavior"[All Fields] OR "choice"[All Fields] OR "choices"[All Fields]) AND ("experiment"[All Fields] OR "experiment s"[All Fields] OR "experiments"[All Fields]) AND ("cigarett"[All Fields] OR "cigarette s"[All Fields] OR "cigaretts"[All Fields] OR "tobacco products"[MeSH Terms] OR ("tobacco"[All Fields] AND "products"[All Fields]) OR "tobacco products"[All Fields] OR "cigarette"[All Fields] OR "cigarettes"[All Fields])) AND (y_10[Filter])	49
10	((discrete choice experiment) AND (cigarettes))		("discrete"[All Fields] OR "discretely"[All Fields] OR "discreteness"[All Fields] OR "discretization"[All Fields] OR "discretizations"[All Fields] OR "discretize"[All Fields] OR "discretized"[All Fields] OR "discretizes"[All Fields] OR "discretizing"[All Fields]) AND ("choice behavior"[MeSH Terms] OR ("choice"[All Fields] AND "behavior"[All Fields]) OR "choice behavior"[All Fields] OR "choice"[All Fields] OR "choices"[All Fields]) AND ("experiment"[All Fields] OR "experiment s"[All Fields] OR "experiments"[All Fields]) AND ("cigarett"[All Fields] OR "cigarette s"[All Fields] OR "cigaretts"[All Fields] OR "tobacco products"[MeSH Terms] OR ("tobacco"[All Fields] AND "products"[All Fields]) OR "tobacco products"[All Fields] OR "cigarette"[All Fields] OR "cigarettes"[All Fields])	50
9	((discrete choice experiment) AND (cigarettes)) AND (latin america)		"discrete"[All Fields] AND ("choice behavior"[MeSH Terms] OR ("choice"[All Fields] AND "behavior"[All Fields]) OR "choice behavior"[All Fields] OR "choice"[All Fields] OR "choices"[All Fields]) AND ("experiment"[All Fields] OR "experiment s"[All Fields] OR "experiments"[All Fields]) AND ("cigarett"[All Fields] OR "cigarette s"[All Fields] OR "cigaretts"[All Fields] OR "tobacco products"[MeSH Terms] OR ("tobacco"[All Fields] AND "products"[All Fields]) OR "tobacco products"[All Fields] OR "cigarette"[All Fields] OR "cigarettes"[All Fields]) AND ("latin america"[MeSH Terms] OR ("latin"[All Fields] AND "america"[All Fields]) OR "latin america"[All Fields])	0
8	((discrete choice experiment) AND		"discrete"[All Fields] AND "choice"[All Fields] AND "experiment"[All Fields] AND "cigarettes"[All Fields] AND ("latin"[All Fields] AND "america"[All Fields])	0

	(cigarettes)) AND (latin america) - Schema: all			
7	((choice experiment) AND (tobacco)) AND (latin america)		("choice behavior"[MeSH Terms] OR ("choice"[All Fields] AND "behavior"[All Fields]) OR "choice behavior"[All Fields] OR "choice"[All Fields] OR "choices"[All Fields]) AND ("experiment"[All Fields] OR "experiment s"[All Fields] OR "experiments"[All Fields]) AND ("tobacco products"[MeSH Terms] OR ("tobacco"[All Fields] AND "products"[All Fields]) OR "tobacco products"[All Fields] OR "tobacco"[All Fields] OR "nicotiana"[MeSH Terms] OR "nicotiana"[All Fields] OR "tobacco s"[All Fields] OR "tobaccos"[All Fields]) AND ("latin america"[MeSH Terms] OR ("latin"[All Fields] AND "america"[All Fields]) OR "latin america"[All Fields])	0
6	((choice experiment) AND (tobacco)) AND (latin america) - Schema: all		"choice"[All Fields] AND "experiment"[All Fields] AND "tobacco"[All Fields] AND ("latin"[All Fields] AND "america"[All Fields])	0
5	((DCE) AND (tobacco)) AND (latin america) - Schema: all		"DCE"[All Fields] AND "tobacco"[All Fields] AND ("latin"[All Fields] AND "america"[All Fields])	0
4	((DCE) AND (tobacco)) AND (latin america)		("digit cult educ"[Journal] OR "dce"[All Fields]) AND ("tobacco products"[MeSH Terms] OR ("tobacco"[All Fields] AND "products"[All Fields]) OR "tobacco products"[All Fields] OR "tobacco"[All Fields] OR "nicotiana"[MeSH Terms] OR "nicotiana"[All Fields] OR "tobacco s"[All Fields] OR "tobaccos"[All Fields]) AND ("latin america"[MeSH Terms] OR ("latin"[All Fields] AND "america"[All Fields]) OR "latin america"[All Fields])	0
3	((DCE) AND (tobacco)) AND (latin america)	in the last 10 years	(("digit cult educ"[Journal] OR "dce"[All Fields]) AND ("tobacco products"[MeSH Terms] OR ("tobacco"[All Fields] AND "products"[All Fields]) OR "tobacco products"[All Fields] OR "tobacco"[All Fields] OR "nicotiana"[MeSH Terms] OR "nicotiana"[All Fields] OR "tobacco s"[All Fields] OR "tobaccos"[All Fields]) AND ("latin america"[MeSH Terms] OR ("latin"[All Fields] AND "america"[All Fields]) OR "latin america"[All Fields])) AND (y_10[Filter])	0

2	((discrete choice experiment) AND (tobacco)) AND (latin america)	in the last 10 years	("discrete"[All Fields] AND ("choice behavior"[MeSH Terms] OR ("choice"[All Fields] AND "behavior"[All Fields]) OR "choice behavior"[All Fields] OR "choice"[All Fields] OR "choices"[All Fields]) AND ("experiment"[All Fields] OR "experiment s"[All Fields] OR "experiments"[All Fields]) AND ("tobacco products"[MeSH Terms] OR ("tobacco"[All Fields] AND "products"[All Fields]) OR "tobacco products"[All Fields] OR "tobacco"[All Fields] OR "nicotiana"[MeSH Terms] OR "nicotiana"[All Fields] OR "tobacco s"[All Fields] OR "tobaccos"[All Fields]) AND ("latin america"[MeSH Terms] OR ("latin"[All Fields] AND "america"[All Fields]) OR "latin america"[All Fields])) AND (y_10[Filter])	0
1	(((((discrete choice experiment) AND (packaging)) AND (warning)) AND (price)) AND (tobacco)) AND (latin America)	in the last 10 years	("discrete"[All Fields] AND ("choice behavior"[MeSH Terms] OR ("choice"[All Fields] AND "behavior"[All Fields]) OR "choice behavior"[All Fields] OR "choice"[All Fields] OR "choices"[All Fields]) AND ("experiment"[All Fields] OR "experiment s"[All Fields] OR "experiments"[All Fields]) AND ("package"[All Fields] OR "packages"[All Fields] OR "product packaging"[MeSH Terms] OR ("product"[All Fields] AND "packaging"[All Fields]) OR "product packaging"[All Fields] OR "packaged"[All Fields] OR "packaging"[All Fields] OR "drug packaging"[MeSH Terms] OR ("drug"[All Fields] AND "packaging"[All Fields]) OR "drug packaging"[All Fields] OR "packagings"[All Fields]) AND ("warned"[All Fields] OR "warning"[All Fields] OR "warnings"[All Fields] OR "warns"[All Fields]) AND ("commerce"[MeSH Terms] OR "commerce"[All Fields] OR "price"[All Fields] OR "prices"[All Fields] OR "costs and cost analysis"[MeSH Terms] OR ("costs"[All Fields] AND "cost"[All Fields] AND "analysis"[All Fields]) OR "costs and cost analysis"[All Fields] OR "pricing"[All Fields] OR "priced"[All Fields] OR "pricings"[All Fields]) AND ("tobacco products"[MeSH Terms] OR ("tobacco"[All Fields] AND "products"[All Fields]) OR "tobacco products"[All Fields] OR "tobacco"[All Fields] OR "nicotiana"[MeSH Terms] OR "nicotiana"[All Fields] OR "tobacco s"[All Fields] OR "tobaccos"[All Fields]) AND ("latin america"[MeSH Terms] OR ("latin"[All Fields] AND "america"[All Fields]) OR "latin america"[All Fields])) AND (y_10[Filter])	0

ECONLIT

#	Query	Limiters/Expanders	Last Run Via	Results
S5	discrete choice experiment AND	Limiters - Publication Date: 20060101-20251231	Interface - EBSCOhost Research Databases	1

	tobacco AND latin america	Expanders - Apply equivalent subjects Search modes - SmartText Searching	Search Screen - Advanced Search Database - EconLit with Full Text	
S4	discrete choice experiment AND tobacco AND latin america	Expanders - Apply equivalent subjects Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - EconLit with Full Text	1
S3	discrete choice experiment AND tobacco AND latin america	Expanders - Apply equivalent subjects Search modes - Proximity	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - EconLit with Full Text	0
S2	discrete choice experiment AND tobacco AND (latin america or south america or central america)	Expanders - Apply equivalent subjects Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - EconLit with Full Text	1
S1	discrete choice experiment AND tobacco AND (latin america or south america or central america)	Expanders - Apply equivalent subjects Search modes - Proximity	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - EconLit with Full Text	0

GOOGLE SCHOLAR

Query	Filters	Results

"discrete choice experiment" AND packaging AND warning AND price AND tobacco AND "Latin America" -e-cigarette -vape -vaping -HTP -"heated tobacco"	in the last 10 years	68

All the publications found in Google Scholar were also found in the results from PUBMED. The result from EconLit was not related to cigarettes. Studies that followed the following conditions were selected:

- Discrete choice experiments performed in any Latin American country
- Study should analyze one or more than one of the following attributes: packaging, health warning, price
- Only DCEs conducted for cigarettes. All DCEs conducted in novel products such as e-cigarettes, vapes, non-smoking products, non-nicotine produccts were excluded.
- As a result seven studies were included.

Appendix 2: Choice sets composition

	Alt	Choice set	Block	Price	Branded Pack	Plain pack	Warning on stick	Branded stick	Illicit
Design 1 (licit & illicit alternatives)	1	1	1	7.7	1	0	0	1	0
	2	1	1	4.6	0	1	0	1	0
	3	1	1	1	0	0	0	0	1
	4	1	1	0	0	0	0	0	0
	1	2	1	7.7	0	1	0	1	0
	2	2	1	7.7	1	0	1	0	0
	3	2	1	4.3	0	0	0	0	1
	4	2	1	0	0	0	0	0	0
	1	3	1	4.6	0	1	1	0	0
	2	3	1	7.7	1	0	1	0	0
	3	3	1	4.3	0	0	0	0	1
	4	3	1	0	0	0	0	0	0
	1	4	1	4.6	1	0	1	0	0
	2	4	1	4.6	0	1	0	1	0
	3	4	1	1	0	0	0	0	1
	4	4	1	0	0	0	0	0	0
	1	5	1	4.6	1	0	0	1	0
	2	5	1	5.3	0	1	0	1	0
	3	5	1	4.3	0	0	0	0	1
	4	5	1	0	0	0	0	0	0
	1	6	1	4.6	0	1	1	0	0
	2	6	1	5.3	1	0	0	1	0
	3	6	1	1	0	0	0	0	1
	4	6	1	0	0	0	0	0	0
	1	7	1	7.7	1	0	0	1	0
	2	7	1	7	0	1	1	0	0
	3	7	1	4.3	0	0	0	0	1

4	7	1	0	0	0	0	0	0
1	1	2	7	0	1	1	0	0
2	1	2	7.7	1	0	1	0	0
3	1	2	1	0	0	0	0	1
4	1	2	0	0	0	0	0	0
1	2	2	4.6	0	1	1	0	0
2	2	2	5.3	1	0	0	1	0
3	2	2	4.3	0	0	0	0	1
4	2	2	0	0	0	0	0	0
1	3	2	7.7	1	0	0	1	0
2	3	2	4.6	1	0	1	0	0
3	3	2	1	0	0	0	0	1
4	3	2	0	0	0	0	0	0
1	4	2	7.7	0	1	0	1	0
2	4	2	7	0	1	1	0	0
3	4	2	1	0	0	0	0	1
4	4	2	0	0	0	0	0	0
1	5	2	4.6	1	0	0	1	0
2	5	2	5.3	0	1	0	1	0
3	5	2	4.3	0	0	0	0	1
4	5	2	0	0	0	0	0	0
1	6	2	4.6	1	0	1	0	0
2	6	2	4.6	0	1	0	1	0
3	6	2	4.3	0	0	0	0	1
4	6	2	0	0	0	0	0	0
1	7	2	7	0	1	1	0	0
2	7	2	7.7	0	1	0	1	0
3	7	2	4.3	0	0	0	0	1
4	7	2	0	0	0	0	0	0
1	1	3	7.7	0	1	0	1	0
2	1	3	7.7	1	0	1	0	0

Design 2 (only licit alternatives)	3	1	3	7	0	1	1	0	0
	4	1	3	0	0	0	0	0	0
	1	2	3	4.6	1	0	1	0	0
	2	2	3	4.6	0	1	0	1	0
	3	2	3	7.7	1	0	0	1	0
	4	2	3	0	0	0	0	0	0
	1	3	3	7.7	1	0	1	0	0
	2	3	3	7.7	0	1	0	1	0
	3	3	3	4.6	0	1	1	0	0
	4	3	3	0	0	0	0	0	0
	1	4	3	4.6	1	0	1	0	0
	2	4	3	5.3	1	0	0	1	0
	3	4	3	4.6	0	1	0	1	0
	4	4	3	0	0	0	0	0	0
	1	5	3	6.4	1	0	0	1	0
	2	5	3	7	0	1	0	1	0
	3	5	3	7.7	0	1	1	0	0
	4	5	3	0	0	0	0	0	0
	1	6	3	6.4	0	1	1	0	0
	2	6	3	7	1	0	1	0	0
	3	6	3	7.7	1	0	0	1	0
	4	6	3	0	0	0	0	0	0
	1	7	3	5.8	1	0	0	1	0
	2	7	3	5.3	0	1	0	1	0
	3	7	3	4.6	0	1	1	0	0
	4	7	3	0	0	0	0	0	0

Appendix 3: Results with the complete database (including low quality respondents)

Marginal effects

Intention to purchase/try

As shown in the upper panel of the Table below, among smokers the marginal effects of the attributes in Design 1 (licit & illicit alternatives) are statistically significant. When the price increased by 10%, the likelihood of purchasing a standard pack decreased by 1% (ME: -0.01, CI: -0.02,-0.01). In addition, both illicit packs (ME: -0.17, CI: -0.20,-0.13) and plain packaging with no stick warning (ME: -0.14, CI: -0.16,-0.11) significantly reduced the probability that a smoker chose these options. However, adding a stick warning to the cigarettes in branded packs (ME: 0.09, CI: 0.06,0.12) or a plain pack (ME: 0.04, CI: 0.03,0.06) increased the chance that a smoker in Design 1 selected one of these alternatives.

In Design 2 (only licit alternatives), when smokers did not have the option of choosing an illicit pack, the average effects of price (ME: -0.02, CI: -0.03,-0.01) and plain packaging with no stick warning (ME: -0.10, CI: -0.14,-0.06) were negative, similar to those observed among smokers in Design 1 (licit & illicit alternatives), although the marginal effect values differed. Branded packs with a stick warning (ME: 0.10, CI: 0.05,0.15) and plain packaging with a stick warning (ME: 0.06, CI: 0.03,0.09) increased smokers' likelihood of choosing these options.

In the case of nonsmokers in Design 1 (licit & illicit alternatives), only price and plain packaging with no stick warning were statistically significant. A 10% price increase lowers the probability of a nonsmoker’s intention to try by 1% (ME: -0.01, CI: -0.01,0.00). Plain packaging with no stick warning decreases the intention to try by 12 percentage points (ME: -0.12, CI: -0.15,-0.08).

For nonsmokers in Design 2 (only licit alternatives), the marginal effect of all attributes were statistically significant and showed a negative impact on the intent to try. Plain packaging with no stick warning was the attribute with the largest effect, reducing the probability of trying by 18 percentage points (ME: -0.18, CI: -0.25,-0.11). This was followed by branded pack with stick warning (ME: -0.11, CI: -0.18,-0.05), plain packaging with stick warning (ME: -0.06, CI: -0.09,-0.03) and price (ME: -0.02, CI: -0.03,0.00).

Risk perception

This section presents the marginal effects of product attributes on the probability of being perceived as the least risky, shown in the lower panel of the following Table. For smokers in Design 1 (licit & illicit alternatives), price did not have a statistically significant effect. However, branded packs with stick warning (ME: 0.05, CI: 0.02,0.08) and plain packaging with a stick warning (ME: 0.02, CI: 0.01,0.03) had a positive effect in the likelihood of being perceived as low risk. On the other hand, illicit packs (ME: -0.14, CI: -0.18,-0.11) and plain packaging with no stick warning (ME: -0.15, CI: -0.17,-0.12) were significantly less likely to be considered low risk. For smokers in Design 2, plain packaging with no stick warning was the only attribute that significantly reduced perceived safety (ME: -0.09, CI: -0.13,-0.06).

For nonsmokers in Design 1 (licit & illicit alternatives), the marginal effect of plain packaging with no stick warning (ME: -0.12, CI: -0.15,-0.09) and illicit packs (ME: -0.09, CI: -0.14,-0.04) were statistically significant and negative. This indicates that they are perceived as riskier. On the other hand, for nonsmokers in Design 2, only the plain packaging with no stick warning had an effect in the risk perception, decreasing the likelihood to be perceived as low risk (ME: -0.06, CI: -0.10,-0.01)

Marginal effects

Product, attributes	Design 1 (licit & illicit alternatives)				Design 2 (only licit alternatives)			
	Smokers		Nonsmokers		Smokers		Nonsmokers	
	Mg. Eff.	95% CI	Mg. Eff.	95% CI	Mg. Eff.	95% CI	Mg. Eff.	95% CI
Intention to purchase/try								
Price	-0.01***	(-0.02--0.01)	- 0.01***	(-0.01-0.00)	-0.02***	(-0.03--0.01)	-0.02***	(-0.03-0.00)
Plain packaging with no stick warning	-0.14***	(-0.16--0.11)	-0.12***	(-0.15--0.09)	-0.10***	(-0.14--0.06)	-0.18***	(-0.25--0.11)
Branded with stick warning	0.09***	(0.06-0.12)	0.00	(-0.03-0.03)	0.10***	(0.05-0.15)	-0.11***	(-0.18--0.05)
Plain packaging with stick warning	0.04***	(0.03-0.06)	0.00	(-0.02-0.02)	0.06***	(0.03-0.09)	-0.06***	(-0.09--0.03)
Illicit	-0.17***	(-0.20--0.13)	-0.03	(-0.09--0.03)				
Risk perception (least risky)								
Price	0.00	(-0.01-0.00)	0.00***	(-0.01-0.00)	0.00***	(-0.01-0.00)	0.00	(-0.01-0.00)
Plain packaging with no stick warning	-0.15***	(-0.17--0.12)	-0.12***	(-0.15--0.09)	-0.09***	(-0.13--0.06)	-0.06***	(-0.10--0.01)
Branded with stick warning	0.05***	(0.02-0.08)	0.01	(-0.02-0.05)	0.04	(0.00-0.09)	-0.02	(-0.07-0.03)
Plain packaging with stick warning	0.02***	(0.01-0.03)	0.01	(-0.01-0.02)	0.03	(0.00-0.06)	-0.01	(-0.05-0.03)
Illicit	-0.14***	(-0.18--0.11)	-0.09***	(-0.14--0.04)				

**** p<0.05; the marginal effects of the opt-out option are not displayed in the output. Branded pack with no stick warning (standard pack) is the reference category. To estimate the marginal effect of price, I used $5.30 USD as the price of the reference pack.*

Willingness to pay

Intention to purchase/ try

The table below provides the WTP for intention to purchase and risk for both designs. When the values are negative, they indicate that the person would not even want the pack with those attributes if it were free; indeed, they would be willing to pay to avoid the attribute. One would have to pay the person to take such a pack.

Regarding intention to purchase, smokers in Design 1 (licit & illicit alternatives) had a WTP of $7.67 USD to avoid plain packaging, and an even higher WTP of $10.07 USD to avoid illicit cigarettes. However, they were also willing to pay $2.98 USD more for a pack that featured a health warning on the stick. Meanwhile, in Design 2, where the illicit option was not available, smokers were willing to pay $2.61 USD to avoid plain packaging.

Nonsmokers in both Designs exhibit consistently negative WTP for all attributes. In Design 1 (licit & illicit alternatives), nonsmokers were willing to pay an additional $13.22 USD to avoid plain packaging. While nonsmokers in Design 2 (only licit alternatives), they presented a WTP of $7.58 USD to avoid plain packaging and $4.24 USD to avoid warning on a stick . Note that none of the WTP estimates related to risk perception were statistically significant.

WTP

Product, attributes	Design 1 (licit & illicit alternatives)		Design 2 (only licit alternatives)	
	Smokers	Nonsmokers	Smokers	Nonsmokers
	WTP	WTP	WTP	WTP
Plain packaging	-7.67***	-13.22***	-2.61***	-7.58***
Warning on stick	2.98***	-0.04	1.69***	-4.24***
Illicit	-10.07***	-2.59	-	-

**** p<0.05; WTP of the opt-out option are not displayed in the output. Branded pack with no stick warning (standard pack) is the reference category. To estimate the WTP, I used $5.30 USD as the price of the reference pack.*

Estimated probabilities

Intention to purchase/ try

As shown in the Table below, for Design 1 (licit & illicit alternatives) the rank order for the likelihood that a smoker will choose each option is as follows: (i) branded pack with stick warning (0.35), (ii) branded pack with no stick warning (0.26), (iii) plain pack with stick warning (0.16), (iv) plain pack without stick warning (0.12); (v) illicit cigarette pack (0.09), and, finally, opting out (0.02). When smokers do not have the option of choosing an illicit pack, as in Design 2 (only licit alternatives), the ranking of preferences among licit packs remains the same as in Design 1; however. The associated probability values differ.

Nonsmokers in both Designs showed similar preferences when asked which option they would most likely try. In Design 1 (licit & illicit alternatives), nonsmokers showed the highest likelihood of choosing branded packs, both without and with stick warnings (0.25 each). The second-ranked choice is the illicit pack (0.22), followed by both plain package options (0.13 for both), with opt-out as the last option (0.00).

For nonsmokers in Design 2 (only licit alternatives), the option they were most likely to try is a branded pack with no stick warning (0.38), followed by the branded pack with stick warning (0.27). Plain packages with no stick warning (0.20) are in third place, followed by plain packages with stick warning (0.14). The opt-out option was the least likely to be chosen, with a probability of 0.00.

Risk perception

The lower panel of the Table below details the predicted probability of each option to be selected as the least risky.

In Design 1 (licit & illicit alternatives), smokers chose the branded pack with a stick warning as the option perceived to be least risky (0.31), followed by the branded pack with no stick warning (0.26), and plain packaging with a stick warning (0.13). However, for smokers in this Design, plain packaging with no stick warning and the illicit pack had the same predicted probabilities of being chosen (0.11), the lowest among the different options.

In the case of Design 2 (only licit alternatives), smokers had the same ranking of predicted probabilities for branded packs with a stick warning, branded packs without stick warning, and plain packaging with a stick warning as in Design 1 (licit & illicit alternatives), although the specific probability values differed slightly. With the illicit pack option removed in Design 1, the opt-out alternative ranked fourth (0.16), and plain packaging without a stick warning came last (0.15).

For nonsmokers in Design 1 (licit & illicit alternatives), based on risk perception, the branded pack with stick warning had the highest predicted probability of being perceived as the least risky option (0.26), followed by the branded pack without stick warning (0.24). The illicit

pack ranked third (0.15), plain packaging with a stick warning was fourth (0.13), followed by plain packaging without a stick warning (0.12).

Regarding nonsmokers in Design 2 (only licit alternatives), the branded pack with no stick warning had the highest predicted value (0.25), while the branded pack with a stick warning ranked second (0.24). Plain packaging with no stick warning was third (0.19), and plain packaging with a stick warning had the lowest predicted value among pack options (0.18). For nonsmokers across both Designs, opt-out had a low predicted probability, whereas in Design 1 (licit & illicit alternatives), the numbers are lower than in Design 2 (only licit alternatives).

Product, attributes	Design 1 (licit & illicit alternatives)				Design 2 (only licit alternatives)			
	Smokers		Nonsmokers		Smokers		Nonsmokers	
	Prob.	95% CI	Prob.	95% CI	Prob.	95% CI	Prob.	95% CI
Intention to purchase/try								
Branded no stick warning	0.26	(0.24-0.28)	0.25	(0.22-0.28)	0.25	(0.22-0.29)	0.38	(0.30-0.43)
Plain packaging no stick warning	0.12	(0.11-0.13)	0.13	(0.12-0.15)	0.15	(0.13-0.17)	0.20	(0.17-0.24)
Branded with stick warning	0.35	(0.30-0.37)	0.25	(0.23-0.28)	0.35	(0.30-0.38)	0.27	(0.23-0.31)
Plain packaging with stick warning	0.16	(0.14-0.18)	0.13	(0.12-0.15)	0.21	(0.17-0.25)	0.14	(0.11-0.18)
Illicit	0.09	(0.07-0.11)	0.22	(0.18-0.26)	-	-	-	-
Opt-out	0.02	(0.02-0.03)	0.00	(.-.)	0.03	(0.02-0.04)	0.00	(.-.)
Risk perception (least risky option)								
Branded no stick warning	0.26	(0.24-0.28)	0.24	(0.22-0.27)	0.24	(0.21-0.27)	0.25	(0.21-0.29)
Plain packaging no stick warning	0.11	(0.10-0.12)	0.12	(0.11-0.14)	0.15	(0.12-0.17)	0.19	(0.16-0.22)
Branded with stick warning	0.31	(0.28-0.33)	0.26	(0.23-0.28)	0.28	(0.25-0.32)	0.24	(0.20-0.27)
Plain packaging with stick warning	0.13	(0.12-0.15)	0.13	(0.12-0.15)	0.17	(0.15-0.20)	0.18	(0.15-0.21)
Illicit	0.11	(0.09-0.13)	0.15	(0.12-0.18)	-	-	-	-
Opt-out	0.08	(0.07-0.10)	0.09	(0.07-0.11)	0.16	(0.12-0.19)	0.14	(0.10-0.18)

$5.30 USD fixed price used to estimate probabilities for it is the average price of a 20-unit pack

Appendix 4: Estimated probabilities

Product, attributes	Design 1 (licit & illicit alternatives)				Design 2 (only licit alternatives)			
	Smokers		Nonsmokers		Smokers		Nonsmokers	
	Prob.	95% CI	Prob.	95% CI	Prob.	95% CI	Prob.	95% CI
Intention to purchase								
Branded no stick warning	0.31	(0.28-0.33)	0.36	(0.31-0.40)	0.27	(0.23-0.32)	0.43	(0.36-0.50)
Plain packaging no stick warning	0.10	(0.08-0.11)	0.10	(0.08-0.12)	0.13	(0.11-0.15)	0.15	(0.12-0.19)
Branded with stick warning	0.42	(0.39-0.45)	0.37	(0.33-0.41)	0.41	(0.37-0.44)	0.31	(0.26-0.36)
Plain packaging with stick warning	0.13	(0.12-0.15)	0.10	(0.08-0.12)	0.19	(0.15-0.23)	0.11	(0.07-0.15)
Illicit	0.03	(0.02-0.04)	0.08	(0.05-0.10)	-	-	-	-
Optout	0.01	(0.01-0.02)	0.00	(.-.)	0.00	(0.00-0.01)	0.00	(.-.)
Risk perception (least risky)								
Branded no stick warning	0.29	(0.27-0.32)	0.31	(0.27-0.35)	0.25	(0.21-0.29)	0.27	(0.22-0.33)
Plain packaging no stick warning	0.10	(0.09-0.12)	0.11	(0.08-0.13)	0.14	(0.11-0.16)	0.18	(0.14-0.22)
Branded with stick warning	0.34	(0.32-0.37)	0.33	(0.29-0.38)	0.30	(0.26-0.34)	0.26	(0.22-0.31)
Plain packaging with stick warning	0.12	(0.11-0.14)	0.12	(0.09-0.14)	0.16	(0.13-0.19)	0.17	(0.14-0.21)
Illicit	0.07	(0.05-0.09)	0.08	(0.05-0.12)	-	-	-	-
Optout	0.07	(0.05-0.08)	0.05	(0.03-0.08)	0.15	(0.11-0.19)	0.11	(0.07-0.16)

Chapter 4: Willingness to pay for legal and illicit cigarettes: evidence from a Becker-DeGroot-Marschak Auction Mechanism in Canada, Ecuador, Chile and Colombia

Abstract

Background

Smoking is one of the modifying risk factors of non-communicable diseases that continues to increase the burden of disease, especially in developing countries. In the Americas, the level of tobacco control policies varies significantly. This study has the objective to examine the consumer preferences in four different countries (Ontario-Canada, Ecuador, Chile and Colombia). This study uses the Becker-DeGroot-Marschak (BDM) auction mechanism to elicit participants' willingness to pay (WTP) for various cigarette pack attributes, including plain packaging, stick warnings, branded packs, and illicit products.

Methods

Adult participants from Canada (province of Ontario), Ecuador, Chile and Colombia were assigned to different blocks where they had to indicate their WTP for two packs. A cross-country comparison was conducted to examine differences in WTP. To examine the association between participants' socioeconomic characteristics and their WTP, separate Ordinary Least Squares (OLS) regression models were estimated for each cigarette pack type within each country.

Results

Across all countries the highest overall mean WTP was for the country's then current legal pack at the time of data collection. In every country, both smokers and nonsmokers had the lowest WTP illicit packs, significantly and substantively less than all legal packs. Additionally, this study found no consistent statistical relationship between most socioeconomic and demographic characteristics and the WTP for the licit and illicit cigarette packs. However, age was negatively associated with WTP for most packs in all countries. Country-specific effects were also observed.

Conclusions

The cross-country evidence presented in this study allows national policymakers to go beyond their own consumer data and assess whether similar trends are observed in comparable contexts. This type of evidence-sharing across countries can help accelerate progress in tobacco control by informing more targeted and context-sensitive policy design. While one can learn from other countries, adaptation and caution are necessary when applying results from another country.

Introduction

Smoking remains one of the primary contributors to mortality and morbidity rates of non-communicable and preventable diseases (1,2). In the Americas region, for instance, in 2020, mortality attributable to cigarette consumption varied from 10% in Ecuador, (5) to 13% in Colombia, (4) and 16% in Chile (3). For these South American countries, the cigarette smoking prevalence adjusted by age for the year 2020 was: 27.6 (CI: 22.6-32.7) for Chile, 7.5 (CI: 5.1-10.0) for Colombia, and 9.0 (CI: 5.9-12.1) for Ecuador (3). In the case of Canada, an estimated 15% of deaths were related to cigarette consumption in 2020 (4), with a current cigarette smoking prevalence adjusted by age of 12.3 (CI: 10.3-14.3).

As a response, many countries have adopted the WHO Framework Convention on Tobacco Control (WHO FCTC) and introduced the MPOWER technical package to develop national policies to reduce tobacco consumption (5). Countries have different levels of implementation of the MPOWER measures, striving to achieve the best practice level in each. MPOWER includes a set of strategies of demonstrated effectiveness and cost-effectiveness to address noncommunicable diseases (NDCs). This study will focus on two strategies, tobacco taxation (R- raise taxes on tobacco) and tobacco packaging and labelling (W- warn about the dangers of tobacco), to generate evidence to inform policy formulation to reduce the burden of tobacco (6,7).

Observational studies have limitations in establishing causation. Measures to reduce the burden of tobacco don't normally happen in isolation, so there is no certainty that changes in observed behaviours are solely the result of such measures. Sometimes there are no suitable observational data; other times, there is a desire to understand potential effects before a policy is implemented. Experimental methods based on randomization can complement observational studies. This study used an experimental design to investigate willingness to pay (WTP) for

cigarettes under alternative packaging and labelling regulations, using the Becker-DeGroot-Marschak (BDM) auction method. As of today, no experimental study employing a BDM auction has been used in Latin American countries to investigate tobacco control measures. The results of this study provide evidence on the impact of packaging and health warnings in different settings (a high-income country (HIC) – Canada - and three Latin American low- and middle-income countries (LMICs) - Chile, Colombia and Ecuador), in addition to understanding how the availability of illicit packs affects people's behaviour.

Canada was one of the first countries in the Americas to adhere to the FCTC and has established itself as a global leader in tobacco control policies (2). Canada was the first country to mandate the display of health warnings in the principal display areas in 2000 (2,8). Currently, pictorial and text health warnings must cover 75% of the front and back of the cigarette pack. They must be in English and French. The warnings must provide information on the health impact, the addictive nature of tobacco, and cessation advice (8,9).

Canada and Uruguay are the only two countries in the Region that have plain packaging legislation (adopted in 2019) (10). In Canada, all packs of cigarettes must have a specific Pantone in brown colour with only permitted text in a standard location, font style, colour and size. However, Canadians upgraded their regulations in 2023, introducing mandatory health warnings printed directly on individual cigarettes. These are pre-determined printed messages intended to inform on the health hazards of tobacco use (11).

In terms of cigarette prices, in 2022, the price of a pack of 20 cigarettes of the most-sold brand in Canada was $10.53 international dollars (US dollars using Parity Purchase Power- PPP to be able to compare across countries). Of this amount, 63.3% corresponds to total taxes, a share below WHO's recommended 75% (5). The inflation-adjusted price of cigarette packs has changed

over time. Affordability, measured by the percentage of Gross Domestic Product (GDP) per capita required to purchase 2000 cigarettes of the most sold brand, increased from 1.61% in 2012 to 2.21% in 2020, but decreased to 2.03% in 2022 (5).

Countries in the rest of the Americas region are working on implementing the guidelines in Article 11 of the FCTC to follow the best available evidence related to packaging and labelling. Ecuador mandated picture and text health warnings on cigarette packs in 2010 when the National Tobacco Control Law was approved (12). Every year, the Ministry of Public Health releases six pictorial and text health warnings that all cigarette packs must have printed covering 60% of the front and back display areas. In addition, on the lateral right side, they must include information about the toxicity of this product (13–15). The health warnings are in Spanish only, not in Kichwa, the other official language of Ecuador. They provide information on the health impact of tobacco consumption and include a helpline number offering free counselling for quitting smoking (8,15).

The last time Ecuador modified the excise tax on tobacco products was in 2018 (16), when an increase in the tax rate and an automatic increase according to the annual inflation was introduced. By 2022, the total tax share in cigarettes was 64%, resulting in a price of $11.95 international dollars (5). Ecuador has not experienced any changes in the tax rate since 2016 due to the low inflation experienced since the American dollar became their national currency (17).

Health warnings in Chile mandate that the picture and text be printed in 50% of the front display area, while the back has text that covers 50% of it. The message content includes the health impact, the addictive nature of tobacco consumption and resources for smokers looking to quit. The warnings follow a 24-month rotation period, after which the National Authority releases four new pairs of health warnings for the next period (8).

Chile is one of the four countries in the Region of the Americas whose total tax share on tobacco exceeds the 75% threshold recommended by WHO, reaching 80.3%. Despite this, the price of a pack of 20 cigarettes of the most sold brand was $7.59 international dollars (5). Chile has a mixed excise tax structure (specific and ad-valorem excise tax), and the percentage of GDP per capita required to purchase 2000 cigarette sticks of the most sold brand decreased in the past two years, going from 3% in 2020 to 2.6% in 2022 (5,18).

Colombia was the last South American country to ratify the FCTC (5). They implemented pictorial and text health warnings that cover 30% of the cigarette pack's principal display areas. The warnings must be printed in Spanish and provide information about the health impact of cigarette smoking. Every 12 months, the Ministry of Health releases six new health warnings (8).

Cigarettes in Colombia have a mixed excise tax structure, with a 65% total tax share. The price of a 20-unit pack of the most sold brand was $5.01 international dollars for 2022 (5,19). A legislative update in 2019 increased the cigarette tax rate in the country, with the objective of reducing affordability over time. Despite this effort, the price in this country remains lower than in Ecuador and Chile (5,19).

To estimate the differences in demand between cigarette packages, a research project that included data collection from Ontario (Canada), Ecuador, Chile and Colombia, using the BDM auction mechanism, was conducted between 2020 and 2022. Drawing on data from that project, this study aims to assess the WTP for different packaging, health warning and stick warning formats, as well as illicit packs in these countries. Having this information provides important information to formulate tobacco policy before implementing it, where there is no prior data. This is important because Ecuador, Chile, and Colombia have been working on policy reforms regarding plain packaging and taxes for the past years and continue to do so, with a focus on

packaging and warnings (20–23). In Ecuador, a plain packaging law proposal has been stalled in the National Assembly since 2016 (21), but the tobacco control community is working on an updated proposal. The Chilean Senate began discussing a plain packaging law proposal in 2015, it was approved by the Health Committee but denied by the Agriculture Committee in 2021. The law returned to the Health Committee for further discussion (21). In Colombia, the National Congress analyzed a reform to the National Tobacco Law. In their 2024 report, they indicated the need to implement plain packaging in the country; however, the proposal didn't include this. The Congress is still discussing the proposal and further changes (20)

WTP is a commonly used metric in economics that allows one to compare the relative effectiveness of monetary and non-monetary policies in altering demand for a good or service. The BDM auction mechanism has desirable properties for eliciting WTP, in particular, it is incentive compatible and so individuals have incentive to reveal their true WTP for different characteristics of cigarette packs, such as plain packaging, stick warnings, branded packs or illicit packs. This information can help policy makers understand how people might respond to a policy where there are changes in the packaging or labelling of a cigarette pack and guide the development of an efficient tobacco control policy. The four countries were chosen because of the diversity of tobacco control policies implemented across them. It offers a unique opportunity to examine how different contexts influence consumer preferences, especially when including both licit and illicit cigarette options. Finally, this study addresses an important gap in the literature by incorporating illicit cigarette packs and enabling cross-country comparisons.

Literature review

Becker-DeGroot-Marschak introduced a methodology to reveal demand based on an auction mechanism (24). This methodology involves first participants bidding an amount of money

they are willing to pay for a good. After they submit their WTP, a price is randomly selected from a bounded distribution of prices. If the individual's bid is higher than or equal to the random price, the person can purchase the product at the randomly drawn price. If the bid is lower than the random price, the person cannot purchase it (25). Participants are motivated to reveal their true WTP (demand) for the product, for the outcome is determined by random draw rather than their bid amount. They are worse off bidding anything other than their true WTP. In implementing the procedure, Becker-DeGroot-Marschak emphasized the importance of starting the auction with examples to familiarize participants with the bidding process dynamics. This leads to more consistent behaviours and thus reduces deviations when they bid for the products whose demand we want to reveal (24).

While BDM is a widely used method in consumer food studies (26,27), this is not the case for tobacco control, especially in LMICs. While researchers have used the BDM auction mechanism to examine how labelling and packaging affect the demand for cigarette products in a study conducted in United States (28–31), the method has not been widely applied to study tobacco control policies. To date, no studies using this method have been identified in Latin American countries.

In that single study from the US, Thrasher et al. conducted an experimental auction in four cities located in different states (South Carolina, Florida, California and Pennsylvania), where individuals were presented with two of four packs of cigarettes, each featuring different health warning labels' characteristics with the same warning message (28–31). They found significant differences in mean bids between packs with text-only warnings ($3.52 USD and $3.43 USD) and those with pictures ($3.11 USD) and plain packaging ($2.93) (31). Additionally, they found that between 20% and 64% of smokers bid less for packs with pictorial warnings and 40%-64%

reduced their demand for cigarettes, with a greater impact in young smokers (30). When they evaluated these results using a value of information methodology, they corroborated previous results, where pictorial health warning labels are more effective in influencing smokers than front text labels (29). Results remained consistent when analyzed against consumer self-reported response scale answers, although the latter presented results two times greater than when using BDM (28).

Methods

The BDM auction used a hypothetical, stated-preference design, and was the second component of the multi-country project funded through a grant from the International Development Research Centre (IDRC) that included Canada (Ontario), Ecuador, Colombia, Chile, South Africa and Vietnam[12]. The first component of the research protocol consisted of a Discrete Choice Experiment (DCE); the second component was the BDM hypothetical auction (see Chapter 3), and a third component was a socio-economic questionnaire. The original project design was led by a team based at McMaster University in Hamilton, Ontario Canada and was approved by the Hamilton Integrated Research Ethics Board (HiREB) (32). Each country customized the project to meet its specific context, which a local Ethics Board later approved. For this study, we used data from Canada (Province of Ontario), Ecuador, Chile, and Colombia.

To be included in the study a person had to be at least 18 years old for the Latin American countries and 19 years old for the Canada (due to differences in the legal age to buy cigarettes in these countries).

[12] These last two countries are not included in this study for it focuses in those in the Region of the Americas.

The participants did not receive any real money and could not get the goods auctioned during the experiment; this was a stated preferences auction, all decisions and consequences were hypothetical. In Colombia and Chile[13], participants were instructed to imagine they had a specific hypothetical budget amount. In contrast, no such budget was mentioned to participants in the Canadian and Ecuadorian auctions. The research team in each country made the decision to include a hypothetical budget or not, the expected differences are analyzed in the Discussion section.

In all countries, participants in the BDM auction first completed a practice round using two non-tobacco-related products (e.g., a granola bar). Upon viewing the initial product (the granola bar), participants were asked: "What is the maximum amount you are willing to pay for the granola bar shown?" Participants entered a value within a predetermined range. After entering their WTP, the computer would randomly draw a price for this product. If the randomly drawn price was higher than the WTP, the person could not "purchase" the product. If the randomly drawn price was lower than or equal to their maximum WTP, they could "purchase" the product. The same steps were repeated for the second non-tobacco-related product, helping participants familiarize themselves with the BDM auction.

After completing the practice rounds, participants were informed that the cigarette pack auction would begin. They were instructed that for each cigarette pack presented, their WTP had to fall within a range specific to each country that reflected the then-current price: Canada $0–$20 CAD (0 to $14.60 USD), Ecuador $0–$10 USD[14], Chile $0–$3,500 CLP (0 to $4.01 USD), and Colombia $0–$10,000 COP (0 to $2.67 USD). Following the same procedure as the previous

[13] In Colombia they were told to imagine they have a $15.000,00 Colombian pesos, while in Chile they were told this hypothetical budget was $5.000,00 Chilean pesos.
[14] The USD is the national currency of Ecuador

exercise, once the participant entered their WTP, the computer randomly selected a price within that same range to determine whether they could hypothetically purchase the pack or not.

There were some differences in design across the countries due to local adaptations. In the cases of Canada, Colombia and Chile, participants were randomly assigned to one of three blocks, in each of which participants were shown a set of two cigarette packs. Participants were asked to indicate their WTP for each of the two packs. The packs presented in each block were as follows (the pictures of the packs that were presented in each country are in Appendix 1):

- Block 1: Branded pack with no warning on the stick and the Illicit pack.
- Block 2: Branded pack with a warning on the stick and Plain pack with no warning on the stick.
- Block 3: Plain pack with a warning on the stick and Plain pack with no warning on the stick.

In the case of Ecuador, in a local adaptation, all participants were assigned to Block 1 and presented with the branded pack with no health warnings on the stick and the Illicit pack. They had to indicate their WTP for both packs.

Canada led the data collection between May and June 2020 using the Ontario Tobacco Research Unit (OTRU) online panel (32), a panel of smokers only. Ecuador, Colombia and Chile independently hired Netquest, a survey research company, to collect data via an online panel that included both smokers and nonsmokers. Each country established quotas based on age and gender for both smokers and nonsmokers. However, due to a particular interest in gathering more information on smokers, they were intentionally oversampled relative to nonsmokers. Colombia conducted its data collection in December 2021 (33), Ecuador in May and June 2022, and Chile at

the end of 2022. It is important to mention that, at that time, all countries had imposed restrictions due to the COVID-19 pandemic, which is why all the information was collected online.

Analysis

Each country developed a local questionnaire based on the one developed by the McMaster-based research team for this project; the differences were made according to the reality of each country. Therefore, not all countries collected the information for the same variables. For this analysis, the following variables were chosen for each country[15]:

- Canada: smoking habits (daily and occasional[16]), gender, income groups[17], age, age at onset of smoking.
- Ecuador: smoking habits (daily, occasional, former, never smoked, don't know, no response), gender, income groups, education, age.
- Chile: smoking habits (daily, occasional, former, never smoked, don't know, no response), gender, income groups, education, age.
- Colombia: smoking habits (daily, occasional, former, never smoked, don't know, no response), gender, income groups, education, age.

In all four countries, participants were asked about their income using predefined categories tailored to the reality of each country's economy. Canada asked about the total annual household income, while Ecuador, Colombia and Chile asked about monthly household income. To

[15] Age at onset was available only for Canada, since Ecuador, Colombia and Chile did not include it in their questionnaire. Canada did not include an education variable.
[16] Occasional smokers refer to people who smoke less often than daily.
[17] Each country defined their income groups according to its specific economic context. I have kept the same groups for this analysis.

standardize these figures, the monthly income ranges from these three countries were annualized by multiplying each category's upper and lower limits by 12.

A cross-country comparison was conducted to examine differences in WTP. For that component, WTPs in each country were converted to US dollars using Purchasing Power Parity (PPP) for 2022 (1.16 for Canada, 426.10 for Chile, 1,345.66 for Colombia, and 0.43 for Ecuador) (34), to standardize the values. The values derived using PPP are referred to as "international dollars".

Low-quality respondents, those who did not appear to engage sufficiently in the exercise, were excluded from the analysis. To identify them, I used the time taken to complete the survey as a proxy, applying a five-minute threshold so that all those who completed the survey in less than five minutes were excluded[18]. This information was available for Chile (none excluded), Colombia (36 observations excluded), and Ecuador (38 observations excluded). For Canada, I used a binary variable that indicated if the participants completed the auction section; 2 observations were deleted.

The first step in the analysis involved a descriptive analysis of the sample characteristics for each country. Then, the mean WTPs across packs from the countries were analyzed. To evaluate the distribution of WTP across countries, because tests of skewness revealed non-normal distributions (see the Appendix), a Kruskal-Wallis test (KW test) was used to assess whether the distributions of WTP differed across cigarette pack types within countries. To understand how much the WTPs represent in the income of the participants, the mean WTP was also calculated as a share of weekly income.

[18] The threshold was chosen based on the DCE publications for Colombia (33).

To examine the association between participants' socioeconomic characteristics and their WTP, separate Ordinary Least Squares (OLS) regression models were estimated for each cigarette pack type within each country. In each model, the dependent variable was the WTP for a given pack, while the independent variables included age, gender/sex, income groups, and smoking habits. For Canada, the age of onset was included as an additional independent variable. Robust errors were estimated.

Results

The presentation of results begins with descriptive statistics of the overall sample and the distribution of bids per pack across all four countries. This is followed by the presentation of the OLS regression results conducted separately for each country. It is important to acknowledge that, given the large number of parameters estimated, to have a standardized analysis for all the countries in this study, and the 5% significance level threshold, it would be expected that coefficients could appear statistically significant by chance. The number of significant results that would be explained below had no consistent pattern across covariates

a. Descriptive Statistics

Table 15 shows the general characteristics of the participants in the BDM component across the four countries, disaggregated by the cigarette pack for which they reported their WTP, to account for the fact that not all participants evaluated the same set of packs. On average, participants in Canada were the oldest (48 years), followed by those in Chile (40 years), Colombia (33 years), and Ecuador (30 years). As previously explained, the Canadian sample only included smokers, with 85% reporting daily smoking and 15% occasional smoking. In the case of the three South American countries, Chile had a higher percentage of daily smokers (35%) compared to

occasional smokers (33%), with 32% nonsmokers. In contrast, in Ecuador and Colombia, occasional smoking was more prevalent (Ecuador 45%, Colombia 25%) than daily smoking (Ecuador 16%, Colombia 18%), nonsmokers representing respectively 39% and 57% of the samples in these two countries.

In Chile, 17% of participants reported being former smokers, while 14% indicated they had never smoked. In the case of Ecuador and Colombia, the pattern is different. In Ecuador, 25% of participants had never smoked and 13% were former smokers. In Colombia, 37% of nonsmokers reported they had never smoked and 19% that they used to smoke.

In terms of gender, most participants in Ecuador (53%) and Canada (62%) were female. While in Chile, the sample was evenly split between males and females. In the case of Colombia, there was a higher proportion of males (53%).

Regarding income, each country collected this information according to its specific economic context. In Canada, on average, the largest share of participants (19%) reported being in the highest-income group. In contrast, in Ecuador, the highest proportion of participants (31%) fell into the second-lowest income category. In both Chile (36%) and Colombia (23%), the largest share of participants was in the middle-income group.

In reference to education, the largest share of the population in the three South American countries indicated that they held an undergraduate degree (Ecuador: 52%, Chile: 29%, Colombia: 48%). In Canada, the average age of smoking initiation among participants was 15 years.

Table 15 Characteristics of the study sample per country

			Branded pack with no stick warning	Branded pack with stick warning	Pain pack with no stick warning	Plain pack with stick warning	Illicit pack
Canada	Age	(Mean)	49.23	51.20	48.60	46.40	49.23
	At the present time, do you smoke cigarettes?	Daily (%)	85.11	85.79	85.18	84.65	85.11
		Occasionally (%)	14.89	14.21	14.82	15.35	14.89
	Gender	Male (%)	35.50	38.99	37.50	36.27	35.50
		Female (%)	63.91	59.12	61.08	62.69	63.91
		Non-binary (%)	0.00	0.63	0.85	1.04	0.00
		Trans male (%)	0.00	0.63	0.28	0.00	0.00
		Prefer not to respond (%)	0.59	0.63	0.28	0.00	0.59
	Estimated annual family income	Less than $20,000 CAD (%)	14.20	13.84	13.07	12.44	14.20
		$20,000 CAD to less than $40,000 CAD (%)	14.20	16.35	14.77	13.47	14.20
		$40,000 CAD to less than $60,000 CAD (%)	18.93	16.35	17.05	17.62	18.93
		$60,000 CAD to less than $80,000 CAD (%)	12.43	12.58	13.64	14.51	12.43
		$80,000 CAD to less than $100,000 CAD (%)	15.98	8.81	9.66	10.36	15.98
		$100,000 CAD and over (%)	14.79	22.01	21.31	20.73	14.79
		Prefer not to respond (%)	8.88	10.06	10.23	10.36	8.88
		Don't know (%)	0.59	0.00	0.28	0.52	0.59
	Age smoking onset	(Mean)	14.82	14.95	15.40	15.78	14.82
Ecuador	Age	(Mean)	30.09	-	-	-	30.09
	At the present time, do you smoke cigarettes?	Daily (%)	15.69	-	-	-	15.69
		Occasionally (%)	45.19	-	-	-	45.19
		Used to smoke (%)	13.09	-	-	-	13.09
		Never smoked (%)	25.31	-	-	-	25.31
		Don't know (%)	0.22	-	-	-	0.22
		Prefer not to respond	0.51	-	-	-	0.51

	Gender	Male (%)	46.35	-	-	-	46.35
		Female (%)	52.93	-	-	-	52.93
		Other (%)	0.29	-	-	-	0.29
		Prefer not to respond (%)	0.43	-	-	-	0.43
	Estimated annual family income	Less than $4,800 USD (%)	24.08	-	-	-	24.08
		$4,800 to less than $9,600 USD (%)	30.95	-	-	-	30.95
		$9,600 to less than $18,000 USD (%)	20.17	-	-	-	20.17
		$18,000 to less than $30,000 USD (%)	12.36	-	-	-	12.36
		$30,000 and over (%)	6.00	-	-	-	6.00
		Don't know (%)	2.53	-	-	-	2.53
		Prefer not to respond (%)	3.90	-	-	-	3.90
	Education	Less than high school (%)	2.10	-	-	-	2.10
		Highschool (%)	30.37	-	-	-	30.37
		Technical degree (%)	12.94	-	-	-	12.94
		Undergraduate degree or higher (%)	52.42	-	-	-	52.42
		Don't know (%)	0.58	-	-	-	0.58
		Prefer not to respond (%)	1.59	-	-	-	1.59
Chile	Age	(Mean)	40.77	40.24	40.87	41.50	40.77
	At the present time, do you smoke cigarettes?	Daily (%)	32.15	38.66	37.39	36.10	32.15
		Occasionally (%)	34.81	30.25	31.87	33.52	34.81
		Used to (%)	17.40	17.09	17.71	18.34	17.40
		Never (%)	15.04	14.01	12.89	11.75	15.04
		Prefer not to respond (%)	0.59	0.00	0.14	0.29	0.59
	Sex	Male (%)	47.79	50.42	51.70	53.01	47.79
		Female (%)	52.21	49.58	48.30	46.99	52.21
	Estimated annual family income	Less than $4,126.88 USD (%)	5.60	5.04	5.81	6.59	5.60
		$4,140.66 USD to $8,253.76 USD (%)	24.78	23.25	22.24	21.20	24.78
		$8,267.51 USD to $16,507.51 USD (%)	33.63	35.85	36.83	37.82	33.63
		$16,508 USD to $27,512.52 USD (%)	14.75	15.41	15.72	16.05	14.75
		More than $27,513 USD (%)	14.45	14.57	13.46	12.32	14.45

		Prefer not to respond (%)	5.60	5.04	4.82	4.58	5.60
		Don't know (%)	1.18	0.84	1.13	1.43	1.18
		Incomplete secondary education (%)	0.88	0.56	0.85	1.15	0.88
		Complete secondary education (%)	13.57	12.61	11.76	10.89	13.57
		Incomplete technical education (%)	5.60	8.12	8.36	8.60	5.60
		Complete technical education (%)	28.32	21.85	22.80	23.78	28.32
	Education	Incomplete university or higher education (%)	15.34	19.89	17.14	14.33	15.34
		Complete university or higher education (%)	27.43	27.73	30.45	33.24	27.43
		Complete postgraduate education (%)	6.78	7.28	6.80	6.30	6.78
		Incomplete postgraduate education (%)	1.18	1.40	0.99	0.57	1.18
		Prefer not to respond (%)	0.59	0.00	0.71	0.86	0.59
		Don't know (%)	0.29	0.56	0.14	0.29	0.29
Colombia	Age	(Mean)	33.58	33.53	33.61	33.69	33.58
	At the present time, do you smoke cigarettes?	Daily	18.30	17.05	18.56	20.11	18.30
		Occasionally	25.79	24.70	24.94	25.19	25.79
		Used to	18.85	19.69	19.11	18.52	18.85
		Never	37.06	38.56	37.39	36.18	37.06
	Gender	Male	52.04	51.19	53.07	55.05	52.04
		Female	46.89	48.81	46.75	44.58	46.89
		Other	0.71	0.00	0.09	0.18	0.71
		Prefer not to respond	0.36	0.00	0.09	0.18	0.36
	Estimated annual family income	Less than $1,602.95USD	17.23	16.21	16.84	17.51	17.23
		$1,602.96 USD to $3,205.91 USD	13.68	13.31	13.16	13.00	13.68
		$3,205.92 USD to $6,411.81 USD	23.98	21.33	22.28	23.29	23.98
		$6,411.82 to $9,617.72USD	15.10	16.38	14.82	13.18	15.10
		$9,617.73 USD to $12,823.63 USD	9.95	10.58	10.44	10.29	9.95
		More than $12,823.64	20.07	22.18	22.46	22.74	20.07
	Education	Less than a bachelor's degree or its equivalent	1.07	0.85	0.88	0.90	1.07
		Bachelor's degree or its equivalent	18.29	18.09	17.54	16.97	18.29

Technician or technologist	33.21	32.08	31.75	31.41	33.21
University degree or higher	46.54	47.78	49.12	50.54	46.54
Prefer not to respond	0.89	1.02	0.61	0.18	0.89
Don't know	0.00	0.17	0.09	0.00	0.00

Table 16 shows how the WTP in international dollars (adjusted by PPP) varied by cigarette pack across the four countries for each of smokers and nonsmokers. In the case of smokers, for the branded pack with no stick warning, the WTP in Ecuador is the highest among the countries at $10.84 international dollars, followed by Canada at $9.64 international dollars, Chile at $6.77 international dollars, and Colombia at $5.16 international dollars. The differences are more pronounced for the illicit packs. Ecuador stands out with a WTP of $8.64 international dollars, followed by Colombia with $4.44 international dollars, Canada with $4.19 international dollars, and Chile with $3.20 international dollars. Notably, Ecuador's WTP for the illicit packs is double that in the other countries, where the WTPs are closer in value.

In the case of the branded packs with stick warning, smokers in Canada had the highest WTP ($9.42 international dollars), followed by Chile ($6.40 international dollars) and Colombia ($5.17 international dollars). The plain packaging with no stick warning had a higher WTP (Canada: $10.29 international dollars, Chile $6.40 international dollars, Colombia $4.89 international dollars) than plain packaging with a stick warning (Canada: $9.28 international dollars, Chile $6.07 international dollars, Colombia $4.51 international dollars) across the three countries.

Canadian smokers expressed their highest WTP for plain packs with no stick warning, followed by branded packs without ($0.65 less) and with stick warning ($0.87 less), plain pack with a stick warning ($1.01 less), while the illicit pack had the lowest WTP ($6.10 less). WTP for the illicit option differed notably from the WTP for all of the legal options

Smokers in Chile the highest WTP was for branded packs with no stick warning, followed by plain packs with no stick warning and branded packs with stick warning ($0.37 less in both cases), plain packs with stick warning ($0.70 less), and lastly illicit packs ($3.57 less). In the case

of Colombia, the branded packs with and without stick warning had the highest WTP, followed by plain packs with no stick warning ($0.29 less), plain packs with stick warning ($0,67) and then illicit packs ($0.73). Smokers in Ecuador were willing to pay more for branded packs with no stick warning than for illicit packs ($2.20 less). The largest differences in WTP happened in Canada and Ecuador, followed by Chile and then Colombia.

As previously reported, Ecuador, Chile and Colombia included nonsmokers in their samples. Similar to smokers, Ecuadorian nonsmokers are willing to pay substantially more than the Chileans and Colombians for the branded pack with no stick warning (Ecuador: $8.53 international dollars, Chile $4.25 international dollars, Colombia $4.16 international dollars) and the illicit pack (Ecuador: $7.16 international dollars, Chile $2.58 international dollars, Colombia $3.65 international dollars). Chilean nonsmokers' WTP is higher for all other packs (branded pack with stick warning: $4.76 international dollars, plain pack with no stick warning $4.79 international dollars, plain pack with stick warning: $4.64 international dollars) than their Colombian counterparts (branded pack with stick warning: $3.76 international dollars, plain pack with no stick warning $3.60 international dollars, plain pack with stick warning: $3.56 international dollars). x

Nonsmokers in Chile showed the highest WTP for the plain pack with no stick warning, followed by the branded pack with stick warning ($0.03 less), plain pack with stick warning ($0.15 less), branded pack with no stick warning ($0.54 less), and finally the illicit pack ($2.21 less). In Colombia nonsmokers' WTP was the highest for the branded pack with no stick warning, followed by the branded pack with stick warning ($0.40 less), the illicit pack ($0.51 less), the plain pack with no stick warning ($0.56 less), and the plain pack with stick warning ($0.60 less). In the case

of Ecuador, the difference between the WTP of the branded pack with no stick warning and the illicit pack was $1.36.

Table 16 Mean WTP in international dollars (adjusted by PPP) per country for smokers and nonsmokers

Types of cigarette packs	Canada	Ecuador		Chile		Colombia	
	Smokers (n=856)	Smokers (n=1684)	Nonsmokers (n=1082)	Smokers (n=716)	Nonsmokers (n=326)	Smokers (n=1417)	Nonsmokers (n=1826)
Branded pack with no stick warning	9.64	10.84	8.55	6.77	4.25	5.16	4.16
Branded pack with stick warning	9.42	-	-	6.40	4.76	5.17	3.76
Plain packaging no stick warning	10.29	-	-	6.40	4.79	4.89	3.60
Plain packaging with stick warning	9.28	-	-	6.07	4.64	4.51	3.56
Illicit pack	4.19	8.64	7.19	3.20	2.58	4.44	3.65

For all packs in the four countries, the skewness test results indicated that the WTP distributions were not normal (see Appendix 2 for details). Therefore, Kruskal-Wallis tests were performed to test for differences across the distributions. The results of the Kruskal-Wallis test for WTP distributions by pack for each country are summarized in Table 17. Except for smokers in Colombia, the results indicate statistically significant differences in the WTP distributions across pack types.

Table 17 Kruskal-Wallis Test for WTP by pack in the four countries

Packs	Canada		Ecuador				Chile				Colombia			
	Smokers		Smokers		Nonsmokers		Smokers		Nonsmokers		Smokers		Nonsmokers	
	Observations	Rank sum	Observations	Rank sum	Observations	Rank sum	Observations	Rank sum	Observations	Rank sum	Observations	Rank sum	Observations	Rank sum
Branded pack with no stick warning	172	97,006	842	802,854	541	313,381	227	200,179	112	37,149	401	530,904	169	93,115
Branded pack with stick warning	335	202,441	-	-	-	-	246	202,180	111	39,833	402	540,412	194	100,238
Plain packaging	163	88,750	-	-	-	-	489	392,640	217	78,975	825	1,030,000	337	166,608
Plain packaging with stick warning	172	92,836	-	-	-	-	243	176,047	106	37,600	425	476,257	143	69,424
Illicit pack	172	33,573	842	615,916	541	272,523	227	54,983	112	23,255	401	436,591	169	83,194
	chi2(4) =	243.29	chi2(1) =	87.76	chi2(1) =	15.80	chi2(4) =	372.33	chi2(4) =	57.69	chi2(4) =	5.87	chi2(4) =	43.98
	Prob=	0.00	Prob =	0.00	Prob =	0.00	Prob =	0.00	Prob =	0	Prob=	0.21	Prob=	0.00
	chi2(4) with ties=	244.76	chi2(1) with ties =	88.57	chi2(1) with ties =	15.93	chi2(4) with ties =	378.60	chi2(4) with ties =	58.6	chi2(4) with ties =	5.91	chi2(4) with ties =	44.22
	Prob=	0.00	Prob =	0.00	Prob =	0.00	Prob =	0.00	Prob =	0	Prob=	0.21	Prob=	0.00

Canada : smokers n=856; Ecuador: smokers n= 1684, nonsmokers n=1082; Chile: smokers n=716,nonsmokers n=326; Colombia: smokers n=1417, nonsmokers n=1826.

Taking advantage of the same option (plain pack with no stick warning) showing up in two different blocks in the BDM auction in Canada, Chile and Colombia. Table 18 shows the WTP for the plain pack with no stick warning for block 2 (options were: branded pack with stick warning and plain pack with no stick warning) and block 3 (options were plain pack with no stick warning and plain pack with stick warning). In Chile, the difference in WTP between those blocks was small for both smokers and nonsmokers; in contrast, the difference was large in both Canada and Colombia, with the largest difference in Canada. Additionally, in Canada and Colombia, WTP was higher when the plain pack with no stick warning was presented before the plain pack with stick warning (block 3). In theory, the WTP for plain pack with no stick warning should have been the same in both blocks. The reason for their differences cannot be precisely identified; it could be an order effect or the comparator presented in the block.

Table 18 WTP for plain pack with no stick warning per block in Canada, Chile and Colombia.

Plain pack with no stick warning	Canada	Chile		Colombia	
	Smokers (n=856)	Smokers (n=716)	Nonsmokers (n=326)	Smokers (n= 1417)	Nonsmokers (n=1826)
Block 2	8.50	3.14	2.36	1.61	1.20
Block 3	9.30	3.12	2.32	1.90	1.43

OLS model results

I next present the results of the OLS regressions with WTP as a dependent variable and socio-economic, demographic, and behavioural characteristics as the independent variables. Please find a univariate WTP analysis per country in Appendix 3.

The results for Canadian participants (smokers) are presented in Table 19. For the branded pack with no stick warning, age was the only statistically significant covariate, with each additional year of age associated with a $0.09 decrease in WTP. None of gender, Age-at-onset, or income showed significant effects. For the plain pack with no stick warning, the age effect was similar to

that for the branded pack with no health warning, with WTP declining by $0.08 per year of age. Although not strictly monotonic, there is an income effect where higher income is associated with higher WTP. Gender and age-at-onset again showed no statistically significant effect.

For the branded pack with stick warning, age was the only statistically significant variable (-0.09). For the plain pack with stick warning, age has an effect, with WTP declining by $0.08 per year. Income showed a weak effect: compared with the lowest income group (reference category), Canadian smokers in the second lowest and second highest income categories reported higher WTP, by $2.75 and $3.95, respectively. In the case of the illicit pack, none of the variables had a statistically significant association with WTP.

Overall, when comparing the WTP across packs for Canadian smokers, no statistically significant effects were found for gender or age-at-onset. However, aging is associated with decreasing WTP for all types of legal packs, and the differences across packs are minimal. In the case of income groups, there is a weak effect for the plain packs with and with no stick warning.

Table 19 OLS model results using WTP as the dependent variable for Canadian smokers

WTP	Coefficients				
	Branded pack with no stick warning	Plain pack with no stick warning	Branded pack with stick warning	Plain pack with stick warning	Illicit pack
			Smokers		
Age	-0.09*	-0.08*	-0.09*	-0.08*	-0.01
	(-0.14,-004)	(-0.11,-0.04)	(-0.14,-0.03)	(-0.14,-0.01)	(-0.05,0.03)
Gender					
Female	0.27	0.36	-0.64	0.95	0.99
	(-1.32,1.85)	(-0.52,1.25)	(-2.05,0.78)	(-0.50,2.41)	(-0.04,2.03)
Income					
$14,900 to less than $29,850	-0.19	2.71*	1.4	2.75*	0.16
	(-3.04,2.66)	(1.01,4.41)	(-1.24,4.03)	(0.08,5.41)	(-1.80,2.12)
$29,850 to less than $44,700	0.47	2.48*	1.69	2.67	-0.11
	(-2.48,3.42)	(0.78,4.17)	(-0.99,4.37)	(-0.06,5.39)	(-2.18,1.97)
$44,700 to less than $59,700	0.61	3.36*	0.97	1.61	-0.55
	(-2.37,3.59)	(1.62,5.11)	(-1.97,3.91)	(-1.48,4.70)	(-2.36,1.25)
$59,700 to less than $74,600	2.04	5.08*	3.51*	3.95*	-0.93
	(-0.59,4.68)	(3.38,6.78)	(1.32,5.70)	(0.14,7.77)	(-2.72,0.86)
$74,600 and over	0.49	4.48*	2.05	4.48	-1.18
	(-2.30,3.28)	(2.84,6.12)	(-0.18,4.27)	(1.73,7.23)	(-2.91,0.55)
Age at Onset	0.04	0.03	0.06	0.11	0.05
	(-0.18,0.25)	(-0.07,0.14)	(-0.10,0.22)	(-0.03,0.25)	(-0.10,0.20)

*statistically significant at p<0.05. smokers n= 856

For Ecuador, the OLS regression results are presented in Table 20. Among Ecuadorian smokers, age had a statistically significant effect for the branded pack without stick warning, with each additional year being associated with a $0.02 decrease in WTP. Income was also statistically significant, with higher income associated with a higher WTP. Neither gender nor education showed any effect. For the illicit pack, none of the covariates were statistically significant.

With respect to nonsmokers, age and income were the only covariates with a statistically significant effect on the WTP for the branded pack with no stick warning. With every additional

year of age, the WTP decreases by $0.03, while higher income was associated with greater WTP. For illicit packs, none of the variables showed a statistically significant effect.

Summarizing the results for Ecuador, age and income were the two variables strongly correlated with the WTP of the branded pack with no stick warning. Gender and education were never significant, and illicit packs showed no association with any covariate.

Table 20 OLS model results using WTP as the dependent variable for Ecuadorian smokers and nonsmokers

	Coefficients			
WTP	Branded pack with no stick warning	Illicit	Branded pack with no stick warning	Illicit
	Smokers (n=1684)		Nonsmokers (n=1082)	
Age	-0.02*	-0.01	-0.03*	-0.02
	(-0.03,0.00)	(-0.03,0.00)	(-0.05,0.00)	(-0.04,0.00)
Gender				
Female	-0.18	-0.11	0.30	0.11
	(-0.46,0.09)	(-0.40,0.17)	(-0.12,0.71)	(-0.27,0.49)
Income				
$4,800 to less than $9,600 USD	0.60*	0.34	0.55*	0.12
	(0.18,1.02)	(-0.07,0.76)	(0.03,1.07)	(-0.36,0.60)
$9,600 to less than $18,000 USD	0.60*	0.13	0.83*	0.52
	(0.17,1.02)	(-0.31,0.57)	(0.20,1.47)	(-0.08,1.13)
$18,000 to less than $30,000 USD	0.67*	0.13	1.00*	0.59
	(0.18,1.15)	(-0.39,0.65)	(0.16,1.84)	(-0.23,1.41)
$30,000 and over	0.79*	0.64	1.32*	0.8
	(0.13,1.45)	(-0.08,1.35)	(0.06,2.59)	(-0.45,2.05)
Education				
Highschool degree	-0.45	-0.54	-0.02	-0.75
	(-1.74.0.84)	(-1.87,0.78)	(-1.74,1.70)	(-2.31,0.81)
Technical degree	-0.43	-0.33	-0.02	-0.59
	(-1.75,0.88)	(-1.68,1.01)	(-1.86,1.82)	(-2.22,1.04)
Undergraduate degree or higher	-0.23	-0.43	-0.34	-0.96
	(-1.50,1.05)	(-1.74,0.88)	(-2.09,1.41)	(-2.54,0.63)
Constant	5.17	4.42	3.97	4.24

*statistically significant at $p<0.05$, income reference group: less than $4,800, education reference group: less than a high school degree

The results of the OLS regression model for Chilean participants are shown in Table 21. For Chilean smokers, the branded pack with no stick warning and the branded pack with stick warning had no statistically significant covariates. For the plain pack with no stick warning, only gender showed a significant effect: female smokers reported a WTP $0.18 higher than males (reference group). No significant effects were found for the plain pack with stick warning. For the illicit pack, some education categories showed statistical significance: compared with individuals with less than secondary education (reference category), those with complete secondary education, complete technical education and complete university education reported lower WTP, by $0.43, $0.52, and $0.38, respectively.

Among nonsmokers, for the branded pack with no stick warning, age was statistically significant, with a WTP decreasing by $0.02 for each additional year of age, but no other covariates were statistically significant. In the case of the branded pack with stick warning and the plain pack with no stick warning, no covariates showed an effect. For the plain pack with stick warning, education had a negative effect on WTP, with all education categories having a lower WTP when compared to that of nonsmokers with less than secondary school education. Like in the case of smokers, no statistically significant associations were found for the illicit packs.

Even more so than was the case for Canada and Ecuador, the overall finding in Chile is essentially no meaningful association between these individual characteristics and the WTP for any of the packs.

Table 21 OLS model results using WTP as the dependent variable in Chile for smokers and nonsmokers

	Coefficients									
WTP	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack
	Smokers (n=716)					Nonsmokers (n=326)				
Age	0.00	-0.01	0.00	0.00	-0.01	-0.02*	-0.01	0.00	-0.01	-0.01
	(-0.01,0.01)	(-0.02,0.00)	(-0.01,0.00)	(-0.01,0.01)	(-0.02,0.00)	(-0.04-0.00)	(-0.03,0.01)	(-0.02,0.01)	(-0.04,0.01)	(-0.02,0.00)
Gender										
Female	0.09	0.22	0.18*	-0.05	0.14	-0.25	0.30	0.08	0.41	-0.22
	(-0.11,0.29)	(-0.03,0.47)	(0.02,0.34)	(-0.28,0.19)	(-0.10,0.39)	(-0.79,0.30)	(-0.24,0.85)	(-0.31,0.46)	(-0.14,0.97)	(-0.65,0.20)
Income										
$4,140.66 USD to $8,253.76 USD	0.26	0.17	0.23	-0.05	-0.29	-0.11	-0.10	0.01	0.70	-0.15
	(-0.22,0.73)	(-0.52,0.86)	(-0.24,0.70)	(-0.43,0.33)	(-1.25,0.67)	(-1.31,1.10)	(-0.95,0.74)	(-0.81,0.83)	(-0.65,2.05)	(-0.97,0.66)
$8,267.51 USD to $16,507.51 USD	0.03	0.17	0.15	-0.20	-0.11	0.50	0.12	0.20	0.62	0.07
	(-0.44,0.49)	(-0.50,0.84)	(-0.32,0.62)	(-0.60,0.19)	(-1.05,0.82)	(-0.65,1.64)	(-0.69,0.92)	(-0.58,0.99)	(-0.70,1.94)	(-0.74,0.88)
$16,508 USD to $27,512.52 USD	0.24	0.26	0.35	-0.34	-0.11	0.59	0.65	0.22	0.48	0.59
	(-0.29,0.76)	(-0.43,0.95)	(-0.14,0.84)	(-0.87,0.19)	(-1.09,0.87)	(-0.65,1.83)	(-0.50,1.80)	(-0.71,1.14)	(-0.98,1.93)	(-0.25,1.43)
More than $27,513 USD	0.23	0.44	0.37	-0.18	-0.17	0.15	0.51	0.11	0.33	0.10
	(-0.27,0.73)	(-0.24,1.12)	(-0.14,0.87)	(-0.81,0.44)	(-1.15,0.82)	(-1.18,0.77)	(-0.47,1.49)	(-0.82,1.04)	(-1.21,1.86)	(-0.84,1.05)
Education										
Complete secondary education	-0.31	-0.21	-0.41	-0.10	-0.43*	1.08	1.41	0.38	-1.84*	0.77
	(-0.91,0.29)	(-0.86,0.45)	(-1.14,0.32)	(-0.96,0.75)	(-0.78,-0.07)	(-1.23,3.40)	(-0.78,3.60)	(-1.52,2.28)	(-3.04,-0.64)	(-0.22,1.77)
Incomplete technical education	-0.17		-0.49	-0.37	-0.27		1.67	0.66	-1.18*	
	(-0.79,0.46)		(-1.23,0.24)	(-1.29,0.56)	(-0.67,0.13)		(-0.63,3.98)	(-1.25,2.58)	(-2.14,-0.22)	
Complete technical education	-0.21	0.4	-0.27	-0.18	-0.52*	1.04	1.02	0.39	-2.04*	0.91
	(-0.78,0.37)	(-0.16,0.95)	(-0.97,0.43)	(-1.04,0.67)	(-0.84,-0.21)	(-1.26,3.34)	(-1.10,3.15)	(-1.48,2.26)	(-3.14,-0.94)	(-0.12,1.94)
Incomplete university or higher education	-0.26	-0.01	-0.38	-0.04	-0.26	0.84	1.67	0.68	-2.22*	0.56
	(-0.88,0.37)	(-0.59,0.57)	(-1.08,0.32)	(-0.90,0.81)	(-0.70,0.17)	(-1.54,3.21)	(-0.46,3.81)	(-1.21,2.57)	(-3.42,-1.02)	(-0.53,1.66)

Complete university or higher education	-0.35	0.07	-0.48	-0.32	-0.38*	1.10	0.80	0.34	-1.91*	0.74
	(-0.96,0.27)	(-0.48,0.63)	(-1.19,0.23)	(-1.20,0.56)	(-0.69,-0.07)	(-1.26,3.45)	(-1.36,2.95)	(-1.53,2.21)	(-2.85,-0.97)	(-0.29,1.77)
Incomplete postgraduate education	-0.33	-0.38	-0.90	-0.63	-0.24		2.35	1.5		
	(-0.96,0.30)	(-1.58,0.82)	(-2.00,0.21)	(-2.05,0.79)	(-0.81,0.34)		(0.17,4.54)	(-0.64,3.63)		
Complete postgraduate education	-0.31	-0.19	-0.53	-0.58	-0.41	0.34	1.01	0.88	-1.08*	0.32
	(-1.00,0.38)	(-0.85,0.46)	(-1.28,0.22)	(-1.76,0.60)	(-0.94,0.13)	(-2.21,2.89)	(-1.41,3.44)	(-1.04,2.80)	(-1.89,-0.26)	(-1.04,1.69)
Constant	3.55	3.07	3.36	3.21	2.34	1.92	1.24	1.79	4.08	1.03

*statistically significant at $p<0.05$, reference group for income: less than $4,140 USD, reference group for education: incomplete secondary education. Must note that in the case of the incomplete technical education, the coefficients are missing for certain pack categories because there were no observations in the sample. Similarly, for incomplete postgraduate education, certain coefficients are missing due to collinearity.

Table 22 presents the OLS regression results for Colombian participants. For smokers, age was the only statistically significant variable for the branded pack with no stick warning: each additional year of age linked with a $0.01 decrease in WTP. For the branded pack with stick warning, both age and the highest income category were statistically significant. In the case of the plain pack with no stick warning, age, gender, and the second lowest income group showed an effect: each additional year reduced WTP by $0.01, females reported a WTP $0.12 lower than males (reference category), and the smokers in the second lowest income group reported a WTP $0.26 lower than the lowest income group (reference category). For the plain pack with stick warning, only the highest income group had a significant effect. Finally, for the illicit pack, age showed significance, with WTP declining by $0.01 per year.

Among nonsmokers, for the branded pack with no stick warning, one income category and all education levels were statistically significant. Those in the middle-income category had a WTP $0.74 higher than the lowest-income individuals (reference category). Compared with participants without a bachelor's degree, WTP was higher by $1.73, $1.71, and $1.73 for those with a bachelor's, technical and university degree, respectively. For the branded pack with stick warning and the plain pack with no stick warning, only one income category showed a significant effect. For the plain pack with stick warning, all education levels were statistically significant, with WTP decreasing as the education level increased. For the illicit pack, education also mattered, but in contrast to the plain pack with a stick warning, WTP increased with higher education levels.

In summary, for smokers, age had a consistent effect across all packs except the plain pack with a stick warning, while income and gender showed only minimal significance, and education had no effect. For Colombian nonsmokers, however, education played a more important role, showing significance for the branded pack with no stick warning, plain pack with stick warning

and the illicit packs. Income also had some effect on the branded packs with and without stick warning, and the plain pack with no stick warning. Age showed no effect.

Table 22 OLS model results using WTP as the dependent variable in Colombia for smokers and nonsmokers

	Coefficients									
WTP	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack
	Smokers (n=1417)					Nonsmokers (n=1826)				
Age	-0.01*	-0.01*	-0.01*	-0.01	-0.01*	-0.03	-0.01	0.01	0.02	-0.05
	(-0.01,0.00)	(-0.02,0.00)	(-0.01,0.00)	(-0.01,0.00)	(-0.02,0.00)	(-0.11,0.04)	(-0.08,0.07)	(-0.05, 0.07)	(-0.06,0.11)	(-0.12,0.03)
Gender										
Female	-0.04	0.01	-0.12*	-0.04	-0.02	-0.19	0.04	0.07	-0.18	-0.30
	(-0.20,0.11)	(-0.15,0.16)	(-0.24,0.00)	(-0.22,0.14)	(-0.18,0.15)	(-0.52,0.15)	(-0.25,0.33)	(-0.15,0.29)	(-0.55,0.18)	(-0.64,0.05)
Income group										
$1,602.96 USD to $3,205.91 USD	-0.03	0.00	-0.26*	-0.24	-0.08	0.45	0.30	0.12	-0.09	0.38
	(-0.32,0.26)	(-0.35,0.36)	(-0.51-0.01)	(-0.59,0.10)	(-0.42,0.25)	(-0.08,0.99)	(-0.16,0.76)	(-0.23,0.47)	(-0.62,0.44)	(-0.19,0.94)
$3,205.92 USD to $6,411.81 USD	-0.09	-0.03	0.05	0.03	-0.06	0.05	0.49*	0.12	-0.21	0.06
	(-0.37,0.18)	(-0.34,0.29)	(-0.16,0.27)	(-0.26,0.33)	(-0.35,0.23)	(-0.42,0.52)	(0.06,0.93)	(-0.22,0.46)	(-0.82,0.41)	(-0.44,0.56)
$6,411.82 to $9,617.72USD	0.22	0.10	0.10	0.20	0.07	0.74*	0.44	0.23	0.13	0.41
	(-0.07,0.50)	(-0.20, 0.41)	(-0.14,0.33)	(-0.15,0.55)	(-0.22,0.36)	(-0.42,0.52)	(-0.02,0.90)	(-0.13,0.59)	(-0.46,0.72)	(-0.10,0.91)
$9,617.73 USD to $12,823.63 USD	0.16	0.24	0.03	0.18	0.08	0.67	0.42	0.50*	0.29	0.65
	(-0.13,0.45)	(-0.07, 0.55)	(-0.20,0.27)	(-0.17,0.53)	(-0.23,0.38)	(-0.14,1.47)	(-0.22,1.06)	(0.07,0.94)	(-0.46,1.04)	(-0.18,1.48)
More than $12,823.64	-0.03	0.30*	0.24	0.37*	0.06	0.37	0.42	0.32	-0.02	0.07
	(-0.31,0.25)	(0.00,0.60)	(0.03,0.45)	(0.07,0.66)	(-0.25,0.36)	(-0.11,0.86)	(-0.11,0.95)	(-0.07,0.72)	(-0.65,0.61)	(-0.46,0.60)
Education										
Bachelor's degree	0.26	-0.46	-0.41	0.22	0.39	-1.73*	0.53	0.16	-1.27*	1.16*
	(-0.42,0.94)	(-1.01,0.10)	(-0.86,0.05)	(-0.84,1.27)	(-0.47,1.26)	(-2.26-1.20)	(-0.89,1.95)	(-1.04,1.36)	(-1.87-0.67)	(0.58,1.74)
Technician or technologist	0.23	-0.36	-0.17	0.57	0.35	-1.71*	0.29	0.01	-1.11*	1.16*
	(-0.43,0.90)	(-0.90,0.18)	(-0.60,0.26)	(-0.45,1.60)	(-0.50,1.21)	(-2.19-1.23)	(-1.12,1.71)	(-1.19,1.21)	(-1.68-0.55)	(0.67,1.64)
University degree or higher	0.45	-0.34	-0.22	0.34	0.48	-1.73*	0.35	0.11	-1.08*	1.29*
	(-0.20,1.11)	(-0.89,0.20)	(-0.64,0.21)	(-0.69,1.37)	(-0.37,1.33)	(-2.40-1.06)	(-1.08,1.79)	(-1.11,1.33)	(-1.82-0.34)	(0.66,1.92)
Constant	1.72	2.43	2.23	1.32	1.56	2.06	0.75	0.71	2.01	1.13

*statistically significant at $p<0.05$, reference group for income: less than $1,602 USD, reference group for education: less than bachelor's degree

Table 23 shows the mean WTP for a cigarette pack expressed as a share of weekly income across income groups in each country. The estimates suggest that for all countries the average WTP of individuals as a share of weekly income is monotonically decreasing in income, so that the lowest income group took a larger share of their mean weekly income than for the highest income group. Because each income group constituted different shares of the sample in each country (e.g., in Chile the lowest income group included the lowest 6.12% of the distribution but in Colombia it was the lowest 16.was the lowest 16.97%), one needs to be cautious in inferring too much from cross-country comparisons.

In Canada, the lowest income group represented 15% of the sample, with a WTP equivalent to 4.5% of their average weekly income. By contrast, 34% of the sample were in the highest income group, where the WTP share fell to 0.62%. In Ecuador, 13% of the sample were in the lowest income group, their WTP share was 9% of their weekly income. In contrast, 6% of the Ecuadorian sample were in the highest income group, where the average WTP represented 0.75% of their weekly income. In Chile, the lowest income group accounted for 6% of the sample, with a WTP share of 6% of weekly income. There were 15% of the sample in the highest income group, with WTP representing 0.50% of their weekly income. Finally, in Colombia, 17% of the sample fell in the lowest income group, where the average WTP was 9.6% of their weekly income, compared with 32% in the highest income group, where the share was only 0.8%.

Table 23 Mean Willingness to Pay as a Share of Weekly Income Across Income Groups and % Sample in each Income Group

Income group	Canada		Ecuador		Chile		Colombia	
	Mean WTP/ Mean weekly income (%)	% sample	Mean WTP/ Mean weekly income (%)	% sample	Mean WTP/ Mean weekly income (%)	% sample	Mean WTP/ Mean weekly income (%)	% sample
Lowest income	4.49%	14.96%	8.85%	13.21%	6.11%	6.12%	9.56%	16.97%
Second-lowest income	1.78%	16.24%	2.87%	33.08%	2.23%	24.59%	3.16%	13.33%
Middle income	1.04%	19.66%	1.51%	21.56%	1.13%	38.16%	1.67%	22.84%
Second-highest income	0.77%	14.74%	0.76%	25.73%	0.65%	16.43%	1.11%	14.91%
Highest income	0.62%	34.40%	0.75%	6.41%	0.50%	14.69%	0.77%	31.94%

Discussion

This study used the BDM auction mechanism to examine how different cigarette packaging features influence consumer WTP for cigarette packs in Canada (province of Ontario), Ecuador, Chile and Colombia. Including the illicit pack in the Latin American context is important for many reasons: the tobacco industry's rhetoric about the rise of illicit tobacco due to tax increases is strong in the region (35), the powerful tobacco industry's influence on policies (36), and the important level of illicit tobacco in these countries (37,38).

A key finding across all countries was that the highest overall mean WTP in each country was for the country's then-current legal pack at the time of data collection: branded packs with no stick warning in the cases of Ecuador, Chile, and Colombia, and a plain pack with no stick warning in Canada. In every country, illicit packs received the lowest WTP, with a significant difference from the legal cigarette packs among both smokers and nonsmokers. In Chile and Colombia, the WTP for plain packs (with and without stick warning) was the lowest among all legal packs. In Chile, smokers' WTP for plain pack with stick warning was 10% lower than for branded packs

with no stick warning, while WTP for plain packs with no stick warning was 5% lower than the branded pack. The reduction in WTP for branded packs with no stick warning compared to plain packs with stick warning was larger, WTP for plain packs with stick warning was 13% lower than the branded packs with no stick warning, and WTP for plain packs with no stick warning was 5% lower. This indicates the potential of plain packaging policies as an effective tool to reduce the appeal of cigarettes in those countries. These findings are consistent with previous publications that used the BDM auction mechanism to evaluate packaging and labelling options (30,39).

In Canada, the results appear counterintuitive, as the WTP for the plain pack with no stick warning was the highest among all legal packs. This suggests that smokers preferred this pack over the branded versions. However, it is important to note that the plain pack with no stick warning was already in the Canadian market when the data collection for this study happened. Therefore, smokers in Canada were more familiar with plain packs than was the case in other countries, who lacked exposure to and knowledge of plain packs. This could suggest that policies such as warnings or plain packs may have short lasting effects on convincing smokers to quit or discouraging nonsmokers to start smoking. However, one evaluation of the plain packaging policy in Canada indicated that the percentage of smokers who believed plain packs reduce the appeal increased from 29% in 2018 to 45% in 2020 (40). Therefore, plain packaging and warnings could make smoking less attractive and lower the WTP among all packs. Even if the WTP for plain packs is higher, it could still be less than what it would have been if plain packs had not been introduced.

This study shows that in all countries; smokers were willing to pay less for the illicit packs. However, the difference in WTP between the branded pack with no stick warning and that of the illicit pack was smaller in Ecuador and Colombia. These are two countries where illicit tobacco is an important percentage of the national market (51% in the case of Ecuador (41), and 21% in

Colombia (42)). In the case of Chile, less educated smokers were attracted to illicit packs. These findings suggest that taxes may not be as effective (because illicit and legal are close substitutes), and policies should focus on additional mechanisms to reduce the illicit market. The WHO Protocol to Eliminate Illicit Trade in Tobacco Products provides guidelines to develop these regulations.

Similar to results in other publications (30,39), this study found no consistent statistical relationship between most socioeconomic and demographic characteristics and the WTP for the legal and illicit cigarette packs. However, age was consistently negatively associated with WTP for most packs in all countries. In Canada, higher-income individuals were willing to pay more than lower-income participants for the plain packs with no stick warning, while education played an important role for the Chilean and Colombian nonsmokers. These findings are crucial to consider which characteristics need to be considered when developing packaging, labelling tobacco control policies, and for identifying population groups that may be more susceptible to the appeal of illicit cigarette products. For instance, when developing packaging and labelling policies, it is essential to consider these findings in the policy formulation, considering what will capture the attention of the young population. By implementing plain packaging with stick warning, we know smokers and nonsmokers will be less attracted to these packs of cigarettes compared to the branded options. For this, the WHO has developed guidelines related to the colours for the plain pack, the size of pictograms, and the suggested information to be included in the health warnings (43,44). Additionally, developing information campaigns about plain packaging and labelling in a way that is well understood by the general population, but with a special focus on the younger ones, who have proven to be willing to pay significantly more for the branded options than the older population.

An interesting methodological implication found in this study relates to the presence or absence of a hypothetical budget constraint when participants are asked about their WTP. As explained in the methods section, participants in Chile and Colombia were instructed to imagine having a budget when asked to express their WTP. In contrast, no such budget instructions were provided to participants in Canada and Ecuador. These results are consistent with the conjecture that the budget framing influenced the reported willingness to pay, as participants in Canada and Ecuador reported higher WTP values compared to those in Chile and Colombia.

Only Canada offered an incentive for completing the whole questionnaire, which could have contributed to having more engaged participants and a lower number of smokers who did not complete the survey.

Limitations

The original protocol for the multi-country project was designed for an in-person auction. Unfortunately, due to COVID-19 restrictions, participants had to complete the questionnaires online. This imposed a first restriction, limiting the participation of lower-income individuals without an electronic device with internet access. The sample population across the four countries was disproportionately composed of highly educated individuals and middle-income groups.

Although the study introduced the bidding process with two non-tobacco-related products, so that participants could get familiar with the dynamics, participants could not contact someone to clarify points of confusion in the instructions. A less-than-full understanding of the bidding process could lead to inaccurate WTP. I recommend performing this BDM auction in person and assessing the difference in the results (45).

As previously indicated, smoking habits, i.e., smoker vs nonsmoker, were significant when determining WTP in all countries except Canada. For all packs, among all countries, smokers had a higher WTP than nonsmokers. There is a difference in smokers' and nonsmokers' knowledge that could influence their maximum willingness to pay. Although participants were instructed about the characteristics and differences between all packs, smokers, since they buy cigarettes, have more information about the price, quality and illegal nature of the illicit packs.

In some real-world settings, people might have difficulty distinguishing between licit and illicit cigarette packs, especially in markets where the same brand is available in both licit and illicit forms. For instance, in Ecuador, the brand Marlboro accounted for the highest proportion of illicit cigarette packs, despite also being legally imported by Philip Morris (46). Therefore, recognizing the difference between a licit and an illicit pack could be a challenge, especially for nonsmokers. Also, there is the added problem in Ecuador of purchasing by the stick, since smokers and nonsmokers might not be exposed to the package; therefore, this undermines the packaging and labelling policies.

Additionally, comparing the results between countries was challenging due to the varying state of label, packaging and tax policies in each context. For instance, the differences in familiarity and experience with the different pack options could influence the WTP in the country. This could have an effect when analyzing the differences between countries.

Future policies

As previously indicated, the results of this study provide valuable information for developing targeted tobacco control policies. The observed variation in WTP by socioeconomic status and age underscores the need to target packaging interventions at younger who exhibit a

greater sensitivity to packaging design. This insight supports integrating plain packaging into comprehensive policies designed to reduce youth smoking initiation and address tobacco-related health inequities.

Additionally, Ecuador and Chile proposed laws to introduce plain packaging as early as 2016; however, neither proposal has been approved by their legislative institutions (47,48). The findings provided in this study offer empirical support that can help National Health Authorities to promote the implementation of plain packaging and stick warnings in Latin American countries. By using the BDM auction mechanism, this study provides valuable insight into consumer preferences prior to policy implementation. The results show that individuals in Ecuador, Chile, and Colombia are willing to pay less for plain packs, indicating that these packaging formats are less attractive and therefore effective in reducing the appeal towards these products.

In Canada, the higher appeal of plain packs may be explained by smokers' familiarity with these designs prior to the introduction of plain packaging. This raises the question of whether the effect of plain packaging could weaken as smokers become used to the plain packs. However, evidence from Australia (43) and the United Kingdom(49) shows that the policy continues to reduce pack appeal and increase the salience of health warnings over time.

The cross-country evidence presented in this study allows national policymakers to go beyond their own consumer data and assess whether similar trends are observed in comparable contexts. For example, countries like Ecuador, Chile and Colombia, where plain packaging has not yet been implemented, can look to the Canadian case, where such policies are already in place and accepted by consumers. Likewise, countries with rising illicit trade concerns, such as Ecuador, can learn from Canada's relatively low WTP for illicit packs, which may reflect effective enforcement and control. This type of evidence-sharing across countries, including from high-income to

middle-income settings, can help accelerate progress in tobacco control by informing more targeted and context-sensitive policy design. While one can learn from other countries, adaptation and caution is needed when inferring results in another country.

When considering the details for a plain packaging policy, decision-makers should consider the evidence and preferences of the individuals with age, smoking habits, income characteristics that are proven significant. Although they cannot customize the packaging and price to each age or income group, the policy can evaluate the colour, pack shape and health warning size, pictograms and health messages can influence the target population (50). To achieve the goal of lower smoking prevalence and prevent nonsmokers from starting smoking, it is essential to work on a set of policies, each of which may impact different subgroups. For instance, taxes may deter the young or lower income more effectively, while packaging might affect the older or higher income population.

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Appendix

Appendix 1: Packs shown per country and block

Canada

Block 1:

Branded pack with no stick warning

Illicit pack

Block2:

Branded pack with stick warning

Plain pack with no stick warning

Block 3:

Plain pack with no stick warning

Plain pack with stick warning

Ecuador

Branded pack with no stick warning

Illicit pack

Chile

Block 1:

Block 2:

Branded pack with no stick warning

Illicit pack

Block 3:

Branded pack with stick warning

Plain pack with no stick warning

Plain pack with no stick warning

Plain pack with stick warning

Colombia

Block 1:

Branded pack with no stick warning

Illicit pack

Block 2:

Branded pack with stick warning

Plain pack with no stick warning

Block 3:

Plain pack with no stick warning

Plain pack with stick warning

Appendix 2: Skewness tests per country

Canada

Variable	Obs	Pr(skewness)	Pr(kurtosis)	Adj chi2(2)	Prob>chi2	
WTP Brand no stick warning	172	0.00	0.73	9.06	0.01	non normal
WTP Plain no stick warning	335	0.00	0.14	19.24	0.00	non normal
WTP Brand with stick warning	163	0.00	0.42	11.91	0.00	non normal
WTP Plain with stick warning	172	0.00	0.89	10.94	0.00	non normal
WTP Illicit	172	0.00	0.00	37.77	0.00	non normal

Ecuador

Variable	Obs	Pr(skewness)	Pr(kurtosis)	Adj chi2(2)	Prob>chi2	
WTP cigarette standard pack	1,383	0.18	0.01	8.05	0.02	close to normal
WTP illicit cigarette pack	1,383	0.00	0.30	40.45	0.00	not normal

Chile

Variable	Obs	Pr(skewness)	Pr(kurtosis)	Adj chi2(2)	Prob>chi2	
Standard pack	339	0.00	0.00	61.69	0.00	not normal
Standard pack with stick warning	357	0.00	0.02	50.05	0.00	not normal
Plain pack with no stick warning	706	0.00	0.00	114.06	0.00	not normal
Plain pack with stick warning	349	0.00	0.01	54.39	0.00	not normal
Illicit	339	0.08	0.97	3.07	0.22	Normal

Colombia

Variable	Obs	Pr(skewness)	Pr(kurtosis)	Adj chi2(2)	Prob>chi2	
Standard pack	570	0.02	0.35	6.72	0.03	not normal
Standard pack with stick warning	596	0.00	0.03	13.94	0.00	not normal
Plain pack with no stick warning	1162	0.18	0.00	9.71	0.01	not normal
Plain pack with stick warning	568	0.42	0.05	4.67	0.10	normal
Illicit	570	0.32	0.10	3.65	0.16	normal

Appendix 3: Univariate WTP analysis per pack among all countries, considering sample characteristics

The following sections further describe the WTPs, considering the context of each country.

Canada

The following table presents the WTP for each cigarette pack type across different sample characteristics among Canadian participants, all of whom are smokers. For the branded pack with no stick warning, occasional smokers had a higher WTP ($12.94) compared to daily smokers ($10.91). Females ($11.37) were willing to pay more for the branded pack with no stick warning than males ($10.89). WTP was higher as income increased, except for the highest income group. Similar results were found for the plain pack with no stick warning, where occasional smokers were willing to pay more than those who smoke daily ($12.29 vs $11.94), as well as females compared to males ($12.15 vs $11.76), and WTP generally increased with income, though not monotonically.

In the case of the branded pack with stick warning, the WTP for daily smokers ($11.06) is higher than for occasional smokers ($10.59). Males had a greater WTP ($11.17) compared to females ($10.78). Regarding income, WTP does not follow a clear trend. For plain packs with stick warning, occasional smokers were willing to pay more ($11.43) than participants who smoked daily ($10.73). Females had a higher WTP ($11.17) than males ($10.51). Except for the middle-income group, the WTP increases with income. Finally, for the case of illicit packs, occasional smokers had a higher WTP ($6.04) than daily smokers ($4.66), females had a higher WTP than males ($5.16 vs 4.18), and WTP for illicit packs decreased consistently as income increased.

WTP per pack according to characteristics in Canada

	Branded pack with no stick warning	Plain pack with no stick warning	Branded pack with stick warning	Plain pack with stick warning	Illicit pack
	Mean WTP				
Smoking habits					
Daily	10.91	11.94	11.06	10.73	4.66
Occasionally	12.94	12.29	10.59	11.43	6.04
Gender					
Male	10.89	11.76	11.17	10.51	4.18
Female	11.37	12.15	10.78	11.17	5.16
Income groups					
Less than $14,900	10.93	9.06	9.52	8.13	5.23
$14,900 to less than $29,850	10.61	11.72	11.15	10.88	5.44
$29,850 to less than $44,700	11.30	11.26	10.82	10.91	5.30
$44,700 to less than $59700	11.46	12.52	10.49	10.33	4.79
$59,700 to less than $74,600	12.85	13.72	11.89	12.77	4.28
$74,600 and over	11.52	13.55	11.62	12.99	4.10
Prefer not to respond	9.15	11.51	10.45	9.13	4.63

A Kruskal-Wallis test was performed between packs to understand whether there were differences in WTP across distributions. The following table lists the p-values for tests of differences between the WTP distributions across the different pack options. The plain pack with no stick warning had a statistically different WTP distribution than the WTP distribution of the branded pack with a stick warning and the WTP distribution of a plain pack with a stick warning. The illicit pack's WTP distribution differed from that of the other four packs.

Pairwise Kruskal-Wallis p-values for Canada

	Branded pack no stick warning	Plain pack with no stick warning	Branded pack with stick warning	Plain pack with stick warning	Illicit pack
Brand no stick warning	-	0.14	0.49	0.46	0.00
Plain no stick warning	0.14	-	0.02	0.02	0.00
Brand with stick warning	0.49	0.02	-	0.98	0.00
Plain with stick warning	0.46	0.02	0.98	-	0.00
Illicit	0.00	0.00	0.00	0.00	-

Ecuador

The following table presents the mean WTP for each pack type among smokers and nonsmokers, according to the different sample characteristics. Among smokers, males were willing to pay more for the branded pack with no stick warning than females ($4.75 vs $4.55). WTP also tended to increase with income, whereas no consistent pattern was observed across education levels. For the illicit packs, males had a higher WTP ($3.76) compared to females ($3.65). In the case of income and education, the WTP showed no clear pattern.

For nonsmokers, the WTP for the branded pack with no stick warning was higher for females ($3.78) than for males ($3.58). WTP also increased with income, while no clear pattern emerged across education levels. For illicit packs, females again reported a higher WTP than males ($3.12 vs. $3.07). In this case, WTP rose with income but declined with higher education, except for nonsmokers with a technical degree, who deviated from this trend.

Mean per pack according to sample characteristics in Ecuador for smokers and nonsmokers

	Branded pack with no stick warning	Illicit pack	Branded pack with no stick warning	Illicit pack
	Mean WTP- smokers		Mean WTP- nonsmokers	
Gender				
Male	4.75	3.76	3.58	3.07
Female	4.55	3.65	3.78	3.12
Income groups				
Less than $4,800 USD	4.17	3.52	3.38	3.02
$4,800 to less than $9,600 USD	4.77	3.85	3.84	3.03
$9,600 to less than $18,000 USD	4.76	3.63	3.90	3.27
$18,000 to less than $30,000 USD	4.81	3.59	4.01	3.30
$30,000 and over	4.94	4.09	4.19	3.47
Education level				
Less than high school	4.75	4.04	3.23	3.47
Highschool	4.43	3.59	3.77	3.10
Technical degree	4.55	3.79	3.77	3.27
Undergraduate degree or higher	4.75	3.71	3.60	2.95

According to the Kruskal-Wallis test performed in the WTP distribution per pack, there were statistically significant differences, as shown in the next Table, for $p<0.05$.

Pairwise Kruskal-Wallis test per pack in Ecuador for smokers and nonsmokers

	Observations	Rank sum	Observations	Rank sum
	Smokers		Nonsmokers	
Branded pack with no stick warning	842	802,854	541	313,381
Illicit pack	842	615,916	541	272,523
	chi2(1) =	87.76	chi2(1) =	15.80
	Prob =	0.00	Prob	0.00
	chi2(1) with ties =	88.57	chi2(1) with ties =	15.93
	Prob =	0.00	Prob =	0.00

Chile

The next Table shows the mean WTP per pack according to different sample characteristics for smokers and nonsmokers in Chile. In the case of smokers, females consistently reported higher WTP than males across all pack types. For the branded pack with no stick warning, income and education level did not show any clear trend. For the branded pack with stick warning, the WTP was higher as income increased, but education had no trend. In the case of plain pack with and with no stick warning, and the illicit pack neither income nor education showed a trend.

Among nonsmokers, females were willing to pay more than males for each of the branded pack with stick warning, plain pack with and without stick warning. However, males had a higher

WTP for the branded packs without stick warning and for the illicit packs. Regarding income and education, there were no clear trends for any of the packs.

Mean WTP per pack according to sample characteristics in Chile

	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack
	Mean WTP- Smokers					Mean WTP- Nonsmokers				
Sex										
Male	3.26	2.99	3.03	2.96	1.49	2.21	2.28	2.33	2.08	1.37
Female	3.34	3.24	3.23	2.97	1.62	1.92	2.4	2.36	2.49	1.14
Annual income										
Less than $4,126.88 USD	2.84	2.92	2.97	3.19	1.59	2.03	2.37	2.17	1.77	1.26
$4,140.66 USD to $8,253.76 USD	3.49	3.12	3.19	3.14	1.46	1.89	2.2	2.29	2.55	1.11
$8,267.51 USD to $16,507.51 USD	3.21	3.12	3.05	2.93	1.62	2.5	2.32	2.48	2.49	1.36
$16,508 USD to $27,512.52 USD	3.39	3.2	3.25	2.78	1.62	2.56	2.56	2.43	2.22	1.8
More than $27,513 USD	3.33	3.26	3.15	2.82	1.57	1.87	2.55	2.41	2.19	1.23
Prefer not to respond	3.21	2.98	3.11	2.98	1.27	1.2	1.98	1.51	1.23	0.8
Don't know	3.15	1.43	3.42	2.98	1.72	1.72	2.29	2.69	2.83	0.69
Education										
Incomplete secondary education	3.63		3.48	3.29	1.91		0.86	1.82	3.78	
Complete secondary education	3.27	2.85	3.11	3.14	1.56	2.24	2.42	2.23	2.34	1.3
Incomplete technical education	3.37	3.04	3.02	2.83	1.73	1.34	2.49	2.52	3.05	0.57
Complete technical education	3.37	3.42	3.24	3.04	1.42	2.15	2.1	2.22	2.16	1.38
Incomplete university or higher education	3.34	3.07	3.2	3.14	1.72	2.2	2.75	2.57	2.09	1.23
Complete university or higher education	3.26	3.15	3.07	2.86	1.6	2.18	2.05	2.18	2.09	1.35
Incomplete postgraduate education	3.24	2.67	2.64	2.58	1.75		3.73	3.44		
Complete postgraduate education	3.34	2.92	3.06	2.63	1.55	1.18	2.2	2.78	3.08	0.82

A pairwise Kruskal-Wallis was conducted to understand if there are statistically significant differences in the WTP distribution between packs. As shown in the next Table, significant differences were found when comparing the WTP for the illicit packs to all legal pack types among both smokers and nonsmokers (p=0.00). For smokers, the WTP for the plain pack with stick warnings was also significantly different from the other pack types (p=0.00). However, this difference was not observed among nonsmokers.

Pairwise Kruskal-Wallis p-values for Chile

	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack
			Smokers					Nonsmokers		
Branded pack with no stick warning	-	0.13	0.10	0.00	0.00	-		0.17	0.42	0.00
Branded pack with stick warning	0.13	-	0.43	0.00	0.00		-	0.76	0.93	0.00
Plain pack with no stick warning	0.10	0.43	-	0.00	0.00	0.17	0.76	-	0.67	0.00
Plain pack with stick warning	0.00	0.00	0.00	-	0.00	0.42	0.93	0.67	-	0.00
Illicit pack	0.00	0.00	0.00	0.00	-	0	0	0	0.00	-

Colombia

The next Table shows the mean WTP per pack by gender, income group and education levels for both smokers and nonsmokers. Among smokers, males were willing to pay more than females for the branded pack with no stick warning, the plain pack with no stick warning and the plain pack with stick warning. In the case of the branded pack with stick warning and the illicit pack, females had a WTP slightly higher than males. In neither of the packs did income and education level follow any consistent pattern

Among nonsmokers, males showed higher WTP than females for the branded pack with no stick warning, the plain pack with stick warning, and the illicit pack. However, nonsmokers in the highest income category did not have the highest WTP across all packs. Except for the plain pack with stick warning, the lowest income generally reported the lowest WTP. No clear trend emerged with respect to education. Nonsmokers with the lowest education level (less than bachelor's degree), had the highest WTP for the branded pack with no stick warning ($3.37, the highest value across all education levels and pack types) and for the plain pack with stick warning. Only for the case of the illicit packs, the nonsmokers with the highest education level had the highest WTP.

Mean WTP per pack according to sample characteristics

	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit
	Mean WTP- Smokers					Mean WTP- Nonsmokers				
Gender										
Male	1.87	1.85	1.81	1.64	1.59	1.59	1.31	1.25	1.35	1.51
Female	1.84	1.86	1.68	1.58	1.61	1.45	1.37	1.32	1.23	1.19
Income groups										
Less than $1,602.95USD	1.85	1.72	1.67	1.49	1.63	1.18	1.04	1.12	1.27	1.12
$1,602.96 USD to $3,205.91 USD	1.78	1.78	1.46	1.28	1.52	1.66	1.31	1.24	1.22	1.42
$3,205.92 USD to $6,411.81 USD	1.71	1.7	1.75	1.55	1.51	1.27	1.53	1.25	1.09	1.22
$6,411.82 to $9,617.72USD	2.03	1.86	1.79	1.69	1.62	1.91	1.44	1.34	1.47	1.46
$9,617.73 USD to $12,823.63 USD	2.03	1.96	1.72	1.63	1.67	1.84	1.44	1.66	1.57	1.83
More than $12,823.64	1.85	2.02	1.92	1.83	1.65	1.56	1.46	1.47	1.3	1.26
Education level										
Less than bachelor's degree or its equivalent	1.44	2.24	1.99	1.2	1.15	3.37	0.94	1.16	2.4	0.3
Bachelor degree or its equivalent	1.77	1.79	1.6	1.41	1.57	1.47	1.49	1.33	1.16	1.27
Technician or technologist	1.73	1.82	1.78	1.75	1.52	1.43	1.26	1.19	1.28	1.28
University degree or higher	1.97	1.88	1.77	1.58	1.66	1.53	1.37	1.37	1.38	1.42

Differences in the WTP distributions between packs were examined using a Kruskal-Wallis test. The next Table shows that for smokers, significant differences were found when comparing the WTP distributions for the plain pack with stick warning and the illicit pack when compared to all other packs (p=0.00). For all other packs, no differences were found. For nonsmokers, no differences were found between WTPs across packs.

Pairwise Kruskal-Wallis p-values for Colombia

	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack	Branded pack with no stick warning	Branded pack with stick warning	Plain pack with no stick warning	Plain pack with stick warning	Illicit pack
	Smokers					Nonsmokers				
Branded pack with no stick warning	-	0.64	0.08	0.00	0.00	-	0.23	0.03	0.06	0.08
Branded pack with stick warning	0.64	-	0.20	0.00	0.00	0.23	-	0.39	0.30	0.44
Plain pack with no stick warning	0.08	0.20	-	0.00	0.00	0.03	0.39	-	0.73	0.92
Plain pack with stick warning	0.00	0.00	0.00	-	0.00	0.06	0.30	0.73	-	0.90
Illicit pack	0.00	0.00	0.00	0.00	-	0.08	0.44	0.92	0.90	-

Chapter 5. Conclusions

This dissertation includes three chapters that address how individual behaviours and systemic factors interact to influence health outcomes and policy effectiveness for NCDs, and specifically health and economic challenges associated with diabetes and tobacco consumption. Two of the three studies focus on Ecuador as a case study of the Latin American region, while the third includes Ecuador along with three other countries from the Americas. This chapter summarizes the main findings from the three original research studies in this dissertation, outlining their strengths, limitations, policy implications, and reflections on future research.

As noted in the introduction, NCDs impose not only a significant global epidemiological burden, but also growing economic pressures on health care systems, patients and their families (1). Diabetes, in particular, has emerged as an increasingly important cause of morbidity and mortality in LMICs. In the Americas, for example, diabetes accounted for 4% of all deaths in 2019 (2). Many of these cases could have been prevented by addressing modifiable risk factors, such as tobacco use. The findings in this dissertation emphasize that addressing NCDs requires a comprehensive approach that combines equitable access to healthcare services, effective policies, including tobacco taxation, packaging and labelling.

Summary of findings

The first study provides a detailed analysis of how socioeconomic factors influence the prevalence and management of diabetes across different populations in Ecuador, providing important insights into health inequalities. The findings highlight age as a key factor that determines the likelihood of being diagnosed with diabetes or having a high glucose level.

Education and income emerge as crucial socioeconomic determinants, with lower educational attainment and being in the lowest income decile strongly linked to poorer diabetes outcomes, as they had a greater likelihood to be in the undiagnosed normal or undiagnosed high-risk group.

For the "controlled diabetic" and "uncontrolled diabetic" groups, income was not statistically associated with being part of these groups, a finding consistent with the complementary analysis of income-related inequalities using the Wagstaff Concentration Index. For the "undiagnosed high-risk" group, individuals in the lowest income group were more likely to be in this category when compared to the highest income decile. Results for the "confirmed non-diabetic" group were mixed: low- and middle-income deciles showed a lower likelihood of being part of this group when compared with the highest-income decile, without a clear pattern, though the Wagstaff Index suggested that this group was concentrated in higher-income groups. The outcomes of this study showed that in the Ecuadorian setting, socioeconomic inequalities could play a key role when accessing healthcare for diabetes.

Study 2 employed a Discrete Choice Experiment (DCE) to assess how plain packaging, health warnings on cigarette sticks, price changes and the availability of illicit cigarettes influence the intention to purchase and the tobacco-related risk perceptions among adults in Ecuador. The main findings indicate that plain packaging may be effective in reducing the intention to purchase by smokers and the willingness to try by nonsmokers. Another result shows that, consistent with the wider literature, price increases also appear effective in reducing tobacco consumption. Finally, smokers and nonsmokers demonstrated a preference for avoiding illicit packs.

The results from the Latent Class Analysis (LCA) further revealed substantial heterogeneity in preferences across individuals. For example, in Design 1, which included both licit and illicit alternatives, smokers in Class 1, slightly younger, with a higher education and higher

income than those in Class 2, clearly avoided illicit packs. By contrast, in Class 2, the coefficient for illicit packs was not statistically significant, indicating little concern over whether a pack was illicit. However, when the illicit pack was removed as an option (Design 2), the combined effect of plain packaging, stick warnings, and higher prices had a more substantial influence on intention to purchase, suggesting that regulatory measures could be more effective when the illicit market is controlled.

Study 3 examined how cigarette packaging features influence consumers' WTP for cigarette packs in Ontario Canada, Ecuador, Chile and Colombia. A key finding across all countries was that the highest overall mean WTP in each country was for the country's then current legal pack at the time of data collection (branded packs with no stick warning in the cases of Ecuador, Chile, and Colombia, and a plain pack with no stick warning in Canada). In every country, both smokers and nonsmokers had the lowest WTP illicit packs, significantly and substantively less than all legal packs. In Chile and Colombia, the WTP for plain packs (with and without stick warning) was the lowest among all legal packs. In Canada, the results appear counterintuitive, as the WTP for the plain pack with no stick warning was the highest among all legal packs, but, as noted above, this the pack currently available in Canada.

Additionally, this study found no consistent statistical relationship between most socioeconomic and demographic characteristics and the WTP for the licit and illicit cigarette packs. However, age was negatively associated with WTP for most packs in all countries. Country-specific effects were also observed: in Canada, higher-income individuals were willing to pay more than lower-income participants for the plain packs with no stick warning, while education played an important role for the Chilean and Colombian smokers.

Implications for Ecuador

The strong reliance of the Ecuadorian health care system on out-of-pocket expenditure as a source of funding (3) has important implications when managing NCDs, for low-income individuals have to spend a greater share of their income to pay for health care (4) . Study 1 clearly indicates the characteristics of individuals who are not accessing the health system to learn about their health status (undiagnosed groups), or who have been misdiagnosed, or have uncontrolled glucose levels. Additionally, income inequalities add another layer of complexity because those in lower income have a greater likelihood to be undiagnosed, misdiagnosed or with high-risk levels of glucose. It is reasonable to consider that a similar situation may be occurring among individuals suffering from other types of NCDs. The state of the Ecuadorian health care system has deteriorated further following the COVID-19 pandemic (5). This suggests that current income-related inequalities have gotten worse, because there is a shortage in health facilities, and therefore, families must pay out-of-pocket for supplies that the facility should be providing

A comprehensive NCD policy is needed in the country to address the care of the population from prevention, diagnosis and treatment of these conditions. This policy needs to have a special focus on the younger, low-income, low-education individuals, who have a higher likelihood of not being accurately diagnosed or properly managing their health condition.

In the case of Ecuador, both studies 2 and 3 highlight the unappealing nature of illicit packs. In the DCE, the estimated marginal effects and WTP indicated that many smokers preferred to avoid the illicit alternative. In the BDM, the participants consistently indicated that they were willing to pay less for the illicit pack compared to the licit option.

However, the WTP for illicit packs was notably higher in Ecuador than in Canada, Chile, or Colombia, both in absolute terms and as a proportion of the WTP for legal packs. This suggests that, while Ecuadorians prefer legal packs, illicit packs are much closer substitutes in Ecuador than in the other countries. This highlights the importance of addressing the illicit market in the country by implementing stricter policies to trace illicit packs and impose appropriate sanctions.

Unfortunately, we cannot compare results for the branded pack with stick warning, and the plain packs with and with no stick warning, for the Ecuadorian BDM did not include these packs as options. However, the convergence of results regarding illicit packs strengthens the credibility of the finding that illicit products are not as attractive to consumers, but the low price and inadequate regulation of the illicit market maintain its large presence in Ecuador. In addition, the results from the DCE show the importance of implementing a plain packaging policy, for smokers and nonsmokers prefer to avoid these packs.

The two methodologies employed to study tobacco control policies are distinct, yet each provides valuable insights into consumer preferences and willingness to purchase different types of cigarette packs. Taken together, these studies are complementary and offer essential evidence to inform the design of more effective tobacco control policies.

Cross-study final reflections

To begin, it is important to reflect on the limitations and unanswered questions arising from the three studies. A key limitation in Study 1 is the use of cross-sectional data. Although it is valuable to have this first analysis and provide a snapshot of the NCD management problem, it would be important to analyze the changes in NCDs management and the relationship with socioeconomic characteristics over time. This would provide information about changes that

should be done, to guarantee timely diagnosis and control of the health conditions in the population.

Another limitation of the three studies is the exclusion of individuals under 18This gap is particularly relevant given the high prevalence of tobacco consumption among adolescents. For instance, in Ecuador, the prevalence of current tobacco use among adolescents aged 13–15 years (13%) is higher than among those aged 15 and older (11.3%) (6). This is a particularly important group to target for tobacco control policies because it is during these early ages that the initiation of tobacco use most often occurs. Preventing consumption at this stage is critical to avoid addiction.

As noted in Study 3, another limitation is not having a complete comparison of willingness to pay (WTP) for all cigarette packs across smokers and nonsmokers was not possible. In Canada, data were not collected for nonsmokers, while in Ecuador, the branded pack with a stick warning, the plain pack without a stick warning, and the plain pack with a stick warning were not included among the options. Therefore, among the LMICs included, only the data from Colombia and Chile allowed for a full comparison of WTP across all pack types.

Both the DCE and BDM auction were, in some sense, hypothetical exercises. To strengthen confidence in the results, we followed methodological recommendations, such as using non-tobacco related examples, to ensure that participants understood the tasks and could reveal their true stated preferences and provide accurate hypothetical bids. Despite these precautions, we encountered some participants who did not pass quality tests (for instance, the dominant choice tests in the DCE or survey completion times), highlighting the limitation of relying on the respondent's motivation to provide truthful responses.

This dissertation has a number of implications for practice and policy that could be applicable not only to Ecuador but also to other LMIC countries. In these countries, like in Ecuador, care for NCDs is often limited to the late management of acute health complications in specialized centers, typically at high cost, as is the case of diabetes (7). As a result, the majority of out-of-pocket expenditures and a substantial share of catastrophic health spending are linked to the treatment of NCDs, largely driven by complications that are highly preventable but nonetheless costly to manage (4). Yet, low-income populations face substantial barriers to accessing care.

Identifying who remains undiagnosed with diabetes, who has been misdiagnosed, and which groups are at high risk of developing the disease provides a critical framework for guiding priority setting in the health system. Such insights help determine which populations should be targeted for early detection and intervention, and which factors must be considered in the clinical management of individuals at risk of disease onset. At the national level, mapping the distribution of individuals across different categories of diabetes diagnosis, management, and control would enable, for the first time in Ecuador, the formulation of a comprehensive policy for integrated diabetes care to develop more equitable, effective interventions.

The methodology applied in the diabetes study could serve as a foundation for future research on other NCDs. Moreover, extending the framework to populations with documented comorbidities would generate valuable information on the cumulative burden of NCDs.

NCDs need multisectoral actions to prevent and control them. Prevention measures to address modifiable risk factors often need to include not only the health sector, but also others, such as finance, tax, and other relevant sectors (8). In this context, the economic evidence generated in these three studies provides essential tools to discuss public health policies to prevent NCDs from an economic perspective.

In recent years, Ecuador (9,10), Colombia (11,12), and Chile (10) have advanced proposals for plain packaging and tobacco tax reforms. Unfortunately, none of these initiatives has been discussed by their respective Parliaments. One possible reason is the limited country-specific economic evidence to support these proposals. The findings of this dissertation could strengthen such policy efforts by offering evidence that makes the case more compelling to non-health sectors and provides information that goes beyond the traditional medical perspective.

The DCE and BDM auction mechanisms represent novel approaches in the Ecuadorian context, as they had not been previously applied to tobacco control research in the country. While a limited number of studies using DCEs have been published in other Latin American settings, both methods offer valuable opportunities to estimate the potential effects of policies before their implementation. This makes them particularly useful for informing evidence-based decision-making. Therefore, future research can use these methods to evaluate other tobacco control policies, such as packaging, labelling and taxes of novel tobacco products that are an emerging concern, especially among the younger population (13). Additionally, these methods could also be used to evaluate policies related to other modifiable risk factors that are important in preventing diabetes and other NCDs.

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