



Research Paper

Municipal socioeconomic environment and recreational cannabis use in Mexico: Analysis of two nationally representative surveys

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ABSTRACT

Background: Recreational cannabis use is increasing in Mexico, where legalization is a possibility. The current area-level socioeconomic context of cannabis use has not been studied in the country, limiting our understanding and public health response. We aimed to analyze the association between the municipal socioeconomic environment and recreational cannabis use in Mexico.

Methods: We used data from the National Survey of Drug, Alcohol and Tobacco Consumption 2016–17, the National Health and Nutrition Survey 2023, the 2015 intercensal survey and the 2020 census to study the association of municipal income and municipal education with past-year recreational cannabis use. We fitted Poisson models with robust variance to obtain prevalence ratios and assessed for effect modification by individual-level sex and age, and household-level education.

Results: For every unit increase in municipal education, we observed a 1.5 % increase in the prevalence of recreational cannabis use in 2016–17, and a 2.9 % increase in 2023. For each unit increase in municipal income, we observed a 1.5 % increase in the prevalence of recreational cannabis use in 2016–17, and a 1.8 % increase in 2023. We found no effect modification except for a single age group (20- to 29-year-olds vs to 12- to 19-year-olds).

Conclusion: Recreational cannabis use in Mexico is currently higher in more socioeconomically advantaged municipalities. Recreational cannabis use through socioeconomic areas should be monitored closely. Further research of the modifiable causes of this association could help inform current and future public health policies.

Introduction

Regular recreational cannabis use, the consumption of the cannabis plant or its derivatives for its psychoactive effects, is associated with negative health outcomes. Evidence shows that it is associated with bronchitis, decreased lung function, testicular cancer, cardiovascular diseases, as well as motor vehicle accidents (Gurney et al., 2015; Hall & Lynskey, 2016; Russell et al., 2017). It is also associated with poor mental health, specifically cognitive impairment, major depression, and psychotic disorders, including schizophrenia (Lev-Ran et al., 2014; Moore et al., 2007). Additionally, one in five cannabis users develops a cannabis use disorder (Leung et al., 2020).

Cannabis use is increasing in Mexico, where its legalization is under discussion. In the country, the prevalence of lifetime recreational

cannabis use has gradually increased among adults, from 3.5 % in 2002 to 8.6 % in 2016–17 (Instituto Nacional de Estadística y Geografía, 2004; Secretaría de Salud and Villatoro-Velázquez, 2017). Since 2019, when a ruling of the Supreme Court of Justice declared its prohibition unconstitutional, the country has been transitioning towards the legalization of recreational cannabis use (Suprema Corte de Justicia de la Nación, 2019). In 2020, the Senate passed a law for the legalization of possession, cultivation, and commercialization of recreational cannabis (Senado de la República, 2020). This law was sent back with modifications by the Chamber of Deputies (Cámara de Diputados LXV Legislatura, 2021), and consensus between chambers was never reached. Since then, recreational cannabis use in Mexico remains in a legal limbo, in which a personal use permit can be obtained through a complicated process, but a legal framework for regulation has not been established

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(Morán Breña, 2021). Defining a legal policy model for recreational cannabis remains a complicated political issue, civil society organizations pushing for decriminalization as a solution to drug violence, the nascent cannabis industry lobbying for a free-market approach and political groups having sent over ten proposals for a federal law over a five-year period with varying levels of restrictiveness (Aguilar, 2024; México Unido Contra la Delincuencia, 2021; Nochebuena, 2023; Ponce Flores, 2024). Given the fast pace of increase in the prevalence of cannabis use and the dynamic political process, it is important to understand how use is changing across the population.

The diffusion of innovations theory is a valuable framework to study change in recreational cannabis use in a society (Ferrence, 2001). This theory states that practices such as drug use are first adopted by certain groups and then spread over time through a social system (Katz et al., 1963; Rogers, 1962). This change pattern is observed through *diffusion variables*, commonly socioeconomic indicators such as education, housing conditions, income or occupation (Galobardes, 2006; Wejnert, 2002). Among these indicators are socioeconomic *contextual variables*, area-level variables that characterize all its members (Diez Roux, 2002). Diffusion through area-level variables was observed for tobacco use throughout the 20th century, which diffused from higher to lower socioeconomic areas (Dwyer-Lindgren et al., 2014; Hiscock et al., 2012; Najman, 2006; Pampel, 2001, 2005; Schaap et al., 2009). Similar socioeconomic diffusion might occur for cannabis in the 21st century (Ferrence, 2001).

Studying the current socioeconomic context of recreational cannabis use in Mexico is pivotal to understand how diffusion of cannabis use might occur in the country, particularly if a legal framework is established. In high income countries, studies have shown recreational cannabis use to be associated with area-level socioeconomic indicators, the association differing by geographic location, indicator used and area size (Karriker-Jaffe, 2011); and when using individual-level indicators differing by sex and age (Daniel et al., 2009; Knaappila et al., 2020; Legleye et al., 2012; Redonnet et al., 2012). In Mexico and other Latin American countries, studies have focused on individual-level indicators, cannabis use usually showing an association with higher individual socioeconomic status (Gaete & Araya, 2017; Peltzer & Pengpid, 2014; Pratta & Santos, 2007; Vázquez et al., 2019; Zapata Roblyer et al., 2015). Currently, there is a significant gap in the literature regarding the association between area-level socioeconomic variables and cannabis use in Mexico, which hinders our understanding and public health response in the context of increasing prevalence and a dynamic political landscape. Thus, we aimed to analyze the association between the municipal socioeconomic environment and recreational cannabis use in Mexico, including its effect modification by sex, age and individual-level education.

Methods

Data sources

We used six data sources: 1) The National Survey of Drug, Alcohol and Tobacco Consumption 2016–17, 2) The National Health and Nutrition Survey 2023, 3) The 2015 Municipal Marginalization Index dataset, 4) The 2020 Municipal Marginalization Index dataset, 5) The 2015 intercensal survey municipal dataset, and 6) The 2020 census municipal dataset.

The National Survey of Drug, Alcohol and Tobacco Consumption 2016–17, is a national and state-level representative household survey with probabilistic, multi-stage and stratified sampling, which was carried out among 12- to 65-year-old Mexicans between June and October 2016. The questionnaire was self-administered using a computer-based interview to minimize response bias, although people who preferred a face-to-face interview were interviewed that way. Complete survey methods with additional detail have been published (Secretaría de Salud and Villatoro-Velázquez, 2017). This dataset contained 56,877

individuals in 727 municipalities, with a median of 41 (IQR: 30, 77) individuals per municipality.

The 2023 National Health and Nutrition Survey is a nationally representative household survey, also with probabilistic, multi-stage and stratified sampling, it was carried out between July and November 2023. It is a multiple theme survey with the objective of describing the health situation of the country and aiding national decision-makers (Romero-Martínez et al., 2023). The drug use section of the survey was included in 2023 for the first time, it was administered by trained field personnel to 12- to 65-year olds. The full methodology has been detailed elsewhere (Romero-Martínez et al., 2024). This dataset contained 8,696 individuals in 171 municipalities, with a median of 38 (IQR: 29, 52) individuals per municipality.

The 2015 and 2020 Municipal Marginalization Index datasets are publicly available datasets constructed and published by the National Population Council of Mexico. They contain municipal-level development indicators, including economic and educational variables, which have been reported since 1990 and are constructed using census data (Villasana Ocampo et al., 2023). The 2015 intercensal survey and the 2020 census are also publicly available datasets, which are published by the National Institute of Geography and Statistics. They contain the official estimates of population counts and percentages at the national, state and municipal level. Its methodologies have been published previously (Instituto Nacional de Estadística y Geografía, 2015, 2021).

Variables

Outcome variable

Our outcome variable was "recreational use of cannabis in the past year", which was constructed from the question: "In the last 12 months, have you consumed marijuana, hashish, also called "pot", "coffee", "yerba", etc., to get high?". The question was only asked to respondents who had earlier answered "Yes" to having ever used marijuana to get high. The question was dichotomous (yes/no). Though different cannabis use frequency cut-off points have been used in the literature (e. g. "ever used", "use in the past month"), we selected "use in the past year" as it was measured identically in both surveys, which facilitated the comparison across years. It is important to note that this variable likely includes people who use cannabis more casually and people who might have a cannabis use disorder.

Exposure variables

We selected two contextual variables to study the socioeconomic environment, municipal education, and municipal income. We constructed both variables using the Municipal Marginalization datasets, which contain the variables *percentage of people with less than middle school* and *percentage of people living in poverty*, which have been detailed elsewhere by the National Population Council (Villasana Ocampo et al., 2023). We inverted these percentages as *new variable* = 100 – *existing variable*, to facilitate interpretations of our results, so that one percentage point increase reflected an improvement in education/income. Thus, we defined *municipal education* as the proportion of people in the municipality who completed middle school or higher. In Mexico this means that a person completed at least all three years of middle school (secundaria, in Spanish) or technical/commercial studies after primary school (estudios técnicos o comerciales, in Spanish). And we defined *municipal income* as the proportion of people working people in the municipality whose income was twice the minimum wage or higher. In Mexico the minimum wage is established by the federal government, increases periodically, and is higher for municipalities in the US border (Campos-Vazquez & Esquivel, 2023). So values were different for each year (68.28 MXN per day in 2015, 123.22 MXN per day in 2020) and for specific municipalities (68.28 vs 70.10 in 2015, 123.22 vs 185.56 in 2020), this was already considered in each dataset (Comisión Nacional de los Salarios Mínimos, 2020). The two variables had a Pearson's correlation coefficient of 0.80, so we expected any

association to be in the same direction, but perhaps different magnitude, so we still we considered informative to study both. Additionally, they represent different aspects of the municipal environment which were both of interest.

Confounder variables

We evaluated potential confounders through a directed acyclic graph (see Supplementary methods) and included rural/urban stratum (rural, urban), municipal population aged 15 to 29, municipal male to female ratio, municipal indigenous population, municipal afrodescendent population, and municipal non-religious population. We constructed *rural/urban stratum* from the classification of the Urban Health in Latin America project, which has been detailed elsewhere (Quistberg et al., 2019); the classification for all municipalities was the same for both years. We constructed the other variables using the 2015 intercensal survey (to use with the 2016–17 survey) and the 2020 census (to use with the 2023 survey). Ethnicity (indigenous/afrodescendent) and religious affiliation were not available at municipal level for 2015. We calculated the *municipal population aged 15 to 29* as the percentage of the total population that was between 15 and 29 years of age. *Municipal male to female ratio* was the division of the total number of men by the total number of women and multiplying it by 100, thus indicating the number of men per 100 women. We calculated *municipal indigenous population* as the percentage of population who inhabit a home where an indigenous language is spoken by the main income earner, their partner or one of their parents. We calculated *municipal afrodescendent population* as the percentage of population who self-identified as afrodescendent. We defined *municipal non-religious population* as the percentage of population who declared having no religion or having no religious affiliation. We considered no other municipal-level variable to be a confounder, but likely rather mediators (e.g. municipal violence or cannabis

availability). We did not consider individual or household-level variables, as they were not possibly parent variables of municipal variables, so could not meet the definition of a confounder.

Effect modification variables

We selected three variables to assess potential effect modification at the individual and household level: sex (female, male), age (12 to 19, 20 to 29, 30 to 39, 40 or older) and household head education (elementary or lower, middle school, high school, bachelor's degree or higher). In studies from high-income countries, sex and age have been previously reported in the literature as effect modifiers between individual-level socioeconomic variables and cannabis use; thus, we decided to assess these potential effect modifiers in Mexico, since they have not been previously studied in the country (Daniel et al., 2009; Knaappila et al., 2020; Legleye et al., 2012; Redonnet et al., 2012). We assessed household head education to evaluate if the area-level effect would be modified by an individual-level socioeconomic indicator. We used *household head education* instead of *individual education*, because for the younger age groups education is likely to be ongoing. We considered including household income as an effect modifier but discarded it because it has been previously reported to be highly biased in self-reported surveys in Mexico (Reyes et al., 2017).

Statistical analysis

We merged the variables of the Municipal Marginalization Index, 2015 intercensal survey and 2020 census datasets into the health surveys' data using a unique five-digit municipality identifier. We explored the data through descriptive statistics by tabulating, plotting histograms and estimating means, medians or percentages of all variables included in the analysis, for the entire survey samples and stratifying by cannabis

Table 1

Study sample characteristics, from Mexico's National Survey of Drugs, Alcohol and Tobacco Consumption 2016–17 and National Health and Nutrition Survey 2023.

Variable	Measurement	2016–17 (n = 56,562, N = 84,820,618)		2023 (n = 7743, N = 98,236,167)	
		Proportion/Median	95 % CI/IQR	Proportion/Median	95 % CI/IQR
<i>Outcome</i>					
Cannabis use in past year	Individual				
No		97.9	97.6, 98.1	97.5	96.9, 98
Yes		2.1	1.9, 2.4	2.5	2.0, 3.1
<i>Exposures</i>					
Education	Municipality	68.3	54.8, 74.5	75.4	63.6, 80.3
Income	Municipality	64.5	50.6, 71.5	34.5	23.2, 41.6
<i>Covariates</i>					
Sex	Individual				
Female		51.7	50.8, 52.6	51.9	50.5, 53.2
Male		48.3	47.4, 49.2	48.1	46.8, 49.5
Age	Individual				
12 to 19		22.6	22.0, 23.2	19.3	18.5, 20.2
20 to 29		23.7	23.0, 24.5	22.0	20.7, 23.4
30 to 39		18.5	17.9, 19.0	19.9	18.6, 21.2
40 or older		35.2	34.5, 36.0	38.8	37.4, 40.3
Household head education	Household				
Elementary or lower		33.8	32.7, 34.9	31.1	28.8, 33.5
Middle school		34.4	33.5, 35.4	31.3	29.0, 33.7
High school		18.7	17.9, 19.6	22.4	20.9, 23.9
Bachelor's degree or higher		13.0	12.2, 13.9	15.2	13.3, 17.2
Urban/rural stratum	Municipality				
Rural		32.3	30.8, 33.7	31.5	28.5, 34.6
Urban		67.7	66.3, 69.2	68.5	65.4, 71.5
Population aged 15 to 29	Municipality	25.8	24.7, 26.7	24.9	23.9, 26.0
Male to female ratio	Municipality	94.4	92.0, 97.0	94.9	92.8, 96.9
Indigenous population	Municipality	Not available		2.1	0.9, 4.5
Afrodescendent population	Municipality	Not available		1.8	1.2, 2.2
Non-religious population	Municipality	Not available		9.3	5.1, 14.9

Education=Proportion of people who completed middle school or higher. Income=Proportion of people with income twice the minimum wage or higher. Population aged 15 to 29=Percentage of municipal population 15 to 29 years of age. Male to female ratio= Division of the total number of men by the total number of women and multiplying it by 100. Indigenous population=Percentage of population who inhabit a home where an indigenous language is primarily spoken. Afrodescendent population=Percentage of population who identifies as afrodescendent. Non religious population=Percentage of population without religious affiliation.

use. Our proportion estimates were consistent with official reports, so we were certain that our variables were correctly constructed. No included continuous variable had a normal distribution, so we decided to present medians and interquartile ranges. In Table 1 we present prevalences, confidence intervals, medians and interquartile ranges of the selected variables accounting for the surveys' complex design.

We used Poisson models with robust variance to obtain prevalence ratios, which have been shown to be more interpretable and easier to communicate than odds ratios (Barros & Hirakata, 2003). We specified robust variance for the regression models, without survey weights to avoid losing statistical power, because the 2023 sample size was relatively small. To ensure the correct specification of the final models (two-level vs single-level model), we evaluated for clustering at municipal level by estimating the intraclass correlation coefficient, using the approach proposed by Austin, et al. for Poisson models (details in supplementary methods) (Austin et al., 2017). We observed no clustering at municipal level (ICC=0.000017 for 2016–17 and ICC=0.00024 for 2023), so we used single-level models. We fitted four single-level Poisson models adjusting for the previously listed confounders, one for each year and exposure. Since both exposure variables were continuous at the municipal level, we report prevalence ratios as a percent point increase in the prevalence of cannabis use for every percent point increase in the exposure. We then fitted twelve additional models (three for each year and exposure) to assess for effect modification by household head education, sex and age. We used the F-test of each category against the reference (woman, 10–19 years old, elementary school) for each variable to determine the presence of modification. We conducted all analyses with Stata 16 (StataCorp, 2019).

Results

Table 1 shows our description of the study sample. Sample size for 2016–17 was 56,562 (weighted N = 84,820,618), for 2023 it was 7,743 (weighted N = 98,236,167). For 2016–17 cannabis use in the past year was 2.1 % (95 % CI: 1.9, 2.4), for 2023 it was 2.5 % (95 % CI: 2.0, 3.1). For 2016–17, the municipal median of the proportion of people who completed middle school or higher in the sample was 68.3 % (IQR: 54.8 %, 74.5 %), and for 2023 the median was 75.4 % (IQR: 63.6 %, 80.3 %). For 2016–17, the municipal median of the proportion of people with income twice the minimum wage or higher in the sample was 64.5 % (IQR: 50.6 %, 71.5 %), and for 2023, it was 34.5 % (IQR: 23.2 %, 41.6 %). This decrease is in line with the report from the National Population Council and is due to a large increase in the established minimum wage (Villasana Ocampo et al., 2023).

In 2016–17, 51.7 % (95 % CI: 50.8, 52.6) of the sample were women; in 2023, they were 51.9 % (95 % CI: 50.5, 53.2). The proportion of household heads that had an education level of bachelor's degree or higher was 13.0 % (95 % CI: 12.2, 13.9) in 2016–17, and 15.2 % (95 % CI: 13.3, 17.2) in 2023. Around two thirds of the sample lived in urban municipalities in both surveys, 67.7 % (95 % CI: 66.3, 69.2) in 2016–17 and 68.5 % (95 % CI: 65.4, 71.5) in 2023. For most municipalities, one quarter of the population were people aged 15 to 29, median of 25.8 % (IQR: 24.7, 26.7) in 2016–17, and median of 24.9 % (IQR: 23.9, 26.0) in 2023.

Table 2 presents the results of the multivariate models to assess the association between socioeconomic conditions of the municipality and recreational cannabis use. For every unit increase in the proportion of people who completed middle school or higher in the municipality, we observed a 1.5 % increase in the prevalence of recreational cannabis use in 2016–17 (prevalence ratio=1.015, 95 %CI: 1.007, 1.022; $p < 0.001$), and a 2.9 % increase in 2023 (prevalence ratio=1.029 95 %CI: 1.006, 1.056; $p = 0.014$). For each unit increase in the proportion of people with income twice the minimum wage or higher in the municipality, we observed a 1.5 % increase in the prevalence of recreational cannabis use in 2016–17 (prevalence ratio= 1.015 95 %CI: 1.010, 1.021; $p < 0.001$), and a 1.8 % increase in 2023 (prevalence ratio=1.018 95 %CI: 1.003,

Table 2

Association of municipal education and income with recreational cannabis use, and its effect modification by sex, age and household-head education, Mexico, 2016–17 and 2023.

Variable	2016–17		2023	
	Prevalence ratio (95 % CI)	p value	Prevalence ratio (95 % CI)	p value
Municipal education	1.015 (1.007, 1.022)		1.029 (1.006, 1.053)	
<i>Effect modification</i>				
Sex				
Female	1.020 (1.008, 1.032)	Reference	1.039 (0.989, 1.091)	Reference
Male	1.012 (1.004, 1.020)	0.193	1.025 (1.002, 1.048)	0.568
Age				
12 to 19	1.007 (0.998, 1.017)	Reference	1.018 (0.975, 1.062)	Reference
20 to 29	1.030 (1.018, 1.042)	<0.001	1.037 (1.004, 1.070)	0.458
30 to 39	1.031 (1.014, 1.049)	0.008	1.029 (0.996, 1.062)	0.648
40 to 65	1.014 (0.999, 1.029)	0.449	1.028 (0.990, 1.068)	0.681
Household-head education				
Elementary or lower	1.019 (1.010, 1.029)	Reference	1.017 (0.987, 1.048)	Reference
Middle school	1.014 (1.003, 1.026)	0.47	1.046 (1.011, 1.083)	0.162
High school	1.006 (0.991, 1.021)	0.105	1.040 (1.000, 1.083)	0.316
Bachelor's degree or higher	1.014 (0.993, 1.036)	0.654	1.009 (0.959, 1.062)	0.806
Municipal income	1.015 (1.010, 1.021)		1.018 (1.003, 1.032)	
<i>Effect modification</i>				
Sex				
Female	1.021 (1.012, 1.030)	Reference	1.035 (1.009, 1.062)	Reference
Male	1.013 (1.007, 1.018)	0.081	1.013 (0.997, 1.028)	0.11
Age				
12 to 19	1.009 (1.002, 1.016)	Reference	0.984 (0.958, 1.010)	Reference
20 to 29	1.026 (1.017, 1.035)	0.001	1.036 (1.014, 1.059)	0.002
30 to 39	1.025 (1.013, 1.038)	0.017	1.012 (0.990, 1.035)	0.087
40 to 65	1.020 (1.008, 1.032)	0.114	1.022 (0.998, 1.047)	0.027
Household-head education				
Elementary or lower	1.019 (1.011, 1.026)	Reference	1.006 (0.985, 1.027)	Reference
Middle school	1.013 (1.005, 1.021)	0.205	1.021 (0.998, 1.044)	0.304
High school	1.010 (0.999, 1.022)	0.182	1.022 (0.995, 1.049)	0.321
Bachelor's degree or higher	1.023 (1.008, 1.038)	0.593	1.026 (0.995, 1.058)	0.279

2016–17 adjusted by municipal urban rural stratum, municipal young population, municipal male to female ratio. 2023 adjusted by municipal urban rural stratum, municipal young population, municipal male to female ratio, municipal indigenous population, municipal afrodescendent population, and municipal non-religious population. Municipal education=Proportion of people who completed middle school or higher. Municipal income=Proportion of people with income twice the minimum wage or higher. P-value=F-test for category against reference.

1.032; $p = 0.015$). We found that the effect of municipal income on cannabis use was higher for 20 to 29 year olds compared to 12 to 19 year olds in both 2016–17 and 2023, and similarly for municipal education in 2016–17. We found no other effect modification by sex, age or household head income in any exposure or year.

Discussion

In this study, we aimed to analyze the association between the municipal socioeconomic environment and recreational cannabis use in Mexico, including its effect modification by individual-level sex, age, and household-level education. We found that higher *municipal education* and higher *municipal income* were associated with higher recreational cannabis use. This association was higher for 20 to 29-year-olds compared to 12 to 19-year-olds and was not modified in other age groups, nor by sex or household-head education.

Literature on area-level socioeconomic indicators and cannabis use show variation in effects. Though our areas were larger, our findings are comparable to results from two 2002 studies in New York City, which showed that higher neighborhood education and income were associated with higher cannabis use among adults (Galea et al., 2007a,b). In contrast, a more recent (2015–19) study in Washington State found an association between neighborhoods with lower socioeconomic indicators and higher cannabis use among adolescents (Rhew et al., 2022). Multiple other US studies have found no association between area socioeconomic indicators and cannabis use (Ennett et al., 1997; Fagan et al., 2015; Ford & Beveridge, 2006; Kulis et al., 2007; Lo et al., 2006). In other countries results have also been inconclusive; a 2016 study in Oslo showed no association between a district-level socioeconomic indicator and cannabis use (Pedersen & Bakken, 2016). For other drugs (alcohol, tobacco and other illicit drugs), a systematic review of the effects of area-level socioeconomic indicators on substance use concluded that the magnitude and direction of the association changes by substance, geographic location, socioeconomic indicator used and studied area size (Karriker-Jaffe, 2011).

Our results can be understood through the lens of the diffusion of innovations theory. We observed higher cannabis use among those who lived in municipalities with higher education or income, constant across the 7-year window of 2016 to 2023. Though the point estimates for municipal education seemed to show a larger effect in 2023 than 2016–17, the confidence intervals were too wide for this to be a conclusive result (PR=1.015 95 %CI: 1.007, 1.022 and PR=1.029 95 %CI: 1.006, 1.053). There is evidence that tobacco use across the late 20th century diffused from high-income and high-education areas towards low-income and low-education areas in the US, England and Australia (Dwyer-Lindgren et al., 2014; Hiscock et al., 2012; Najman, 2006). The occurrence of this diffusion has been explained by mechanisms such as networks, perception, availability and customs which transfer from one area to another (Ferrence, 2001). This experience with tobacco could offer a possible explanation of why cannabis use is currently higher in advantaged municipalities in Mexico. Tobacco use diffusion from high to low socioeconomic areas became apparent only after historical trends accumulated, serving as a lesson for current cannabis monitoring. Though in the seven-year period we did not observe diffusion, as cannabis becomes normalized in Mexico, especially if recreational use moves towards a legal framework, efforts to monitor its use and impacts across socioeconomic areas should be actively conducted to enable effective timely public health response to help to avoid accentuation of health disparities.

The higher prevalence of recreational cannabis use in socioeconomically advantaged municipalities of Mexico is important for policy development and further research. Evidence from Latin America that points to possible reasons for the pattern include higher availability (Schleimer et al., 2019), reduced stigma (Rafei et al., 2023), inelastic prices (Donnan et al., 2022) and lower perceived harm risk (Camberos-Barraza et al., 2023). Future research should identify whether these reasons explain higher cannabis use among advantaged municipalities in Mexico to help inform policies that aim to reduce prevalence in affected areas as well as to prevent a shift towards disadvantaged areas. More granular data and/or quantitative-qualitative approaches are needed (Diez Roux, 2001), including the study of use frequency.

Our study has some limitations that must be mentioned. First, the cross-sectional design limits our ability to establish causal relationships between socioeconomic environment variables and recreational cannabis use, though it is unlikely that cannabis use causes people to move to advantaged municipalities. Secondly, our data are possibly subject to information bias, particularly due to stigma surrounding cannabis consumption (Bhattacharyya & Schoeler, 2013; Reid, 2020), which could also be greater for the National Health and Nutrition Survey, as it is a wider health survey, not with the sole objective of gathering drug use data. Though information bias due to stigma could be present, both surveys took measures to minimize it, using a self-administered questionnaire in 2016–17 and sensitivity training for survey administrators in 2023. We lacked data to assess the extent of this limitation, but think it warrants further research. We analyzed “use in past year” because “use in past month” and “use frequency” were measured differently across surveys and diffculted comparison, however they are important variables as they are more likely to be associated with negative health outcomes. To assess the extent of this limitation, we fitted a model for “use in past month” using the 2016–17 survey, in which the variable was measured, and found the same direction and magnitude of the associations (PR=1.019, 95 %CI: 1.012, 1.026; $p < 0.001$ for municipal education, and PR=1.015, 95 %CI: 1.005, 1.025; $p = 0.004$ for municipal income), so we expect the extent of this limitation to be minor. Furthermore, while we adjusted for confounding, residual confounding from variables of which the direction of the association might be debatable (e.g. municipal violence) or other unmeasured variables may still exist for both years, and we were not able to adjust for municipal indigenous population, municipal afrodescendent population, and municipal non-religious population in 2016–17 as that municipal-level data was not available from the 2015 intercensal survey; this could influence the magnitude of the observed associations, though we would not expect the association to disappear or change direction, as for 2023 that was not the case. We fitted the Poisson models using robust variance without survey weights. The use of weights when fitting regression models with complex surveys is a debated issue. Research suggests that use of survey weights inflates variance and reduces statistical power, especially for smaller sample sizes. The 2023 survey had a relatively small sample size, as it is a multiyear survey (2020–2024) with the goal of merging all years. However, drug use was only measured in 2023. Based on this context, applying weights on our analyses was considered to yield inefficient estimates (Bollen et al., 2016; West et al., 2018). While not an ecological study, it could be possible to incur in the ecological fallacy when interpreting our results (Diez Roux, 2002). It is important to emphasize that we studied the association of cannabis use with municipal-level income and education, not individual-level socioeconomic status. Additionally, our observed associations were not modified by household head education, our proxy for individual socioeconomic level.

Conclusion

Our study shows that recreational cannabis use in Mexico is currently higher in more socioeconomically advantaged municipalities. We did not observe any shift towards greater last year use among less developed municipalities over the seven-year period of observations, but this should be monitored closely to identify in a timely manner if diffusion starts to occur. Further research to understand modifiable causes of this association could help inform current and future public policies. Considering the dynamic political scenario, if a legal framework moves forward in the country, it should consider the differences in cannabis use across area-level income/education groups, through measures on supply such as price and availability, and demand such as construction of healthy environments and focused efforts on education and health promotion.

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CRediT authorship contribution statement

Andrés Sánchez-Pájaro: Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Carolina Pérez-Ferrer:** Writing – review & editing, Visualization, Supervision, Methodology. **David A. Barrera-Núñez:** Writing – review & editing, Methodology. **Magdalena Cerdá:** Writing – review & editing, Methodology. **James F. Thrasher:** Writing – review & editing, Methodology. **Tonatiuh Barrientos-Gutiérrez:** Writing – review & editing, Visualization, Supervision, Methodology, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.drugpo.2025.104704](https://doi.org/10.1016/j.drugpo.2025.104704).

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