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Trends in marijuana use in two Latin-American countries: an age, period, and cohort study

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Abstract

Background and Aims—Uruguay and Chile have the highest levels of marijuana use in Latin America and experienced consistent increases over the last 2 decades. We aim to calculate separate age-period-cohort (APC) effects for past-year marijuana use in Uruguay and Chile, which have similar epidemiologic and demographic profiles, but diverging paths in cannabis regulation.

Design—Age, period and cohort study in which period and cohort effects were estimated as first derivative deviations from their linear age trend, separately by country and gender.

Setting—Uruguay and Chile.

Participants—General population between 15 and 64 years of age.

Measurements—Past-year marijuana use from household surveys with five repeated cross-sections between 2001–2018 in Uruguay (median n=4,616) and 13 between 1994–2018 in Chile (median n=15,895).

Findings—Marijuana use prevalence in both countries peaked at 20–24 years of age and increased consistently across calendar years. Period effects were strong and positive, indicating that increases in use were evident across age groups. Relative to 2006 (reference year), Chilean period effects were about 48% lower in 1994 and about four times higher in 2018; in Uruguay, these effects were about 56% lower in 2001 and almost quadrupled in 2018. We observed non-linear cohort effects in Chile, and similar patterns in Uruguay for the overall sample and women.

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In both countries, marijuana use increased for cohorts born between the mid-1970s and early 1990s even in the context of rising period effects. Prevalence was consistently larger for men, but period increases were stronger in women.

Conclusions—Age-period-cohort effects on past-year marijuana use appear to have been similar in Chile and Uruguay, decreasing with age and increasing over time at heterogeneous growth rates depending on gender and cohort. Current levels of marijuana use, including age and gender disparities, seem to be associated with recent common historical events in these two countries.

Keywords

Age-period-cohort; marijuana; Chile; Uruguay

Introduction

Over the last decades, marijuana use, commercialization, distribution, and production have become a hotly debated issue around the globe, with several countries introducing changes in cannabis policy, law, and regulation (1). In 2013, Uruguay became the first country worldwide to fully regulate the legal marijuana market, including production, sales, and use. Uruguay's non-commercial model of legalization has three mutually exclusive ways in which to access marijuana: home cultivation, cannabis clubs, and pharmacies. The Uruguayan government maintains control over the commercial production and distribution of marijuana through pharmacies and regulates marijuana potency, sale amounts, and packaging (i.e., plain packaging with product information and warning labels) of marijuana (2).

Several other countries across the world have moved towards (or have *de facto*) less restrictive drug policies, decriminalizing possession, decriminalizing use, permitting use for medical reasons, or enacting a combination of these changes (3, 4). In the United States (U.S.), for example, 33 states and the District of Columbia (D.C.) passed laws allowing the use of marijuana for medical purposes, while 11 states and D.C. legalized recreational use. Canada implemented in 2019 a law that permits the use of marijuana for recreational purposes and allows provinces to define and implement specific regulations such as possession limits and minimum legal age (5). In Latin America, Chile has a system in which possession and use of "small" amounts of marijuana for "personal use" are decriminalized; medical use of cannabis is considered legal under special circumstances requiring prior authorization, though it operates mostly in a grey legal area through informal markets and home cultivation (6).

Parallel to changes in marijuana policy, inter-country prevalence of use over time reveals diverging trends, even within the Americas. While prevalence of use has remained fairly stable among U.S. high school students, it has increased consistently over the last two decades in countries like Uruguay and Chile, though the latter has not enacted major changes in cannabis regulation (7). Prevalence of use among Chilean adolescents remained steady for about a decade, with around 15% of adolescents between 13 and 18 reporting past-year marijuana use since standardized measures began in the early 2000's; however,

since 2011 this prevalence has more than doubled (8). Uruguay has experienced similar patterns though at lower levels of use (9).

Chile and Uruguay are two interesting case studies because today they have the highest marijuana prevalence in the region among adolescent and adult populations (7). Among the latter, Chile is the country with the highest prevalence of use in the past year with 14.5%, followed by Uruguay (9.3%), Argentina (7.8%), and Costa Rica (4.8%) (7). In addition, the two countries have similar profiles, with mostly urban populations (87% of the 18.1 million inhabitants in Chile, and 95% of the 3.5 million inhabitants in Uruguay live in urban areas (10)), similarly advanced demographic and epidemiological transitions (e.g., life expectancy at birth: 80 years in Chile and 78 years in Uruguay (11); 85% of deaths by non-communicable diseases in both countries(12)), and have a similar gross domestic product per capita (current international dollars: \$25,284 in Chile and \$23,531 in Uruguay) well above the average Latin American gross domestic product (13).

Disentangling age, period, and cohort (APC) effects in marijuana use in Uruguay and Chile can help us to begin understanding the drivers of increasing marijuana use in these two countries. Age effects in cannabis use refers to variation in the incidence and prevalence of use that varies across development; adolescence is a key risk period for the onset of first cannabis use, which tends to peak in young adulthood and decline thereafter (14). However, while these age effects are well documented (15), the overall prevalence of cannabis use rises and falls across historical periods, independent of variation across age. Period effects capture variation in prevalence that simultaneously affects all age groups, or variation that changes year to year in a whole population and can provide insights into specific historical and social factors that drove changes in marijuana use across these populations. Furthermore, some variation across time may also be attributable to cohort effects, or effects that refer to groups of individuals who were born in or around the same year and that share covariation in cannabis use prevalence. For example, the baby boom cohort in the US had higher prevalence of cannabis use during young adulthood, and retained a higher prevalence in middle and later adulthood compared to other generational cohorts (16, 17). If changes in cannabis policy, for example, influenced cannabis use among some age groups more than others, this variation over time would manifest as cohort effects. Available evidence regarding age-period-cohort effects in cannabis use have historically (18–20) found strong evidence for cohort effects that explain initiation and trends of use over time, and more recently, period effects that describe recent increases in use among adults (21, 22). To provide new insights to the substance use context in Latin America, we estimated and compared the age-period-cohort effects for past-year marijuana use in Uruguay and Chile, using methodologically comparable repeated cross-sectional surveys in the general population since 1994 to 2018.

Methods

Data and sample

We used 13 waves of secondary data for 238,206 individuals (overall median sample of 15,895) from the 1994–2018 National Drug Survey in the General Population in Chile (23) and five waves of data for 22,360 individuals (overall median sample of 4,616) from

Uruguay's 2001–2018 National Drug Surveys of the General Population (24). Both surveys are nationally representative of the urban population aged 15 to 64 and use a three-stage random sample stratified by region: the primary sample units are blocks, the secondary units are houses within blocks, and the tertiary units are individuals within houses selected using a Kish table (25). Face-to-face interviews lasted 30 to 45 minutes, with response rates ranging from 62% to 89% in Chile and from 72% to 93% in Uruguay. In the two countries, however, response rates have been declining at an annual rate of 1 to 1.5 percentage points. Survey's procedure, including the sample design, questionnaire, and coverage, remain for the most part unchanged in both countries. To our knowledge, the most important change was replacing (gradually in Chile) the paper-and-pencil questionnaire for a computer assisted interview in 2010 in Chile and 2016 in Uruguay; in both cases, interviews continued using a face-to-face format. As an example, in 2012 in Chile about 3/5 of the interviews were conducted using a tablet device and the rest using paper-and-pencil. In that survey, there were no differences in the prevalence of use of marijuana by mode of interview after adjusting for sex, age, SES, neighborhood quality and health status: paper-and-pencil = 5.5% (95%CI: 5.0, 6.0) vs. tablet = 5.2% (95%CI: 4.7, 5.6); $p=0.343$.

The research protocol for this article was reviewed by the University of California Davis's and the Columbia University Mailman School of Public Health's Institutional Review Board and was considered research that does not involve human subjects as defined by Department of Health and Human Services. The analysis of our article was not pre-registered; thus, the results should be considered exploratory.

Measures

Age (a) of respondents was self-reported at the interview date, period (p) was indicated by the survey calendar year, and birth cohort (c) was computed as the difference between period and age ($c = p - a$). Following methodological recommendations to avoid low counts and to gain precision in APC estimates (22), we recoded age and cohort in five-year groups, obtaining 10 ages and 66 cohort categories in Chile, and 10 ages and 33 cohort categories in Uruguay.

The outcome of interest was any past-year marijuana use, measured through similar questions across surveys. All participants were asked if they had ever used marijuana. If they reported lifetime use, they were subsequently asked if they had used marijuana within the past 12 months. We identified past-year marijuana users as the respondents who had self-identified as having used marijuana at least once in the past year. Missing responses to this item were low, with overall levels across all surveys of 0.46% in Chile and 0.03% in Uruguay. Other outcome measures were considered (i.e., past month use, number of days of use in the past month), though low number of respondents resulted in very imprecise APC estimates, particularly when stratifying by gender in Uruguay.

Statistical Analysis

We began by plotting the observed rates by age, period, and cohort. Next, we modeled past-year prevalence as a function of age, period, and cohort using Clayton and Shiffler's approach (26) which iteratively estimates models including linear age, linear 'drift' (a

combination of linear period and cohort effects), and non-linear deviations from drift that are uniquely attributable to period, and cohort effects. Best fitting model are selected by considering likelihood-based deviance fit statistics and penalizing additional degrees of freedom (27). This approach addresses the identification problem in age-period-cohort models (i.e., that a model of only linear effects is completely identified because cohort = period – age) by assessing the linear trend in period and cohort as their combined effect, and estimating the cohort effect and period effect as first derivative deviations from linearity, the variance for which can be uniquely attributed to period and cohort. In both countries we used 1970's birth cohort as the reference cohort and 2006 as the reference period as these were around the midpoint. Following prior APC research documenting gender differences on marijuana use (22), we ran country-specific models for the overall sample and stratified by gender.

The main analyses were conducted using `apc.fit` function in the Epi package (28) in R software version 3.6.1 (The R Foundation for Statistical Computing). We ran additional models using the weighted sample to account for unequal distribution of population strata in survey samples across years (because of changes in population structure and response rates). Also, to check for robustness of study findings to model specification, we conducted a sensitivity analysis that estimated cross-classified hierarchical age-period-cohort models in Stata 15 (StataCorp LLC), including age and age square to allow for non-linear effects, and adding period and cohorts as cross-classified second-level variables (29).

Results

During the study period, Chile's past-year prevalence increased from 3.6% in 1994 to 10.4% in 2018 (average annual increase of 0.27 percentage points), and in Uruguay from 1.4% in 2001 to 13.3% in 2018 (average annual increase of 0.70 percentage points). Figure 1 portrays cohort-specific past-year marijuana prevalence for individuals born between 1937–2003 in Uruguay and 1935–2003 in Chile. In both countries, the higher prevalence of marijuana use was found among younger cohorts (those born between 1990 to 1999) and between 20 and 29 years of age. Past-year use declined with age for Chilean cohorts born between 1955 and 1984, except for the oldest age groups for each cohort. In Uruguay, birth cohorts of respondents born between 1965 and 1974 exhibited a similar pattern, while cohorts born between 1980 and 1984 exhibited an inverted U-shape.

Figure 2 displays the results from the APC model. Age and period effects in Chile and Uruguay are very similar. Prevalence of use reaches its highest level between 15–19 in Chile and 20 and 24 years of age in Uruguay (about 9–10% in the total sample), and then declines in a quadratic form. Past-year marijuana use increases consistently across calendar years. In Chile, the period effect for the prevalence of use in 1994 (first survey) was about 48% (RR=0.52; 95%CI: 0.47, 0.58) lower than 2006 (reference year), while more recent estimates of the period effect were more than four times the period effect of that year (RR=4.41; 95%CI: 4.12, 4.73). In Uruguay, the period effect in 2001 (first survey) was about 56% (RR=0.44; 95%CI: 0.36, 0.53) lower than the period effect in 2006 (reference year), while estimates for 2018 increased by a factor of 3.97 (95%CI: 3.26, 4.84) compared to the reference year. We observed a non-linear cohort effect in Chile and similar patterns in

Uruguay, though for the latter, 95% confidence intervals largely included the null. In Chile, the cohort effect in marijuana use increased at a higher rate for cohorts born in 1970–1979, reaching its highest level for cohorts born in 1975 (RR=1.06; 95% CI=1.05, 1.07); while in Uruguay, the greatest increase in the cohort effect for marijuana use was observed for cohorts born in 1980–1990, reaching its highest level for cohorts born in 1988 (RR=1.16; 95% CI=0.98, 1.37).

The gender-stratified results in Figure 3 suggest that past-year marijuana use prevalence reaches its peak between 20 and 24 years of age (males: 19.95% in Chile and 8.79% in Uruguay; females: 4.15% in Uruguay), except for females in Chile, in which the highest prevalence (11.47%) was found in the younger age group (15 to 19 years of age). After those age groups, prevalence estimates decrease monotonically with age. Period and cohort effects were, relative to their gender-specific reference groups, stronger for females than males, meaning that, on average, observed period and cohort effects differentiated marijuana use more strongly for women, in the context of overall lower rates compared to males. Females in Chile experienced a small decline in the prevalence of use in latest period available (2018's survey).

Table 1 reports alternative APC model specifications. The best fitting model can be identified by a positive change in deviance relative to the adjacent row above. Age-period-cohort provided the best fit in Chile and Uruguay, though for Uruguayan females there was no significant improvement from an age-cohort to an age-period-cohort model.

Sensitivity Analysis

We did not observe meaningful difference between weighted and unweighted analysis using the `apc.fit` function. Likewise, we found consistent results using hierarchical age-period-cohort models with cross-classified random effects for birth cohort and period, though confidence intervals were narrower. Particularly for Uruguay, this means a clearer cohort effect, which reached its highest level between 1980 and 1990. Overall, the probability of past-year marijuana use decreased with age and increased with period in both countries. See supplementary material for full details on sensitivity results.

Discussion

In the present study we estimate the age, period, and cohort effect of past-year marijuana use in Uruguay and Chile, two similar South American countries in their epidemiologic and demographic profiles, but with diverging paths in regard to their national marijuana policies. Our study showed that men and women, both in Chile and Uruguay, have experienced similar age declines and period increases in the prevalence of marijuana use. A cohort effect with a risk function similar to an inverted U-shape, in which the highest risk ratio was observed in the cohorts born in late 1970's and early 1980's, was also evident in Chile. Uruguay experienced a similar cohort effect in the total sample and for women, but not for men.

The observed age declines were consistent with APC results by Miech et al., (17) Kerr et al. (22), and Piontek et al. (30) in the US and Germany, with prevalence peaking in late

adolescence or young adulthood and monotonically declining afterwards. These age effects have been reported across long age spans in general population surveys and support the idea of a common developmental pattern in substance use across countries (31), though more research is needed in non-western and low-income countries.

The period effect observed in Uruguay and Chile showed a clear upward pattern consistent with descriptive reports in both countries (23, 24). The observed period increases are also consistent with recent results by Chawla et al. using the U.S. National Survey on Drug Use and Health (NSDUH) data for past-month marijuana use in both males and females (21), though other APC studies in the U.S. (17) and Germany (30) suggest that period effects are negligible after accounting for age and cohort effects. The strong period effects in Chile and Uruguay may be partly due to global changes towards increasing liberalization of marijuana, including: the proliferation of marijuana grow shops, the high visibility of pro-cannabis advocate groups, and increasing perceptions of cannabinoids as having promising medical properties, among other changes (8, 32). In Uruguay, these changes could be operating in conjunction with the local implementation of a legalized cannabis market, though period increases are similar to those observed in Chile, where marijuana legal market has not been regulated (33). The extent to which increased liberalization of marijuana has influenced social norms, risk perception, public acceptance, access, and use of marijuana, and whether it had a differential impact across countries is still unknown and deserves further study.

Cohort effects showed similar patterns overall and for women across countries, as well as for men in Chile. In both countries, individuals born between the mid 1970's and the early 1990's experienced the largest cohort effects. Given the period increase, this means that the mid 1970's to early 1990's birth cohort experienced a faster growth in marijuana use than older and younger cohorts. From a sociological perspective, local political and economic shifts constitute a plausible hypothesis to explain part of these idiosyncratic cohort effects. Both countries endured violent coups in 1973 and were ruled by authoritarian military governments for more than a decade, until 1985 in Uruguay and 1990 in Chile. In both countries, most people born between 1970 and 1990 were exposed during early socialization processes to systematic political repression and human rights violations. Having been socialized in more restrictive environments, these cohorts may have been differentially impacted by the liberalization of marijuana and other social changes that followed the transition to democracy, increasing the likelihood of marijuana use as a way of expressing their newly acquired political and social freedom.

Overall, the intersection of cohort and period effects suggests that prior sociopolitical history seems to shape the response of different cohorts to the same social change. Future research should investigate the extent to which changes in drug policies, and in particular marijuana legalization, affect population groups in different ways, for example, maintaining or reducing disparities in health and social consequences of marijuana use, depending on the historical period the group has lived through prior to the policy change. In this sense, we believe that our understanding of the effects of ongoing cultural and policy changes on marijuana use requires looking at the present through traditional surveillance instruments (e.g., national surveys), but also going back in historical and life-course time by, for example, separating age, period and cohort effects.

Limitations

Our results should be interpreted in light of the following limitations. First, our results are of a descriptive and observational nature and are not meant to identify causality or evaluate the impact of changes in cannabis policy, law, and regulation. Second, the sample size and frequency of household surveys in Uruguay resulted in more imprecise estimates than in Chile, and this may have limited our ability to (potentially) identify cohort effects for Uruguayan women. Third, we do not know the extent to which self-reported use of marijuana may be biased, and if recent changes in marijuana policy and social norms may affect sample responses in the national drug surveys for the two countries. However, sensitivity analyses on response patterns have not shown a difference before versus after legalization in Uruguay, thus we believe this potential bias is negligible. Finally, prevalence of use is an outcome measure that may be insensitive to other population changes and differences in marijuana use. We restricted our study to past-year marijuana use mostly because other measures were not measured consistently across surveys or because sample size was not enough to have reasonably precise estimates.

Conclusions

We observed similar age, period, and cohort effects on past-year marijuana in Chile and Uruguay. Prevalence of use decreases with age and has increased over time, but period increases have been especially high among cohorts born between the late 1970's and 1980's. Although prevalence of use was consistently larger for men than women, increases in rates were especially fast among women. Overall, these findings are consistent with other APC studies looking at marijuana use, though cohort and to some extent period effects in Chile and Uruguay may be shaped by idiosyncratic factors. The impact of repressive socialization environments during the 1970s and 1980s in both countries and of recent changes in cannabis policy in Uruguay, comprise interesting research areas that should be explored in future studies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1: Marijuana use in the past year by age and cohort in (a) Chile (1994–2018) and (b) Uruguay (2001–2018).

Figure 2: Age-period-cohort effects on trends in past-year marijuana use in (1994–2018) and Uruguay (2001–2018)

The cohort and period are expressed as risk ratio for the effect of cohort (far left line) and period (far right line). Dashed lines indicate 95% confidence intervals. The cohort estimates were compared with a referent cohort of 1970. Those estimates can be interpreted as comparative change in the relative risk of past-year marijuana use associated specifically with cohorts, net of time period, compared with the average cohort effect in 1970. The period estimates were compared with a referent period of 2006. Those lines can be interpreted as the average proportion of the population in Chile and Uruguay that use

marijuana in the past year, regardless of cohort, compared with the average proportion in 2006.

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Figure 3: Age-period-cohort effects on trends in past-year marijuana use in (1994–2018) and Uruguay (2001–2018) among males and females

The cohort and period are expressed as risk ratio for the effect of cohort (far left line) and period (far right line). Dashed lines indicate 95% confidence intervals. The cohort estimates were compared with a referent cohort of 1970. Those estimates can be interpreted as comparative change in the relative risk of past-year marijuana use associated specifically with cohorts, net of time period, compared with the average cohort effect in 1970. The period estimates were compared with a referent period of 2006. Those lines can be interpreted as the average proportion of the population in Chile and Uruguay that use marijuana in the past year, regardless of cohort, compared with the average proportion in 2006.

Table 1:

Model Fit Statistics for Age-Period-Cohort Model of Marijuana Use in the Past Year of the General Population in Chile and Uruguay.^a

Chile	All			Males			Females		
	deviance	df	p-value	deviance	df	p-value	deviance	df	p-value
Age-drift	2291.0	1	<0.001	1501.8	1	<0.001	1012.9	1	<0.001
Age-Cohort	392.2	3	<0.001	235.4	3	<0.001	178.3	3	<0.001
Age-Period-Cohort	468.3	3	<0.001	285.8	3	<0.001	215.4	3	<0.001
Age-Period	-493.2	-3	<0.001	-311.9	-3	<0.001	-221.8	-3	<0.001
Age-drift	-367.2	-3	<0.001	-209.4	1	<0.001	-171.9	-3	<0.001
Uruguay									
Age-drift	397.9	1	<0.001	142.0	1	<0.001	126.0	1	<0.001
Age-Cohort	26.9	3	<0.001	14.2	3	0.003	11.1	3	0.011
Age-Period-Cohort	14.7	2	<0.001	8.4	2	0.015	2.5	2	0.283
Age-Period	-24.2	-3	<0.001	-11.2	-3	0.011	-10.2	-3	0.017
Age-drift	-17.4	-2	<0.001	-11.4	-2	0.003	-3.5	-2	0.175

^aEach model is compared with the one above (i.e., deviance model above – deviance model below) through the likelihood ratio test. df = change in degrees of freedom.