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Investigating how perceived risk and availability of marijuana relate to marijuana use among adolescents in Argentina, Chile, and Uruguay over time

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Abstract

Aims: Amid changing marijuana policies in the Southern Cone, we examined relationships between marijuana-related risk factors and marijuana use among adolescents in Argentina, Chile, and Uruguay from 2001–2016.

Methods: Using cross-sectional surveys from 8th, 10th, and 12th graders and weighted time-varying effect models, we estimated associations between perceived risk (no/low risk versus

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Conception and design: Schleimer, JP, Rivera-Aguirre, A, Castillo-Carniglia, A, Martins, SS, Cerdá, M. Led statistical analyses and manuscript writing: Schleimer, JP. Interpretation of results, critical revision of manuscript, and final approval of manuscript: Schleimer, JP, Rivera-Aguirre, A, Castillo-Carniglia, A, Laqueur, HS, Rudolph, KE, *Suárez*, H, Ramírez, J, Cadenas, N, Somoza, M, Brasesco, MV, Martins, SS, Cerdá, M. Statistical expertise: Castillo-Carniglia, A, Laqueur, HS, Rudolph, KE. Obtaining of funding: Cerdá, M. Collection and assembly of data: Schleimer, JP, Rivera-Aguirre, A, *Suárez*, H, Ramírez, J, Cadenas, N, Somoza, M, Brasesco, MV. All authors have approved the final article.

Conflict of Interest

No conflict declared.

moderate/great risk) and perceived availability (easy/very easy versus difficult/very difficult/not able to obtain) of marijuana, and any past-month marijuana use.

Results: In all countries, marijuana use increased over time and adolescents who perceived no/low risk and easy availability had higher odds of use. In Argentina, the bivariate risk/use association weakened from 2001 (OR=15.24, 95%CI=9.63, 24.12) to 2004 [OR=3.86 (2.72, 5.48)] and strengthened until 2011 [OR=8.22 (7.56, 10.30)]; the availability/use association strengthened from 2005 [OR=5.32 (4.05, 6.98)] to 2009 [OR=20.77 (15.57, 27.70)] and weakened until 2014 [OR=11.00 (9.11, 13.27)]. In Chile, the risk/use association weakened from 2001 [OR=7.22 (6.57, 7.95)] to 2015 [OR=5.58 (4.82, 6.48)]; the availability/use association weakened from 2001 [OR=5.92 (4.96, 7.06)] to 2015 [OR=4.10 (3.15, 5.34)]. In Uruguay, the risk/use association weakened from 2003 [OR=34.22 (22.76, 51.46)] to 2016 [OR=6.23 (4.96, 7.83)]; the availability/use association weakened from 2005 [OR=29.13 (13.39, 63.39) to 2007 [OR=9.42 (3.85, 23.07)], and strengthened until 2016 [OR=22.68 (12.03, 42.76)].

Conclusions: Overall, the association between risk and use weakened in all countries, suggesting risk perceptions became a weaker determinant of marijuana use. Perceived availability remained strongly associated with use and may become an increasingly important driver of use (particularly in Uruguay and Argentina).

Keywords

Marijuana; Adolescent; Perceived Risk; Perceived Availability; Time-Varying Effect Modeling

1. Introduction

Marijuana is the most widely used controlled substance in the world (WHO, 2017). In 2016, 192.2 million people (3.9% of the world's population) used marijuana (UNODC, 2018). Regular marijuana use, particularly initiated in adolescence, is associated with a range of adverse consequences, including poor cognitive (Meier, Caspi et al. 2012, Meruelo, Castro et al. 2017) and educational (Silins et al., 2015) outcomes, low self-reported life satisfaction (Fergusson and Boden, 2008), downward socioeconomic mobility (Cerdá et al., 2016), psychiatric illness (Carney et al., 2017; Charilaou et al., 2017), marijuana-involved injury (Asbridge et al., 2005), and substance use disorders (Charilaou et al., 2017; Stinson et al., 2006).

Perceived risk (Bachman et al., 1998; Danseco et al., 1999) and perceived availability of marijuana (Piontek et al., 2013; ter Bogt et al., 2006) have historically been important drivers of adolescent marijuana use, and often targets of interventions to prevent or reduce adolescents' use (Azofeifa et al., 2016). However, these relationships may be changing.

Most extant research on the changing associations between adolescent perceived risk, availability, and use of marijuana has been conducted in the United States (US), where 28 states and the District of Columbia (DC) have legalized medical marijuana since 2000, and 10 states and DC have legalized recreational marijuana since 2012 (ProCon.org, 2018a, b). In this context, more adolescents now perceive no/low risk of marijuana use, but the prevalence of marijuana use has not increased simultaneously (Sarvet et al., 2018). Research

on changes in the individual-level association between no/low perceived risk and use has been mixed. Some have found that the association weakened in recent years (Sarvet et al., 2018; Terry-McElrath et al., 2017), while others have reported that it strengthened or remained stable (Fleming et al., 2016; Miech et al., 2017; Terry-McElrath et al., 2017). Additionally, perceived easy availability of marijuana has largely declined among US adolescents (Azofeifa et al.,, 2016; Salas-Wright et al., 2017). Evidence suggests that the association between perceived availability and use of marijuana has remained strong and stable over time (Fleming et al., 2016). Understanding these relationships is particularly important in light of recent liberalization of marijuana access, as perceived risk and availability are two key mechanisms through which legalization could impact use.

In this study, we focus on the Southern Cone context (Chile, Uruguay, and Argentina) for two reasons. First the Southern Cone has recently experienced changes in marijuana regulation, which could impact perceived risk and availability. Second, trends in adolescent marijuana use and perceived availability are different from those in the US, which could suggest distinct relationships between perceived risk and availability and use of marijuana.

In 2013, Uruguay enacted a law providing the government full regulation over the large-scale production and sale of recreational marijuana. Adults in Uruguay can purchase marijuana at pharmacies, grow marijuana at home, or acquire it through a cannabis club (Cerdá and Kilmer, 2017). In Argentina, possession of marijuana for personal use continues to be illegal (Art 14. Law 23,737); however, a 2009 court judgment marked the beginning of a paradigm shift in the criminalization of marijuana since it raised a contradiction between Law 23,737 and Article 19 of the Constitution, which protects individuals' freedom from state regulation (Llovera and Scialla, 2017). In 2017, Argentina approved access to medical marijuana under specific circumstances (De Vito, 2017). In Chile, marijuana is decriminalized, a limited set of cannabis-based pharmaceutical products are available for medical use, and a new bill allowing other sources of access (e.g. home cultivation) and formulations (cannabis-based oils) is under debate (Corda and Fusero, 2016).

Since the early 2000's, past-month adolescent marijuana use has increased in Uruguay (Observatorio Uruguayo de Drogas, 2016), Chile (Observatorio Chileno de Drogas, 2016), and Argentina (Observatorio Argentino de Drogas, 2016). These trends are distinct from the US where marijuana use has remained stable (Miech et al.,, 2018), and from other South American countries where past-year use is less than 5% (Inter-American Drug Abuse Control Comission, 2015). Although perceived risk of marijuana use has decreased in both the Southern Cone and the US, perceived availability has increased in the Southern Cone, but decreased in the US (Azofeifa et al., 2016; Observatorio Argentino de Drogas, 2010; Observatorio Chileno de Drogas, 2016).

We know of no study that has assessed the individual-level relationships between adolescent perceived risk, availability, and use of marijuana in the context of the Southern Cone. Such research may inform the priority and scope of context-specific public health interventions to prevent adolescent marijuana use and help identify the drivers of use during these historical shifts. As more regions debate or enact policies to decriminalize or legalize marijuana use, the impetus for cross-country comparisons increases.

In this study, we used survey data from adolescents in Argentina, Chile, and Uruguay to 1) estimate associations between perceived availability and perceived risk of marijuana use and past-month marijuana use, and 2) describe how these associations changed over time.

2. Materials and Methods

2.1 Data Source

Individual-level data from adolescents enrolled in secondary education in Uruguay, Chile, and Argentina were obtained from the National Surveys on Drug Use Among Secondary School Students (Inter-American Drug Abuse Control Comission, 2015). These cross-sectional surveys, carried out every 2–3 years, collect information on substance use and related risk factors. The sampling design and survey instruments are similar to the Monitoring the Future Surveys (Miech et al., 2018) and were implemented comparably across countries. Surveys were self-report and administered confidentially in students' classrooms.

The sample included 8th, 10th, and 12th graders in schools classified as public, private, and other (in Chile other refers to subsidized private, and in Uruguay to technical public schools) in mostly urban areas. Net secondary school enrollment was 80–90% in Chile and Argentina over the last decade and increased from 67.6–82.8% from 2007 (earliest year available) to 2016 in Uruguay (The World Bank, 2018). The sample was selected via clustered, multi-stage random sampling from areas with 10,000+ and 30,000+ inhabitants in Uruguay and Chile, respectively, and schools with at least 20 students in the grades under study in Argentina. In Uruguay and Argentina, strata were types of school within urban areas of geographical regions in each country; primary sampling units were schools followed by classrooms. In Chile, strata were school type by grade within mostly urban areas and primary sampling units were classrooms. Individual-level survey weights were used. Recent school cooperation rates ranged from 76–86%. This study was determined not human subjects research by the University of California, Davis Institutional Review Board.

2.2. Study Population

We restricted the sample in two ways. First, we removed adolescents with poor quality data [i.e. those who responded "yes" to any past-month use of five or more illicit substances (including methamphetamines, heroin, and crack which are basically unavailable in these three countries), lifetime users of a fictional drug, and those with more than four inconsistencies in reporting age of initiation of use, past month, past year, and lifetime use of marijuana] based on criteria used in Uruguay before data entry. To maintain comparability, we removed observations in Chile (n=6,484; 2.58%) and Argentina (n=2,684; 0.66%) based on the same criteria. Second, we restricted the sample to the years our variables of interest were collected.

The total sample (N=700,178) ranged from 2001–2016 across surveys/countries, collected between 2001–2014 in Argentina, 2001–2015 in Chile, and 2001–2016 in Uruguay. For the analysis of perceived risk and marijuana use (herein risk/use), data were available for Argentina in 2001, 2005, 2007, 2009, and 2011 (n=293,433), for Chile in 2001, 2003, 2005,

2007, 2009, 2011, 2013, and 2015 (n=244,364), and for Uruguay in 2003, 2005, 2007, 2009, 2011, 2014, and 2016 (n=46,872) (Table 1). For the analysis of perceived availability and marijuana use (herein availability/use), data were available for Argentina in 2005, 2007, 2009, 2011, and 2014 (n=394,131), for Chile in 2001, 2003, 2005, 2007, 2009, 2011, 2013, and 2015 (n=244,364), and for Uruguay in 2005, 2007, 2009, 2011, 2014, and 2016 (n=41,525). Within each sample, we used multiple imputation for data missing due to nonresponse using fully conditional specification (mi impute in Stata version 15.1), which has been shown to reduce bias and improve precision compared to listwise deletion and other forms of imputation (van Buuren, 2007). We imputed separately by country and analytic sample (risk/use, availability/use), accounted for the complex sampling design by including design variables in the imputation models (Berglund, 2015; Rubin, 2004; StataCorp LP, 2013), and performed five imputations with auxiliary variables common across countries within each analytic sample. Auxiliary variables differed slightly between analytic samples because of differential variable availability across years/countries. The percent of missing data is reported in Table 1.

2.3. Measures

2.3.1. Exposures.—Perceived risk of regular marijuana use was measured by asking: “how much risk do you think people face by smoking marijuana frequently?” Responses were categorized into “no risk” or “low risk” versus “moderate risk” or “great risk” versus “don’t know”. Perceived availability of marijuana was measured by asking: “how easy or difficult would it be to obtain marijuana?” Responses were categorized into “it would be very easy” or “it would be easy” versus “it would be very difficult”, “it would be difficult”, or “would not be able to obtain” versus “don’t know”. To maintain proper sample design variance, the domain statement was used in all analyses to restrict the sample to those who did not report “don’t know”.

2.3.2. Outcome.—In Uruguay and Argentina, past-month marijuana use was measured by asking: “have you used marijuana within the last 30 days?”. Responses were “yes” versus “no”. In Chile, past-month use was measured with the question: “when was the last time you used marijuana?”; responses were “in the past 30 days”, “more than month but less than a year”, “more than a year”, and “never”. Past-month use was recorded as present for those who responded they last used marijuana in the past 30 days, and absent otherwise.

2.3.3. Covariates.—Covariates included grade, sex, past-year alcohol use, and past-year tobacco use. Alcohol and tobacco use were measured with the questions “have you had alcoholic beverages in the last 12 months?” and “have you smoked tobacco cigarettes in the past 12 months?”, respectively. Responses options for both were “yes” or “no”. We included alcohol and tobacco use because declining use in the US has been offered as an explanation for the absence of an increase in adolescent marijuana use amid decreasing risk perceptions. Specifically, it is hypothesized that, given the high prevalence of marijuana use among adolescents who use alcohol and tobacco, declines in alcohol and tobacco use may have caused an average decrease in the prevalence of marijuana use, even if within each group (alcohol and tobacco users and non-users), marijuana use has not declined (Fleming et al., 2016; Miech et al., 2017).

2.4. Statistical Analyses

Analyses were done in Stata 15.1 and SAS 9.4 and conducted separately per country. We used the svy suite in Stata for descriptive analyses and weighted time-varying effect modeling (TVEM) in the SAS macro %WeightedTVEM to estimate odds ratios (ORs) for past-month marijuana that vary smoothly over time, accounting for the complex survey design (Dziak, 2017). This method, made available in 2017 with the %WeightedTVEM macro, uses unpenalized B-splines to estimate coefficients and point-wise 95% confidence intervals (CIs) as continuous functions over time, thus relaxing parametric assumptions about how the relationships between perceived risk, availability and marijuana use vary over time, and allowing for non-linearity (Dziak et al., 2017; Lanza et al., 2014). TVEM has been used to assess historical trends in the US in associations between adolescent marijuana use and related attitudes (Lanza et al., 2016; Terry-McElrath et al., 2017). TVEM models were run on each imputed data set, and then estimates and standard errors were combined with the PROC MIANALYZE procedure in SAS.

For each country and analytic sample, we present bivariate TVEM results. Graphs are shown with consistent x-axes (i.e. years), but different y-axes (i.e. ORs) per country to aid interpretation.

2.4.1. Sensitivity Analyses.—Because of the small sample sizes given the relatively low prevalence of marijuana use, our ability to adjust for covariates was limited. When possible, we adjusted for grade and gender, alcohol use, and tobacco use. Additionally, in Chile, the only country with enough observations and overlapping years of data (i.e. years in which both questions were asked) to run TVEM models, we also included risk and availability simultaneously. For this analysis, we used a separate imputation model that included both variables in the same process. All covariates were time-varying. Finally, to better understand trends in the relationships between perceptions and use, we examined how the prevalence of marijuana use changed over time within each level of perceived risk and availability.

3. Results

3.1. Descriptive

Across countries and years, approximately 5–10% of adolescents reported past-month marijuana use, with greater prevalence in Chile followed by Uruguay (Table 1). Marijuana use generally increased over time (Figure 1), and there was a notable increase in use among Chilean adolescents from 2009–2013 (Castillo-Carniglia, 2015).

On average, approximately 7–25% of adolescents perceived no/low risk of regular marijuana use, with greater prevalence in Chile followed by Uruguay (Table 1). The proportion of adolescents who perceived marijuana to pose no/low risk increased over the study period despite year-to-year fluctuations (Figure 2). In Chile, there was a large increase in the proportion of adolescents who perceived no/low risk from 2011–2013, in addition to greater overall change (increasing from 8–12% in 2001 to 30–53% in 2015) and yearly variation,

compared to Argentina and Uruguay, where the prevalence increased to a lesser degree with less variation (Figure 2).

On average, one-third to one-half of adolescents perceived marijuana to be easily available, with greater prevalence in Uruguay followed by Chile (Table 1). Trends varied over time (Figure 3). In Argentina, perceived availability increased from 2005 to 2009–2011 (depending on grade) and then decreased or plateaued until 2014 (Figure 3A). In Chile, perceived availability of marijuana generally declined from 2001 to 2009–2011 and increased thereafter (Figure 3B). In Uruguay, perceived availability increased from 2005 to 2007–2009, plateaued or declined slightly until 2011, then increased until 2016 (Figure 3C).

3.2. TVEMs

3.2.1. Bivariate Risk/Use TVEMs.—Across countries, perceived risk of regular marijuana use was consistently associated with past-month marijuana use. In Chile and Uruguay, the magnitude of the association weakened over time; in Argentina, the association weakened and then strengthened again.

The bivariate low risk/use association in Argentina weakened from 2001 [OR=15.24 (9.63, 24.12)] to 2004 [OR=3.86 (2.72, 5.48)], and then strengthened again until 2011 [OR=8.22 (7.56, 10.30)] (Figure 4A). Thus, by 2011, those who perceived no/low risk had 8.22 times the odds of past-month marijuana use compared to those who perceived moderate/great risk. In Chile, the bivariate low risk/use association weakened from 2001 [OR=7.22 (6.57, 7.95)] to 2015 [OR=5.58 (4.82, 6.48)] (Figure 5A). In Uruguay, the bivariate low risk/use association weakened from 2003 [OR=34.22 (22.76, 51.46)] to 2006 [OR=7.69 (5.41, 10.94)], strengthened until 2010 [OR=13.06 (10.67, 16.00)], and weakened thereafter until 2016 [OR=6.23 (4.96, 7.83)] (Figure 6A).

3.2.2. Bivariate Availability/Use TVEMs.—Perceived availability was also consistently associated with higher odds of past-month marijuana use. However, the stability of the association varied across time and countries.

In Argentina, the bivariate availability/use association strengthened from 2005 [OR=5.32 (4.05, 6.98)] to 2009 [OR=20.77 (15.57, 27.70)], and weakened again until 2014 [OR=11.00 (9.11, 13.27)] (Figure 4A). In Chile, the bivariate availability/use association weakened from 2001 [OR=5.92 (4.96, 7.06)] to 2008 [OR=3.27 (2.91, 3.67)], strengthened until 2013 [OR=5.79 (4.76, 7.04)], and weakened until 2015 [OR=4.10 (3.15, 5.34)] (Figure 5A). In Uruguay, the bivariate availability/use association weakened from 2005 [OR=29.13 (13.39, 63.39)] to 2007 [OR=9.42 (3.85, 23.07)] and strengthened until 2016 [OR=22.68 (12.03, 42.76)] (Figure 6A). Wide CIs indicate that these estimates are not robust.

3.3. Sensitivity Analyses

3.3.1. Adjusted TVEMs.—Results remained strong, but attenuated, when adjusted for covariates (Figures 4B–C, 5B–D, 6B; Supplementary Figures 3–5)[1]. Notably, when

[1]Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:…

controlling for tobacco use (Figure 5B), alcohol use (Figure 5C), and perceived risk (Figure 5D) in Chile, the availability/use association became weaker over time.

3.3.2. Marijuana Use Within Levels of Perceived Risk and Perceived Availability of Marijuana.—

In all countries, despite year-to-year fluctuations, marijuana use generally increased overall within both levels of perceived risk (Supplementary Table 1A–C)*. Marijuana use increased consistently in Uruguay among those who perceived moderate/great risk during and after the legalization of the production and sale of marijuana (2011–2016), whereas use among those who perceived no/low risk mostly decreased from 2011–2014 before increasing again (Supplementary Table 1C)*. Across countries, marijuana use increased overall within both levels of perceived availability (Supplementary Table 2A–C)*.

4. Discussion

4.1. Risk/Use

Consistent with prior studies from South America and the US, our results indicate that the less risk an individual attributes to marijuana use, the more likely he/she is to use marijuana (Gaete and Araya, 2017; Galvan et al., 2016; Lopez-Quintero and Neumark, 2010; Pacek et al., 2015). However, in the Southern Cone countries, the overall magnitude of this association weakened, although it strengthened again most recently in Argentina. This suggests that risk perceptions became a weaker correlate of adolescent marijuana use over time.

There are several implications of these results. First, given the overall increase in the proportion of adolescents who perceive marijuana use to pose no/low risk of harm, marijuana use would have likely increased to a greater degree in the Southern Cone had the risk/use relationship not weakened. Second, factors other than risk perceptions, such as marijuana availability, may have played a greater role in the increase in adolescent marijuana use observed during our study period. This highlights the need to consider changes in multiple individual and environmental determinants of marijuana use. Third, there may be a cross-national weakening of the risk/use relationship. We found this trend in all Southern Cone countries, and some have identified the weakening of this relationship in the US as well (Sarvet et al., 2018; Terry-McElrath et al., 2017). This would suggest that risk perceptions may be, at least in part, shaped by broader societal norms that extend beyond local or national context. Increases in global information sharing via internet use, social media, and international news coverage may contribute to this trend (Roditis et al., 2016).

4.2. Availability/Use

Consistent with extant research in Europe (Pejnović Franelić et al., 2011; Piontek et al., 2013) and the US (Fleming et al., 2016; Martins et al., 2016), we found that adolescents who perceive marijuana to be easily available are more likely to use marijuana. However, the stability of this association varied over time and between countries. In Chile, the availability/use association weakened, and became increasingly similar to the risk/use association, both in magnitude and trajectory, when risk and availability were modeled

together. In contrast, the relationship between availability and use strengthened in Argentina and Uruguay, becoming stronger at times than the relationship between perceived risk and use in both countries. However, because we were not able to model both variables together in Argentina and Uruguay due to finite sample limitations, it is unclear how the associations relate to one another.

Variation in the relationship between perceived availability and use of marijuana over time and between countries may be explained by several factors. First, different trends in availability by country may explain differences in the contribution that perceived availability makes to marijuana use. In Chile, perceived availability generally declined from 2001 to the late 2000's and then increased until 2016, though at lower rates than use. Local context may affect such trends in perceptions of availability. For example, marijuana availability may depend on where individuals buy, grow, or use marijuana, neighborhood police presence and enforcement of laws, or norms about diversion of marijuana to youth (Friese and Grube, 2013; Harpin et al., 2018; Pacula et al., 2015). Second, alternative contributing causes of marijuana use may have arisen in Chile to a greater extent than in Uruguay and Argentina, displacing the contribution that perceived availability (and risk) make to marijuana use. Such factors may include changes in peer or family substance use (Lobato et al., 2017), changes in the illegal drug market (Horner et al., 2011), or social and cultural changes toward marijuana, influenced by strong lobbying for drug policy reform–particularly for cannabis–in a context of massive social movements among students (Castillo-Carniglia et al., 2017). While examination of such exposures was outside the scope of the current study, future research should examine whether the contribution of perceived availability and risk to marijuana use is moderated by other potential contributing causes in the local environment.

In Uruguay, the increase in perceived availability is not surprising, as the 2013 law created a concrete path to marijuana access for adults. Therefore, greater perceived availability in Uruguay likely corresponds to greater actual availability. For example, it is possible that a surplus of self-cultivated marijuana has tipped over into the streets. Second, even though minors cannot buy it, marijuana may seem more accessible because it sold to adults in pharmacies. Third, there may be increased exposure to marijuana use (e.g. visibility of consumption in public places) and contact with peers or family members who use marijuana, which could predictably result in a growing sense of availability.

Our findings provide several insights about the availability/use association. First, in this region, where marijuana regulation is becoming progressively liberal and where adolescent marijuana use is increasing, perceived availability may be an increasingly important driver of marijuana use trends (particularly in Argentina and Uruguay). Second, given the strengthening of the availability/use relationship in Argentina and Uruguay, and the high prevalence of perceived easy availability in all three countries, public health professionals in the Southern Cone may consider devoting additional resources towards regulating and intervening on the pathways by which adolescents gain access to marijuana. Relatedly, our findings raise questions about how perceptions of availability relate to real access to marijuana, including how adolescents most often obtain marijuana and whether modes of acquisition have changed over time. Lastly, future studies examining the effect of marijuana legalization on adolescent marijuana use should assess mediation by marijuana availability

as a potentially important locus of intervention, particularly as more governments are likely to adopt liberalized marijuana policies. Researchers should seek to better understand this association and its environmental determinants, including in South America with additional years of data, in other legalization contexts, and where perceived availability and marijuana use have not increased, such as the US.

5. Strengths and Limitations

The present study has several strengths. We used 1) a large, representative sample, 2) novel methods to analyze time-varying associations, and 3) comparable surveys among secondary school students across multiple years and countries. This is the first study to our knowledge to examine time-varying associations between adolescent risk factors for marijuana use and use of marijuana amid changing marijuana policies in the Southern Cone.

This study should also be considered in light of its limitations. First, cross-sectional data preclude assuming temporal relationships between risk factors and marijuana use. Although this was not a study of causal effects, potentially important confounders were not considered. Because of finite sample limitations, our ability to examine covariates (including modeling perceived risk and availability simultaneously) was restricted, particularly in Uruguay where the sample size was smallest. Relatedly, we were not able to model perceived risk and perceived availability together in Argentina, or include all countries in a single model because this would have restricted the analysis to only four years (2005, 2007, 2009, and 2011), resulting in insufficient coverage of the time axis for TVEM models (The Methodology Center, 2018). In light of these limitations, we modeled the relationships separately per country, utilizing all years of available data, and note that the strength of associations across countries and within Argentina and Uruguay (risk vs. availability) should be compared with caution. Additionally, these data are self-report, which may contribute to misclassification, for example by social desirability bias. However, methods of data collection and validation used aimed to minimize these biases (Brener et al., 2003). While these data are designed to be representative of secondary school students in urban areas, they are not generalizable to other populations. Lastly, although a strength of our study is that it compares secondary school-attending adolescents across countries, slight differences in student populations between Argentina (public, private), Uruguay (public, private, technical), and Chile (public, private, subsidized private) may have limited comparability.

6. Conclusions

Perceived risk and availability of marijuana are significant risk factors for adolescent marijuana use in the Southern Cone. However, amid the liberalization of marijuana policies, risk perceptions have become a weaker correlate of adolescent marijuana use. On the other hand, the strength of the relationship between perceived availability and use grew in Argentina and Uruguay, and may partly explain the increase in marijuana use in the region. Overall, our findings suggest interventions that limit adolescents' access to marijuana may be particularly effective.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Adolescent marijuana use increased amid liberalized marijuana regulation.
- Perceived risk became a weaker correlate of adolescent marijuana use.
- Perceived availability remained strongly associated with use.
- Marijuana availability may become an increasingly important driver of use.

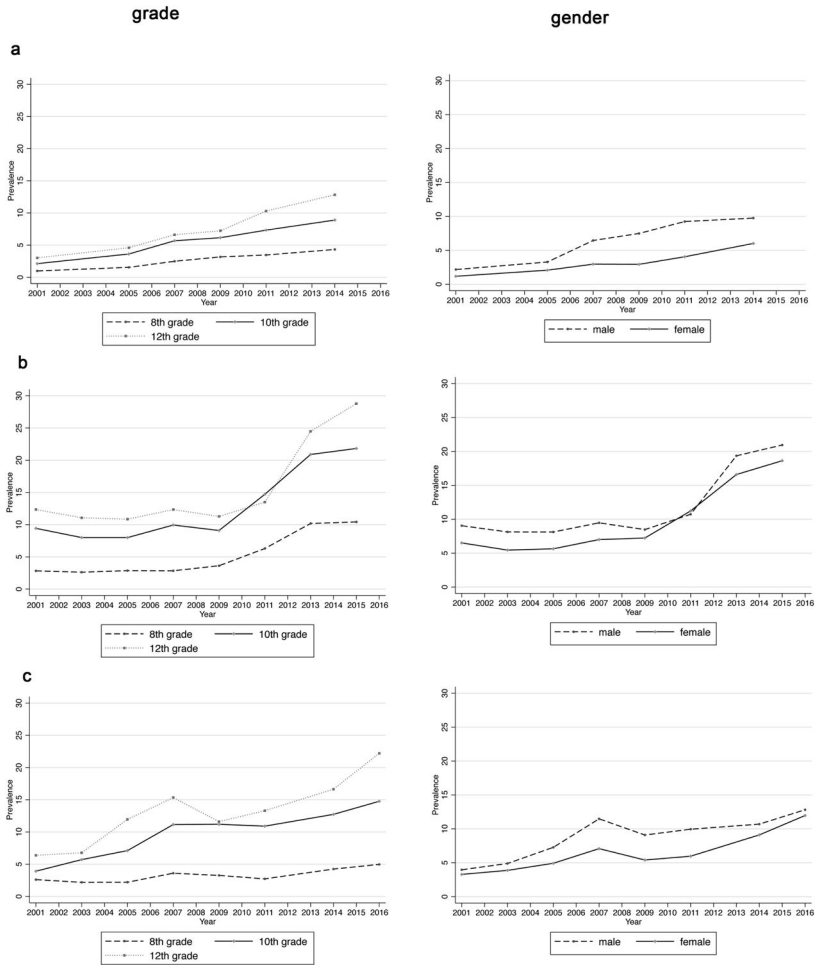

Figure 1.

Prevalence of past-month marijuana use by country, grade, sex

Note. A) Argentina; B) Chile; C) Uruguay.

Note. Results are weighted and imputed.

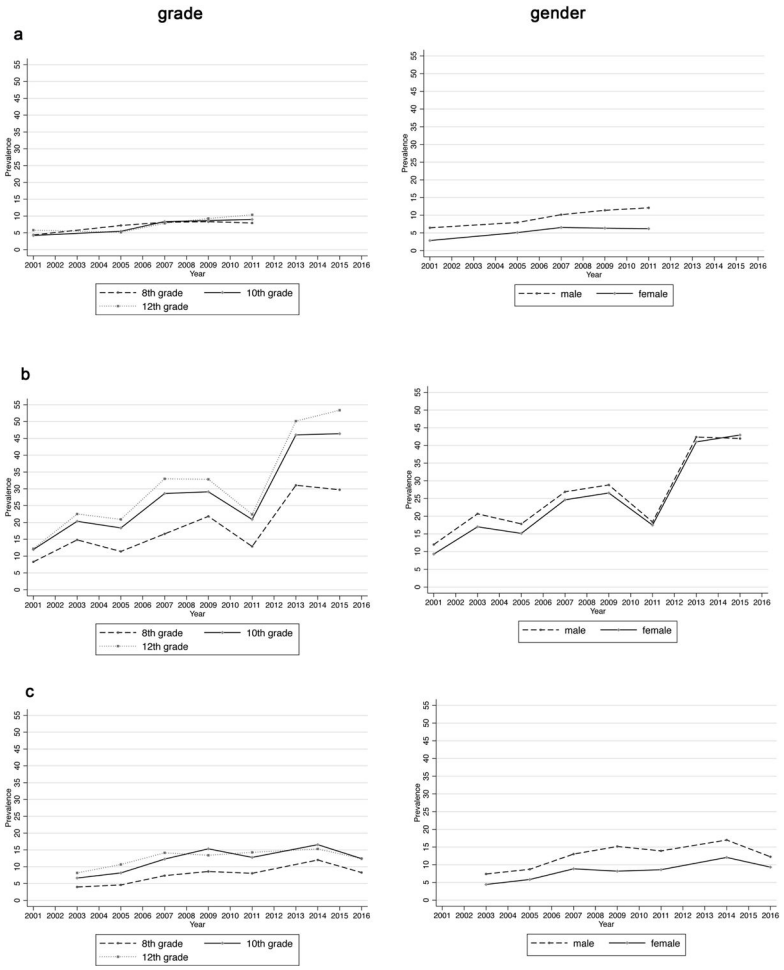

Figure 2.

Prevalence of no/low perceived risk of regular marijuana use by country, grade, and sex

Note. A) Argentina; B) Chile; C) Uruguay.

Note. Results are weighted and imputed.

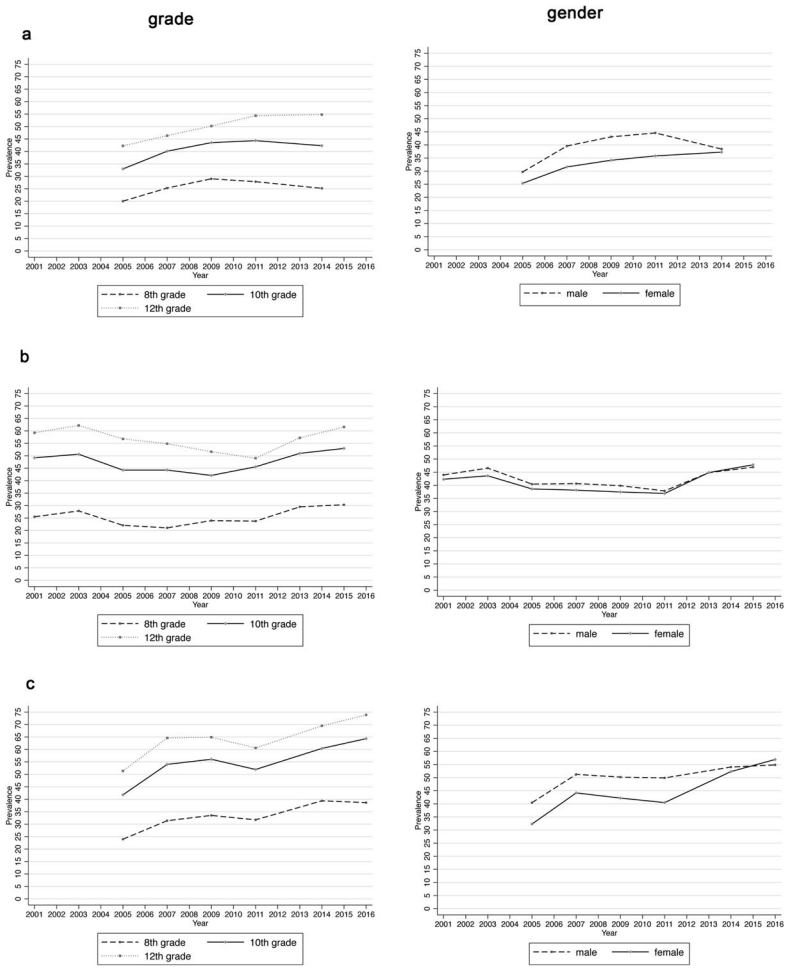

Figure 3.

Prevalence of perceived easy/very easy availability of marijuana by country, grade, and sex

Note. A) Argentina; B) Chile; C) Uruguay.

Note. Results are weighted and imputed.

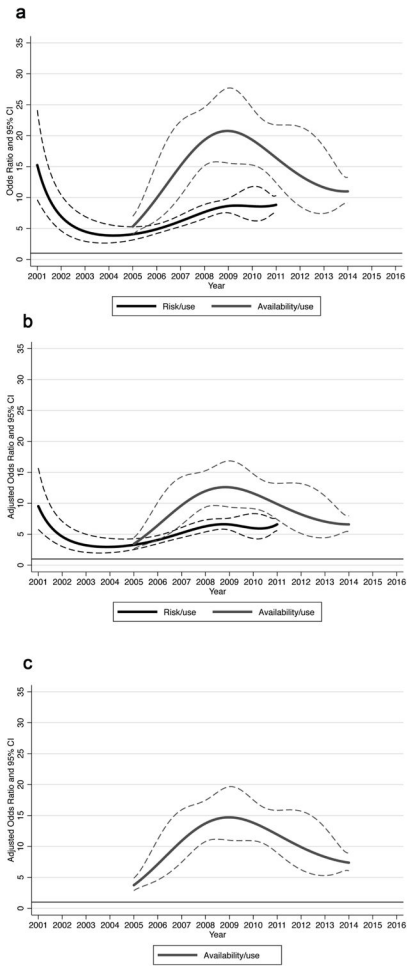

Figure 4.

Time-varying associations between risk/use and availability/use in Argentina

4A. Bivariate associations.

4B. Each association is adjusted separately for past-year tobacco use.

4C. Adjusted for past-year alcohol use.

Note. Results are weighted and imputed.

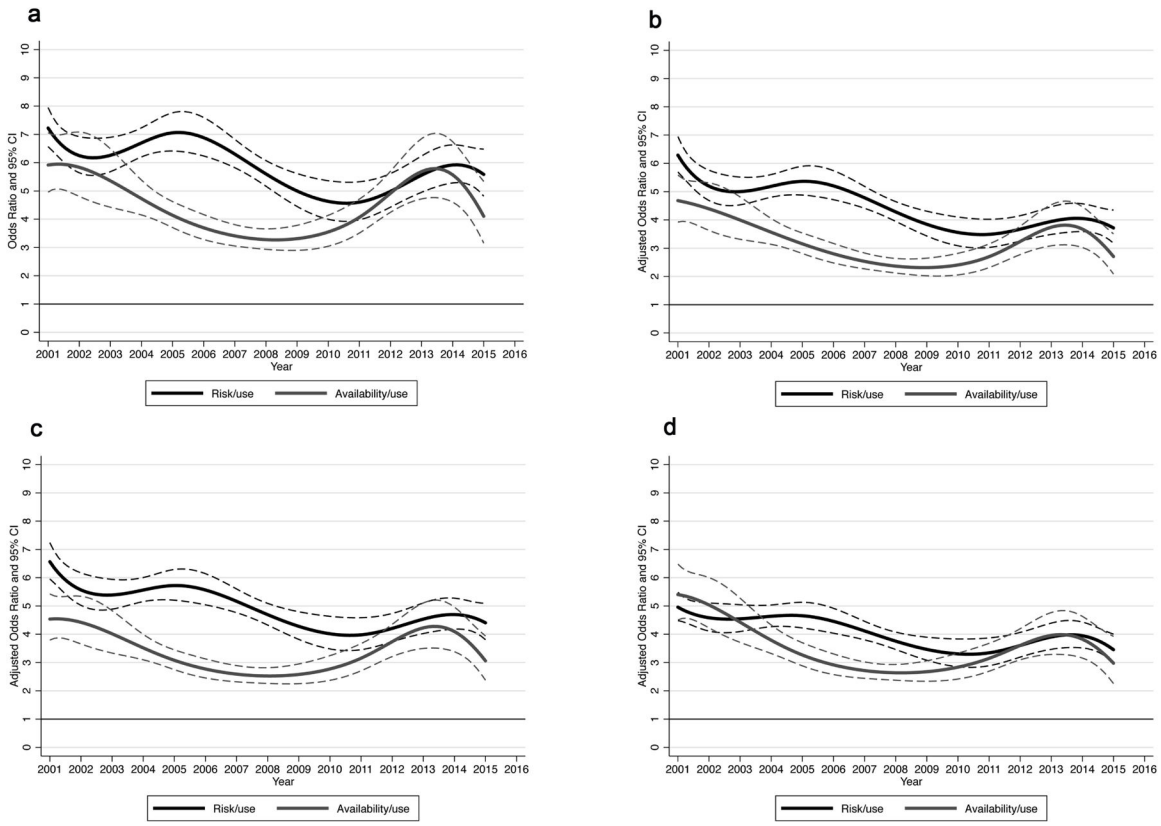

Figure 5.

Time-varying associations between risk/use and availability/use in Chile

5A. Bivariate associations.

5B. Each association is adjusted separately for past-year tobacco use.

5C. Each association is adjusted separately for past-year alcohol use.

5D. Model includes both perceived availability and perceived risk.

Note. Results are weighted and imputed.

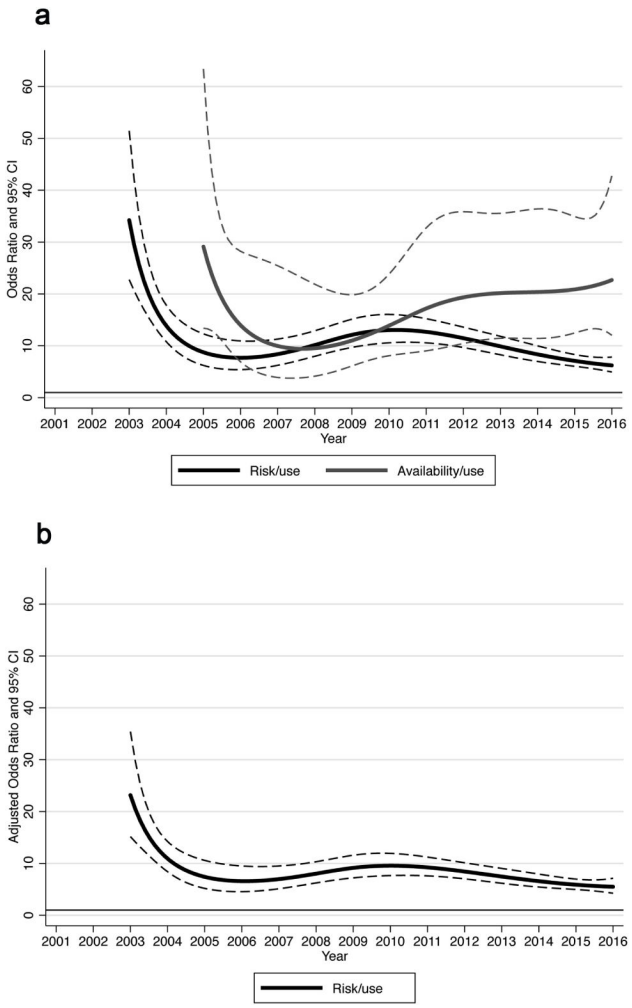

Figure 6.

Time-varying associations between risk/use and availability/use in Uruguay

6A. Bivariate associations.

6B. Adjusted for past-year tobacco use.

Note. Results are weighted and imputed.

Table 1.

Descriptive statistics, national secondary school student surveys on drugs: total sample [*], availability/use sample [**] (N=680,020), and risk/use sample [***] (N=584,669), in Chile (CL), Argentina (AR), and Uruguay (UY).

	Total*			Availability/Use**						Risk/Use***					
	CL	AR	UY	CL (n=244,364)		AR (n=394,131)		UY (n=41,525)		CL (n=244,364)		AR (n=293,433)		UY (n=46,872)	
	% (n)	% (n)	% (n)	% (n)	%+	% (n)	%+	% (n)	%+	% (n)	%+	% (n)	%+	% (n)	%+
Age															
<13	0.11 (272)	1.20 (4,842)	0.10 (53)	0.11 (272)	0.21	1.19 (4,678)	2.03	0.10 (42)	0.20	0.11 (272)	0.22	0.70 (2,043)	1.30	0.09 (44)	0.23
13–14	33.90 (82,834)	31.88 (129,183)	35.62 (18,041)	33.90 (82,834)	33.14	31.75 (125,153)	37.23	35.21 (14,621)	37.45	33.90 (82,834)	33.14	31.45 (92,281)	39.18	35.27 (16,530)	37.44
15–16	33.95 (82,957)	33.85 (137,144)	34.41 (17,426)	33.95 (82,957)	34.77	33.66 (132,679)	34.01	34.82 (14,461)	35.06	33.95 (82,957)	34.76	34.11 (100,079)	33.76	34.46 (16,152)	35.02
17–18	27.93 (68,260)	26.97 (109,261)	22.96 (11,627)	27.93 (68,260)	28.92	27.29 (107,545)	23.91	23.49 (9,755)	23.52	27.93 (68,260)	28.81	27.02 (79,285)	22.85	23.40 (10,970)	23.53
>18	2.88 (7,036)	3.31 (13,428)	4.47 (2,263)	2.88 (7,036)	2.96	3.32 (13,087)	2.82	4.28 (1,779)	3.76	2.88 (7,036)	2.97	3.57 (10,472)	2.90	4.45 (2,086)	3.79
Missing	1.23 (3,005)	2.79 (11,308)	2.44 (1,238)	1.23 (3,005)	----	2.79 (10,989)	----	2.09 (867)	----	1.23 (3,005)	----	3.16 (9,273)	----	2.33 (1,090)	----
Gender															
Male	48.94 (119,603)	45.55 (184,561)	45.38 (22,982)	48.94 (119,603)	49.20	45.50 (179,318)	46.22	45.58 (18,927)	46.46	48.94 (119,603)	49.19	44.85 (131,598)	45.54	45.43 (21,294)	46.44
Female	50.81 (124,163)	53.61 (217,194)	54.20 (27,452)	50.81 (124,163)	50.80	53.70 (211,648)	53.78	54.11 (22,468)	53.54	50.81 (124,163)	50.81	54.36 (159,518)	54.46	54.19 (25,400)	53.56
Missing	0.24 (598)	0.84 (3,411)	0.42 (214)	0.24 (598)	----	0.80 (3,165)	----	0.31 (130)	----	0.24 (598)	----	0.79 (2,317)	----	0.38 (178)	----
Grade															
8th	37.93 (92,697)	38.50 (155,976)	43.84 (22,206)	37.93 (92,697)	36.81	38.72 (152,613)	44.96	42.74 (17,749)	45.24	37.93 (92,697)	36.81	38.55 (113,124)	46.85	43.04 (20,173)	45.24
10th	35.40 (86,511)	34.73 (140,724)	35.48 (17,968)	35.40 (86,511)	35.82	34.59 (136,323)	32.76	36.02 (14,959)	34.50	35.40 (86,511)	35.82	35.05 (102,861)	31.72	35.86 (16,808)	34.50
12th	26.66 (65,156)	26.77 (108,466)	20.68 (10,474)	26.66 (65,156)	27.36	26.69 (105,195)	22.28	21.23 (8,817)	20.26	26.66 (65,156)	27.36	26.39 (77,448)	21.43	21.10 (9,891)	20.26
Missing	0.00	0.00	0.00	0.00	----	0.00	----	0.00	----	0.00	----	0.00	----	0.00	----

	Total*				Availability/Use**							Risk/Use***					
	CL	AR	UY		CL (n=244,364)		AR (n=394,131)		UY (n=41,525)			CL (n=244,364)		AR (n=293,433)		UY (n=46,872)	
	% (n)	% (n)	% (n)		% (n)	%+	% (n)	%+	% (n)	%+		% (n)	%+	% (n)	%+	% (n)	%+
Perceived Risk																	
No/low	23.73 (57,986)	7.48 (21,938)	9.99 (4,681)		----	----	----	----	----	----		23.73 (57,986)	25.29	7.48 (21,938)	7.80	9.99 (4,681)	11.68
Moderate/ great	63.25 (154,555)	83.60 (245,317)	83.80 (39,279)		----	----	----	----	----	----		63.25 (154,555)	63.75	83.60 (245,317)	87.18	83.80 (39,279)	84.90
Don't know	11.06 (27,033)	5.18 (15,214)	2.98 (1,398)		----	----	----	----	----	----		11.06 (27,033)	10.95	5.18 (15,214)	5.03	2.98 (1,398)	3.42
Missing	1.96 (4,790)	3.74 (10,964)	3.23 (1,514)		----	----	----	----	----	----		1.96 (4,790)	----	3.74 (10,964)	----	3.23 (1,514)	----
Perceived Availability																	
Easy	40.37 (98,640)	33.66 (132,659)	45.56 (18,917)		40.37 (98,640)	41.94	33.66 (132,659)	36.66	45.56 (18,917)	49.65		----	----	----	----	----	----
Difficult	20.45 (49,982)	24.38 (96,084)	17.54 (7,284)		20.45 (49,982)	20.30	24.38 (96,084)	25.59	17.54 (7,284)	17.60		----	----	----	----	----	----
Don't know	37.33 (91,219)	36.78 (144,966)	33.59 (13,950)		37.33 (91,219)	37.77	36.78 (144,966)	37.75	33.59 (13,950)	32.75		----	----	----	----	----	----
Missing	1.85 (4,523)	5.18 (20,422)	3.31 (1,374)		1.85 (4,523)	----	5.18 (20,422)	----	3.31 (1,374)	----		----	----	----	----	----	----
Past-month Marijuana Use																	
Yes	10.12 (24,726)	5.17 (20,967)	7.59 (3,842)		10.12 (24,726)	10.68	5.26 (20,741)	5.73	8.45 (3,508)	9.25		10.12 (24,726)	10.71	4.47 (13,105)	4.57	7.93 (3,718)	9.16
No	87.82 (214,601)	89.81 (363,862)	89.80 (45,484)		87.82 (214,601)	89.32	89.67 (353,436)	94.27	89.84 (37,307)	90.75		87.82 (214,601)	89.29	90.47 (265,482)	95.43	89.66 (42,026)	90.84
Missing	2.06 (5,037)	5.02 (20,337)	2.61 (1,322)		2.06 (5,037)	----	5.06 (19,954)	----	1.71 (710)	----		2.06 (5,037)	----	5.06 (14,846)	----	2.41 (1,128)	----
Past-year alcohol use																	
Yes	60.14 (146, 960)	58.76 (238,067)	68.52 (34,705)		60.14 (146,960)	61.23	58.58 (230,889)	60.41	68.36 (28,387)	69.65		60.14 (146,960)	61.33	60.06 (176,226)	61.84	68.61 (32,160)	69.67
No	37.58 (91,833)	36.98 (149,820)	29.36 (14,869)		37.58 (91,833)	38.66	37.11 (146,269)	39.60	29.31 (12,172)	30.35		37.58 (91,833)	38.67	36.35 (106,652)	38.16	29.20 (13,688)	30.33

	Total*				Availability/Use**							Risk/Use***					
	CL	AR	UY		CL (n=244,364)		AR (n=394,131)		UY (n=41,525)			CL (n=244,364)		AR (n=293,433)		UY (n=46,872)	
	% (n)	% (n)	% (n)		% (n)	%+	% (n)	%+	% (n)	%+		% (n)	%+	% (n)	%+	% (n)	%+
Missing	2.28 (5,571)	4.26 (17,279)	2.12 (1,074)		2.28 (5,571)	----	4.31 (16,973)	----	2.33 (966)	----		2.28 (5,571)	----	3.60 (10,555)	----	2.18 (1,024)	----
Past-year tobacco use																	
Yes	46.48 (113,581)	28.36 (114,911)	28.42 (14,392)		46.48 (113,581)	46.95	28.14 (110,919)	28.17	25.49 (10,584)	22.15		46.48 (113,581)	46.95	30.13 (88,425)	30.41	27.28 (12,785)	22.40
No	51.55 (125,968)	68.45 (277,319)	69.25 (35,073)		51.55 (125,968)	53.05	68.69 (270,719)	71.83	71.93 (29,870)	77.85		51.55 (125,968)	53.05	66.53 (195,210)	69.59	70.27 (32,937)	77.60
Missing	1.97 (4,815)	3.19 (12,936)	2.34 (1,183)		1.97 (4,815)	----	3.17 (12,493)	----	2.58 (1,071)	----		1.97 (4,815)	----	3.34 (9,798)	----	2.45 (1,150)	----

+ Percentages are weighted and imputed.

* Results are presented for each variable across all of the years that variable was available: in Chile, all variables reported in the table were available in all years (i.e. 2001, 2003, 2005, 2007, 2009, 2011, 2013, and 2015); in Argentina, all variables reported in the table were available in all years (i.e. 2001, 2005, 2007, 2009, 2011, and 2014), except “perceived risk” and “perceived availability”, which were available in years 2001, 2005, 2007, 2009, and 2011, and 2005, 2007, 2009, 2011, and 2014, respectively; in Uruguay all variables reported in the table were available in all years (i.e. 2001, 2003, 2005, 2007, 2009, 2011, 2014, and 2016), except “perceived risk” and “perceived availability”, which were available in years 2003, 2005, 2007, 2009, 2011, 2014, and 2016, and 2005, 2007, 2009, 2011, 2014, and 2016, respectively.

** The risk/use sample includes years 2001, 2005, 2007, 2009, and 2011 in Argentina; years 2001, 2003, 2005, 2007, 2009, 2011, 2013, and 2015 in Chile; and years 2003, 2005, 2007, 2009, 2011, 2014, and 2016 in Uruguay.

*** The availability/use sample includes years 2005, 2007, 2009, 2011, and 2014 in Argentina; years 2001, 2003, 2005, 2007, 2009, 2011, 2013, and 2015 in Chile; and years 2005, 2007, 2009, 2011, 2014, and 2016 in Uruguay.

Note. Dashes indicate not applicable.