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Longitudinal study of electronic cigarette use and outset of conventional cigarette smoking and marijuana use among Mexican adolescents*

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Abstract

Purpose—This study evaluated whether e-cigarette trials among adolescents in Mexico who had not previously smoked cigarettes or used marijuana increased the likelihood of trial and use of conventional cigarettes or marijuana use at follow-up.

Method—A school-based longitudinal survey was conducted in 60 public middle schools from the three largest cities in Mexico. Students (12–13 years old) were surveyed in 2015 and followed up 20 months later (n= 6,574). Generalized estimating equations models were used to evaluate the association between e-cigarette trial at baseline and conventional cigarettes smoking and marijuana use at follow-up.

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Contributors

PL conceived of the research, statistical analyses, and drafted and revised the manuscript. IB conceived of the research and revised the manuscript. PM, RM and JS assisted with data interpretation and critically revised the manuscript. JFT conceived of the research, assisted with data interpretation and critically revised the manuscript. All authors approved of the final manuscript before submission.

Conflict of Interest

No conflict declared

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Result—Our findings suggest that early adolescents who have tried e-cigarettes but not cigarettes, were more likely to try conventional cigarettes, 20 months later (43% vs. 24%, respectively; RR 1.41, 95% CI 1.18–1.70). We also found that dual trial of conventional cigarettes and e-cigarettes at baseline was associated with marijuana use at follow-up (20% vs. 4%, respectively; RR 2.67, 95% CI 1.78–4.02), whereas trial of only e-cigarettes was not independently associated.

Conclusions—Although the importation, distribution, and marketing of e-cigarettes have been banned in Mexico, adolescents who had tried e-cigarettes were more likely to have tried conventional cigarette and marijuana 20 months later. Policies and public health campaigns that promote information about the dangers and risk of e-cigarette use may be important to reduce adolescent use of e-cigarettes.

Keywords

Electronic cigarettes; Trial; Marijuana; Mexico; Adolescents

1. Introduction

Electronic nicotine delivery systems, also known as e-cigarettes, have rapidly increased in popularity, providing consumers with a nicotine delivery alternative to cigarettes. In many countries, these products are marketed through various media channels (i.e., radio, television, social media) as a safer, more fashionable alternative to conventional cigarettes and an effective method for quitting smoking (Kong et al., 2015). E-cigarette proponents view these devices as a safer alternative to tobacco smoke. At the same time, however, tobacco control advocates are concerned that e-cigarettes, which have become increasingly more popular among youth (Kong et al., 2015), may also serve as a “gateway” to cigarette smoking among relatively low-risk adolescents who would not have otherwise become cigarette users (Leventhal et al., 2015; Primack et al., 2015). In order to gauge the public health impact of e-cigarettes on public health, it will be important to assess the extent and consequences of e-cigarette use amongst youth who have not previously smoked combustible cigarettes. Furthermore, to assess the potential impact of different regulatory options, it is important to assess similarities and differences in patterns of e-cigarette use and transitions across countries whose policies contrast in permissiveness towards e-cigarettes, while also considering contrasting tobacco use patterns, tobacco control policies, and level of economic development.

Longitudinal studies in the US, where there are few e-cigarettes regulations, have consistently found that nonsmoker adolescents are more likely to transition to conventional cigarette use if they have experimented with e-cigarettes than if they have not (Leventhal et al., 2015; Primack et al., 2015; Soneji et al., 2017; Unger et al., 2016; Wills et al., 2016b; Wills et al., 2016c). Similarly, studies in the US have found that adolescents who use e-cigarettes are more likely to use marijuana (Unger et al., 2016; Wills et al., 2016a). Adolescent e-cigarette users in the US are often exposed to pro-vaping culture (i.e., vape shops, vaping websites, social media) that promotes opportunities to learn how to use and purchase vaping equipment (Budney et al., 2015a, b; Lee et al., 2016; Unger et al., 2016), which can be used to vaporize marijuana (Budney et al., 2015b; Morean et al., 2015). A

study among middle school students in Connecticut found that students were more likely to vaporize marijuana using e-cigarettes if they were lifetime e-cigarette users (Morean et al., 2015). Likewise, this study found that among students who had tried e-cigarettes, 18% vaporized marijuana using e-cigarettes (Morean et al., 2015).

To inform future e-cigarette regulations, it is important to evaluate whether these trajectories of substance use initiation differ across policy environments. The transition from e-cigarettes to conventional cigarettes and marijuana use has only been studied in the US (Leventhal et al., 2015; Primack et al., 2015; Unger et al., 2016; Wills et al., 2016b; Wills et al., 2016c) and to date, there are no studies that have evaluated these trajectories in Latin American countries. However, in 2015, 10% of early adolescents in Mexico (12.5 years old) had tried e-cigarettes, including 4% who had not tried conventional cigarettes (Thrasher et al., 2016). Although risk factors for e-cigarette initiation among Mexican youth were mostly the same as those for cigarettes, results suggested that e-cigarette recruit low- to medium-risk youth who may not have otherwise initiated nicotine product use (Thrasher et al., 2016), as has been found in the US (Wills et al., 2014).

The aim of this study was to evaluate if e-cigarette trial among Mexican youth who had not previously smoked cigarettes or used marijuana increased the likelihood of trial and use of conventional cigarettes or marijuana use at 20-month follow-up.

2. Methods

2.1 Study Population

A school-based, longitudinal survey was conducted in 60 public middle schools from the three largest cities in Mexico (Mexico City, Guadalajara, and Monterrey) that were selected using a stratified, multi-stage random sampling scheme. A detailed description of school selection has been published (Thrasher et al., 2016).

The baseline survey was administered in February and March 2015 among all first-year students in selected schools (i.e., usually 12–13 years old), with a response rate of 84% (Thrasher et al., 2016). A follow up survey was conducted in October and November 2016, with 57 schools and a total of 63% of students successfully followed up (n= 6,574). For both surveys, passive parental consent was used, with students providing active consent. Self-administered questionnaires were completed under the supervision of trained research staff unaffiliated with the schools. The protocol was approved by the IRB at the National Institute of Public health in Mexico.

The analytic sample for assessing trial and use of conventional cigarettes at follow-up consisted of participants (n=4695) who had not tried conventional cigarettes, cocaine, or marijuana at baseline (n=1748 users of these products excluded), who also had no missing data for key covariates at baseline (n=124 excluded) or for conventional cigarette use at follow-up (n=7 excluded). The analytic sample for marijuana use at follow up consisted of participants (n=5672) who had not experimented with marijuana or cocaine at baseline (n=699 excluded), and who had no missing data for key covariates at baseline (n=156 excluded) or for marijuana use at follow-up (n=47 excluded).

2.2 Measures

2.2.1 Dependent Variables (Assessed at Follow-Up)

2.2.1.1 Trial of Conventional Cigarettes: We measured conventional cigarette trial by asking participants: “Have you ever tried or experimented with cigarette smoking, even one or two puffs?” (yes/no) (Thrasher et al., 2016).

2.2.1.2 Conventional Cigarette Use: To measure current smoking, students were asked: “During the past 30 days, on how many days did you smoke cigarettes?”, with current smokers defined as those who reported smoking at least once.

2.2.1.3. Marijuana Users: Marijuana use was assessed by asking whether students had used marijuana in the past 12 months (yes/no).

2.2.2 Independent Variables (Assessed at Baseline)

2.2.2.1 Trial of E-Cigarettes: We measured trial by asking students: “Have you ever tried e-cigarettes?” (yes/no). (Thrasher et al., 2016). For some analyses, we combined this question and the question on trial of conventional cigarettes: 1= did not try either, 2=tried e-cigarette only, 3=tried conventional cigarettes only, and 4=tried both.

2.2.2.2 Covariates: Sociodemographic characteristics assessed included age, sex and parental education, which was defined as the highest level reported for either parent (i.e., primary, secondary, high school, university, unknown) (Leventhal et al., 2015; Primack et al., 2015; Unger et al., 2016; Wills et al., 2016b). Social network smoking behavior included: parent smoker (either vs. none), sibling smoker (any vs. none), smoking among close friends (any vs. none) (Leventhal et al., 2015; Primack et al., 2015; Wills et al., 2016b). Personal risk factors included a four-item scale of sensation seeking (i.e., “I like to do frightening things”; alpha= .80) (Primack et al., 2015; Wills et al., 2016b), previously validated for Mexican youth (Thrasher et al., 2009); trial of alcohol; binge drinking (more than 3 alcoholic beverages in the last 30 days) (Unger et al., 2016); trial of drugs (ever use of marijuana, cocaine) (Leventhal et al., 2015; Morello et al., 2016; Thrasher et al., 2016). Internet tobacco product advertising was queried with a general question that could capture either e-cigarette or conventional cigarette advertising (“When you are on the internet, how often do you see tobacco advertising?”). This was included because the internet is likely the primary mode to encounter e-cigarette information and marketing in countries where e-cigarettes are banned (Morello et al., 2016; Thrasher et al., 2016).

2.3 Statistical Analysis

We calculated descriptive statistics for all variables of interest in the analytical samples analyzed in this study (trial and use of conventional cigarettes and marijuana use). We used generalized estimating equations (GEE) with log-binomial models to account for the school-level nested structure of the data (Fleischer et al., 2014). Trial and current use of conventional cigarettes at follow-up was regressed on e-cigarette trial at baseline. GEE models regressed any marijuana use in the previous year at follow-up on different baseline categories of use for e-cigarettes and cigarettes (ref=never tried either; tried e-cigarettes

only; tried cigarettes only; dual trial of cigarettes and e-cigarettes). All data analyses were conducted with Stata version 14 (StataCorp, College Station, Texas).

3. Results

Selected characteristics are presented in Table 1. For both analytical samples studied (trial and use of conventional cigarettes and marijuana use), more than half of participants were 13 years or older and did not have parents, friends or siblings that smoked and had not tried alcohol. Moreover, less than 7% of the sample had tried e-cigarettes.

Non-smoking participants, who had tried e-cigarettes at baseline, were more likely than those who had not, to try conventional cigarettes (43% vs. 24%, respectively; RR 1.41, 95% CI 1.18–1.70; see Table 2) at follow-up. Compared to adolescents who had tried neither e-cigarettes nor conventional cigarettes, those who were dual triers of conventional cigarettes and e-cigarettes at baseline were more likely to have tried marijuana at follow-up (20% vs. 4%, respectively; RR 2.67, 95% CI 1.78–4.02; see Table 2).

4. Discussion

Consistent with prior studies (Leventhal et al., 2015; Primack et al., 2015; Wills et al., 2016b), our findings suggest that early adolescents, who have tried e-cigarettes but not cigarettes were more likely to try conventional cigarettes 20 months later. In this study, we did not find a significant association between trial of e-cigarettes at baseline and e-cigarette use at follow-up. A study in California, found that adolescents that used e-cigarettes (past month users) in 2014 were more likely to be current smokers (past month users), one year later (Unger et al., 2016). However, this study evaluated e-cigarette use and not e-cigarette trial, this may explain the differences with our study. These data are consistent with previous studies that raise concerns about the increase risk of conventional cigarette smoking among adolescents who experiment with e-cigarettes, as cigarettes are a more harmful and more efficient nicotine delivery device (Primack et al., 2015). Nevertheless, the association that we found was not particularly strong (ARR=1.40) compared to other studies in the US. Although, there are many differences between the US and Mexico which could contribute to this difference, a recent meta-analysis that examined smoking initiation, estimated a pooled adjusted odds ratio of 3.62 for the association between baseline ever e-cigarette use and subsequent cigarette smoking (Soneji et al., 2017). The contention that e-cigarettes are a gateway to other substance use has been met in some countries with data showing an overall population decline in youth's use of conventional cigarettes, with faster declines since the introduction of e-cigarettes (Ambrose et al., 2014). A key question for research going forward concerns quantifying how individual-level benefits and harms from e-cigarette use translate into overall public health impact (Levy et al., 2017).

This study also found dual trial of conventional cigarettes and e-cigarettes at baseline was associated with marijuana use at follow-up, whereas trial of only e-cigarettes was not independently associated. These findings contrast with Unger et al., who found that adolescent e-cigarette users in California were more likely to become past month marijuana users one year later (Unger et al., 2016). It is possible that exposure to pro-vaping culture

may increase opportunities for adolescents to learn about vaping equipment (Budney et al., 2015a, b; Lee et al., 2016; Unger et al., 2016), which can be used to vaporize marijuana (Budney et al., 2015b; Morean et al., 2015). Furthermore, vaporizing marijuana by using e-cigarettes may be a more attractive alternative of consumption among adolescents, as vaporization results in a less pungent odor compared to combustible means of smoking marijuana (Morean et al., 2015). In general, it is possible that Mexican adolescents are less likely to consume marijuana, compared to adolescents in California, where medical marijuana is legal and marijuana shops are somewhat commonplace (Unger et al., 2016). In other words, the relationship between e-cigarette use and marijuana use may be stronger in jurisdictions where policies and cultures are relatively liberal for both substances.

There are several study limitations that should be acknowledged. We had a representative sample of public schools but they were only from three urban cities; hence, the results may not generalize to the rest of Mexico (i.e., rural areas). However, these cities are the three largest in Mexico, and more than 75% of Mexicans live in urban areas. Thus, we expect results to be broadly representative. We were only able to evaluate trial of e-cigarettes at baseline and how it would influence a transition to conventional cigarettes. To better understand transitions to conventional cigarettes, it may be important to assess frequency and duration of e-cigarette use, as well as the influence of different types of e-cigarettes products used (i.e., nicotine strength, flavoring, device generation). To evaluate marijuana use at follow-up, we were limited to a question that asked past 12-month use of marijuana. A measure of past month use of marijuana may have provided a fuller picture of use. More detailed measurement and longer periods of follow-up would be useful in further assessing transitions between substances, polyuse, and the emergence of problematic substance use as this cohort ages.

Attrition bias may have influenced our results, as there were statistically significant differences between some potentially confounding variables (i.e., age, parental education, sensation seeking, parent smoking, sibling smoking, friend smoking, electronic devices and trial of e-cigarettes) among participants in our sample and those who were lost to follow-up. However, we conducted a sensitivity analysis to assess the potential bias from differential attrition using a propensity score analysis. The patterns of results for this sensitivity analysis were similar in direction, magnitude and statistical significance when compared to the results from our main analysis.

The findings in this study have several implications for health education and smoking prevention. Although, the importation, distribution and marketing of e-cigarettes have been banned in Mexico, because of the informal economy, e-cigarette users can easily obtain these devices. It is possible that most e-cigarettes imported into Mexico come from China, as China dominates the production of e-cigarettes and refill solutions around the world (Goniewicz et al., 2015). However, to the best of our knowledge there are no studies that have systematically examined where Mexican adolescents get their e-cigarettes. In this study we found that, adolescents who had tried e-cigarettes were more likely to have tried conventional cigarette and marijuana one year later. Policies and public health campaigns that promote information about the dangers and risk of e-cigarette use may be important to reduce adolescent use of e-cigarette and its sequelae; however, there are also concerns that such

campaigns could exaggerate the harms of e-cigarettes and discourage their use amongst conventional cigarette users, who are the group that is most likely to reap the immediate health benefits from e-cigarettes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Nothing declared

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Highlights

- Early adolescents, who have tried e-cigarettes, but not cigarettes, were more likely to try conventional cigarettes 20 months later.
- Dual trial of conventional cigarettes and e-cigarettes at baseline was associated with marijuana use at follow-up
- Trial of only e-cigarettes at baseline was not independently associated with marijuana use at follow-up

Table 1

Baseline characteristics for analytic samples of Mexican adolescents, 2015

Baseline Variable	Analytic Sample: trial and current use of conventional cigarettes at follow-up (n=4,695)	Analytic Sample: Marijuana use at follow-up (n=5,672)
Sex (%)		
Male	48	48
Female	52	52
Age		
11 to 12	33	35
13 or more	67	65
Parental education (%)		
Primary	16	17
Secondary	38	38
High school	19	18
University	19	18
Unknown	8	8
Sensation seeking (mean, SD)	2.67 (1.02)	2.74 (1.04)
Friend smoking (%)		
Yes	23	28
Parent smoking (%)		
Yes	36	39
Sibling smoking (%)		
Yes	10	12
Binge drinking (%)		
Yes	1	2
Tried alcohol (%)		
Yes	35	41
Online ads (%)		
Never	53	52
Sometimes	40	42
Always	7	7
E-cigarette trial (%)		
Yes	5	7
Tried smoking (%)		
Yes		17
Current smoking (%)		
Yes		1

Table 2

Association between e-cigarette trial in 2015 and subsequent trial and use of conventional cigarettes or marijuana in 2016, among Mexican adolescents

	Conventional cigarette trial at follow-up (n=4,695 ^a)			Conventional cigarette use in the past 30 days at follow-up (n=4,695 ^a)			Marijuana use in the past 12 months (n=5672 ^a)		
	(%)	RR 95% CI	ARR ^b 95% CI	(%)	RR 95% CI	ARR ^b 95% CI	(%)	RR 95% CI	ARR ^b 95% CI
Trial of e-cigarette									
No	24	1.00	1.00	5	1.00	1.00			
Yes	43	1.82 [1.54–2.14]	1.40 [1.22–1.60]	10	1.87 [1.25–2.78]	1.43 [0.94–2.16]			
Trial of e-cigarettes and/or conventional cigarettes									
Had not tried either							4	1.00	1.00
Tried e-cigarettes							8	1.93 [1.14–3.28]	1.42 [0.84–2.37]
Tried conventional cigarettes							13	3.11 [2.44–3.97]	2.05 [1.53–2.75]
Tried both							20	4.90 [3.47–6.92]	2.67 [1.78–4.02]

^a Analytic sample excluded those who had tried conventional cigarettes at baseline

^b Models were adjusted for: sex, age, parent SES, sensation seeking, friends that smoke, parents that smoke, siblings that smoke, tried alcohol, binge drinking and internet tobacco product advertising