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E-cigarette use frequency and motivations among current users in middle school

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ABSTRACT

Introduction: The popularity of electronic cigarettes (e-cigarettes) has increased worldwide among youth, even in countries like Mexico that ban them. This study aimed to assess the correlates of e-cigarette use frequency among Mexican students who currently use ecigarettes, as well as to describe their reasons for use.
Methods: Data were analyzed from a school-based survey of 57 public middle schools from the three largest cities in Mexico. Primary analyses were confined to those who used e-cigarettes in the prior 30 days. Censored binomial models for truncated distributions were estimated, regressing lifetime and past month frequency of use on participant sociodemographics, other substance use (smoking, alcohol, drugs), technophilia (appeal of new technologies), characteristics of e-cigarettes used, and family's and friends' use of nicotine products.
Results: Being male (APR = 1.93 95% CI 1.53–2.44), using drugs, (APR = 1.51 95% CI 1.03–2.20), higher technophilia (APR = 1.66 CI 1.21–2.29) and having a family member who uses e-cigarettes and cigarettes were associated with more frequent use in the last month. Students who preferred fruit and combined flavors had used e-cigarettes more often in their lifetime compared to students who preferred mint/menthol flavors.
Conclusions: Some risk factors for more frequent e-cigarette use among Mexican youth are similar to those foudn in other countries (having relatives who use ecigarettes, using drugs, and use of fruit flavors). Additionally, the novel measure of technophilia was positively associated with frequency of e-cigarette use. The appeal of flavors, in particular, suggests the importance of reducing youth access to flavored products to impede product initiation and progression.

1. Introduction

The popularity of electronic cigarettes (e-cigarettes) has increased rapidly among youth around the world, even in countries that ban them (Glasser et al., 2017; Thrasher et al., 2016; US Food and Drug Administration, 2016; Czoli et al., 2014; Adkison et al., 2013). E-cigarette use among youth is a potential public health concern as several studies suggest that it is a "gateway" to combustible cigarette smoking initiation, including among youth who are at relatively low risk for smoking (Lozano et al., 2017; Wills et al., 2017; Barrington-Trimis et al., 2016; Leventhal et al., 2015; Primack et al., 2015). On the other hand, results from national surveys suggest that the decrease in

smoking prevalence in recent years among US youth coincides with an increase in e-cigarette use, suggesting that e-cigarette use may be displacing cigarette use (Levy et al., 2018).

Studies of adolescents have focused primarily on the correlates of trial and current use of e-cigarettes (i.e., any use in the last 30 days); however, in low- and middle-income countries (LMICs), little is known about factors associated with e-cigarette use frequency and motivations for use among more regular users. The current study aimed to understand these factors among middle-school students in Mexico, where e-cigarettes are banned yet the prevalence of e-cigarette trial and current use among adolescents is high and similar to that for conventional cigarettes (Barrientos-Gutierrez et al., 2018; Zavala-Arciniega et al.,

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2018).

1.1. Frequency of E-Cigarette use

Correlates of e-cigarette use frequency have been evaluated almost exclusively in high-income countries (HICs). Cross-sectional studies among youth in the United States and South Korea have found that higher frequency of use in the last month was associated with combustible cigarette use (Lee et al., 2017; McCabe et al., 2017; Villanti et al., 2017; Warner, 2016; Neff et al., 2015). Frequency of use in the last month was also associated with impulsivity (Bold et al., 2017), receiving the first e-cigarette from a family member (Vogel et al., 2018), using a greater number of flavors (Morean et al., 2018), particularly sweet flavors (*e.g.*, fruit and dessert) or alcohol flavors, using a customizable e-cigarette device (Vogel et al., 2018), and using e-cigarettes with nicotine (Miech et al., 2017; Vogel et al., 2018). A longitudinal study of e-cigarette use frequency among high schoolers in California found that for every level of increase in baseline self-reported nicotine concentration in e-cigarettes used (*i.e.*, none, low, medium and high), there was an increase in e-cigarette use frequency at six month follow up (Goldenson et al., 2017). Finally, drug and alcohol use has been associated with more frequent e-cigarette use in the last year (Dunbar et al., 2017).

1.2. Motivations for E-Cigarette use

School-based studies in the US using nationally representative samples found that the primary motivations for e-cigarette use among middle schoolers were the availability of flavors (Tsai et al., 2018; Patrick et al., 2016), curiosity (Patrick et al., 2016), peer influence (Tsai et al., 2018), the belief that e-cigarettes are less harmful than combustible cigarettes (Tsai et al., 2018), and boredom (Patrick et al., 2016). A nationally representative survey of South Korean adolescents found that less frequent users of e-cigarettes (*i.e.*, less than 3 days a month) were more likely to report curiosity as the main reason for use, while the main reasons among more frequent users (*i.e.*, 10 or more days a month) were the desire to quit smoking and to use in places where smoking was prohibited (Lee et al., 2017).

1.3. Mexican context

The importation, distribution, sales, and marketing of e-cigarettes are banned in Mexico (Cámara de Diputados del H and Congreso de la Union, 2008). Nevertheless, a 2016 nationally representative survey found that 6.5% of Mexican adolescents (12–17 years) had tried e-cigarettes, 1.1% were current e-cigarette users, and being a current smoker was a strong correlate of e-cigarette use (E-cigarette use: Non-smokers 0.7%, Current smokers 9.1%) (Zavala-Arciniega et al., 2018). Furthermore, a cohort study of public middle school students in the three largest cities of Mexico (Guadalajara, Monterrey, Mexico City) found that 10% of first-year students had tried e-cigarettes at baseline (2015) (Thrasher et al., 2016), and, after 20 months of follow up, students who had tried e-cigarettes but not cigarettes at baseline were more likely to have tried combustible cigarettes than those who had not tried either product (Lozano et al., 2017). At follow up (2016), 19% had tried e-cigarettes and 12% had used e-cigarettes in the prior month, which was similar to the prevalence of current smoking (11%), with 8% exclusively using e-cigarettes (Barrientos-Gutierrez et al., 2018). Similar to studies in other countries, trial of e-cigarettes in Mexico was associated with higher sensation seeking, internet exposure to tobacco advertising, and having friends and parents who smoke combustible cigarettes or use e-cigarettes (Barrientos-Gutierrez et al., 2018; Thrasher et al., 2016). Also, previous Mexican studies show that adolescents with higher levels of technophilia a positive orientation toward new technologies, emphasizing the pleasures and positive emotions that accompany the adoption of new technologies (Ronit, 2011) were more

likely to have tried e-cigarettes (Barrientos-Gutierrez et al., 2018; Thrasher et al., 2016).

The current study aimed to examine the correlates of e-cigarette use frequency (last month and lifetime) among Mexican adolescents who used e-cigarettes in the prior 30 days and to describe their motivations for use. Based on the research reviewed above, we hypothesized that higher frequency of e-cigarette use would be associated with use of other substances (*i.e.*, smoking, alcohol use, drug use), using e-cigarettes with nicotine, having a preference for sweet e-cigarette flavors, and having family members and friends who use e-cigarettes. We also hypothesized that those who used e-cigarettes more frequently would be more likely to use them to avoid smoking cigarettes and to use e-cigarettes in smoke-free places. By contrast, we expected that students who use e-cigarettes less frequently would report curiosity as their main motivation for using e-cigarettes.

2. Methods

2.1. Study population

Data come from a school-based sample of 8718 students surveyed in the last year of middle school in 57 public middle schools that were randomly selected from the three largest cities in Mexico (Mexico City, Guadalajara, and Monterrey). A detailed description of school selection has been published elsewhere (Lozano et al., 2017; Thrasher et al., 2016). Passive parental consent was used, with students providing active assent. Students completed a self-administered, Spanish-language questionnaire developed from prior, validated surveys and pretested to ensure student comprehension (Thrasher et al., 2016). The survey was administered in October and November 2016. Study protocols were approved by the IRB at the Mexican National Institute of Public Health. Analyses were limited to those who reported using e-cigarettes in the prior 30 days, excluding students who had missing data for covariates (n = 66). In addition, for analysis of lifetime e-cigarette use, we excluded students who answered "don't know" to the question for lifetime e-cigarette use frequency (n = 119). Therefore, the lifetime e-cigarette use frequency analytic sample consisted of 832 students and the last month e-cigarette use frequency sample included 951 students.

2.2. Measures

Lifetime e-cigarette frequency use: Students who indicated they had used e-cigarettes in the last 30 days were asked how many times they had used e-cigarettes in their lifetime (1 time, even 1 or 2 puffs; 2–10 times, 11–20 times; 21–50 times; 51–99 times; 100 or more; don't know) (National Institutes of Health (NIH), 2014).

E-cigarette frequency of use in the last month: Students who indicated they had used e-cigarettes in the last 30 days were asked how many days they used e-cigarettes over that time (1–2 days/month; 3–5 days/month; 6–9 days/month; 10–19 days/month; 20–29 days/month; and 30 days) (Miech et al., 2018; Lee et al., 2017).

Motivations for e-cigarette use: Students who indicated they had used e-cigarettes in the last 30 days were asked to indicate whether they had ever used e-cigarettes for any of these following reasons: "curiosity", "to use in places where smoking is banning", "smoking fewer cigarettes", "to quit combustible cigarettes" and "others". Students could select all reasons that applied to them.

2.3. Independent variables

Use of cigarettes and other substances: Using standard questions, (International Agency for Research on Cancer. IARC, 2009) student use of combustible cigarettes was categorized into: never use; trial (tried smoking, but no smoking in the past 30 days); occasional smoking (smoked 1 to 2 days cigarettes in the last month); and regular smoking (smoked on 3 or more days cigarettes in the last month). Occasional and

regular smoking categories were derived from the median number of days that students smoked (18% occasional smokers and 17% regular smokers). Alcohol use was categorized as: never use; trial (tried alcohol, but no use in the past 30 days); current use (past 30 day use, but no binge drinking in this period); and current binge drinking (in a single drinking session, drank 3 or more alcoholic beverages for females or 4 or more for males in the past 30 days). (Siqueira and Smith, 2015). Drug use was queried by asking "Have you used marijuana in the 12 months" and "Have you used cocaine in the last 12 months?". Those who answered "yes" to either question were classified as drug users.

E-cigarette preferences: Students reported their favorite e-cigarette flavors (i.e., "never used flavors," "fruit," "mint," "tobacco," "combined," "others," "no favorite flavor"). Mint flavor was the reference category because only 3% selected tobacco flavor and because fruit flavor was identified in prior research as a risk factor for e-cigarette use frequency (Morean et al., 2018). Students reported ever using e-cigarettes with different ingredients (i.e.,with nicotine, without nicotine and with marijuana), with responses categorized as either with or without nicotine.

Psychosocial factors: We derived a four-level variable for nicotine product use among family members (i.e., no family member uses; only cigarette smokers; only users of e-cigarettes; users of both products) and five closest friends (i.e., no friends use; only users of e-cigarettes; only cigarette smokers; users of both products). We also assessed: the frequency of exposure to internet advertising for nicotine products in the last month ("no exposure," "combustible cigarette advertising," "e-cigarette advertising" and "both"); sensation seeking, using a scale which has been validated for Mexican youth in prior research (4-item brief sensation seeking scale, alpha = 0.80). (Stephenson et al., 2003); social acceptability of e-cigarettes ("In your opinion people disapprove or approve e-cigarette use by other people?", with responses re-coded to "disapprove", "neither approve nor disapprove", "approve", and "don´t know"); and technophilia (i.e., positive orientation toward new technology adoption), using a validated scale with questions about the number of electronic devices owned, frequency of internet activities, and the pleasure from learning new technologies, with scores divided into quartiles (Barrientos-Gutierrez et al., 2018).

Sociodemographic variables: Questions assessed sex (female, male) and household wealth, using the Family Affluence Scale (FAS) (Boyce et al., 2006), which sums responses to questions regarding household ownership of cars (0,1, 2 or more), the number of computers in the home (0, 1, 2 or more), the student having their own room (0 = no; 1 = yes), and the number of vacations taken in the past year (0, 1, 2, 3 or more).

2.4. Analysis

For analyses involving consumption frequency, we derived new variables for analyzing interval-censored count data with regression models based on truncated distributions because our data include censored responses (include 1–2, 3–5, 6–9, 10–19, 20–29, and 30 days to assesses frequency of e-cigarette use in the last month and the distribution of responses is truncated (not less than 1 and not greater than 30). Bivariate and adjusted censored truncated binomial regression models were estimated for each dependent variable (number of days using e-cigarettes in the last month; lifetime frequency of e-cigarette use), adjusting for school-level clustering of the data (57 middle schools). For the model of e-cigarette use frequency in the last month, sensitivity analyses were conducted using multinomial logistic regression using three response categories (0–2 days/month, 3–9 days/month and 10 days/month). Finally, the percentage of students who endorsed each reason for e-cigarette use was estimated. Then, the average frequency of past 30 days and lifetime e-cigarette use was estimated for those who endorsed each reason for use. To calculate this average, the median value for the range in each response option (i.e., "3–5 days/month" = 4) was assigned to students, and the average of these median

Table 1
Characteristics of the middle school students who currently use e-cigarettes.

Variables	E-cigarette frequency use in the last month (n = 951) %	Lifetime e-cigarette frequency use (n = 832)* %
Sex		
Female	48	49
Male	52	51
FAS (1-9) (mean ± SD)	4.47 (2.18)	4.44 (2.22)
Smoking status		
Never	32	34
Trial	31	31
Occasional smokers	18	19
Regular smokers (3 days or more in the last month)	17	16
Alcohol use		
Neither	11	12
Tried	25	25
Current	32	33
Binge	31	29
Drug use		
No	74	75
Yes	26	25
Technophilia Index (mean ± SD)[a]	0.004 (0.47)	−0.03 (0.47)
Sensation seeking (1-5) (mean ± SD)	4.11 (0.78)	4.10 (0.78)
Internet advertising		
Neither	35	36
Cigarettes	6	6
E-cigarette use	33	33
Both	25	25
Family use of nicotine products		
Neither	17	17
Cigarettes	59	60
E-cigarette use	2	3
Both	21	21
Friends use of nicotine products		
Neither	10	11
Cigarettes	18	19
E-cigarette use	12	12
Both	60	59
Societal approval		
Disapprove	22	22
Neither approve nor disapprove	37	37
Approve	19	19
Don´t know	23	22
Flavor e-cigarette		
Mint	15	16
Fruit	45	46
Tobacco	3	3
Combined	7	7
Do not have favorite flavor	18	17
Other	11	11
Type of liquids		
Liquids without nicotine	55	55
Liquids with nicotine	45	45

*This subsample excluded current users who reported that they did not know the number of lifetime vaping sessions.

[a] The mean of the technophilia measure was close to "zero" because the items were standardized to perform the factorial analyses.

values was calculated. All data were analyzed using Stata 15.

3. Results

About 35% of students who currently used e-cigarettes were current smokers (i.e., any smoking in the last 30 days), 30% had engaged in past month binge drinking, and 25% had used illegal drugs in the last year (see Table 1). Approximately 20% of these students had a family member who used e-cigarettes and cigarettes, and most (59%) only had

Table 2
Lifetime frequency of e-cigarette use among current e-cigarette users (n = 832)[a] among middle school students.

Mean number of e-cigarette sessions		PR	95% CL		APR	95% CL	
Sex							
Female	13.4	1.00			1.00		
Male	21.8	1.89***	1.36	2.62	2.46***	1.75	3.47
FAS (1-9) (mean ± SD)		1.16*	1.06	1.26	1.13*	1.03	1.24
Smoking status							
Never	12.7	1.00			1.00		
Trial	17.8	1.45*	1.00	2.10	1.16	0.74	1.82
Occasional smoker	18.1	1.41	0.90	2.20	1.16	0.66	2.03
Regular smoker (3 or more days)	27.5	2.65***	1.63	4.30	1.81*	1.03	3.19
Alcohol use							
Neither	10.2	1.00			1.00		
Tried	17.6	1.88	0.95	3.70	1.57	0.84	2.94
Current	15.3	1.55	0.81	2.93	1.14	0.60	2.17
Binge	23.4	2.71*	1.37	5.34	1.67	0.87	3.21
Drug use							
No	14.9	1.00			1.00		
Yes	27.6	2.49***	1.75	3.54	1.89**	1.25	2.86
Technophilia Index							
Quartile 1	13.2	1.00			1.00		
Quartile 2	16.8	1.30	0.83	2.05	1.19	0.75	1.91
Quartile 3	18.2	1.38	0.87	2.18	1.14	0.68	1.90
Quartile 4	22.7	1.91*	1.14	3.19	1.84*	1.06	3.19
Sensation seeking (1-5) (mean ± SD)		1.42**	1.11	1.82	1.31*	1.02	1.68
Internet advertising							
Neither	16.2	1.00			1.00		
Cigarettes	22.7	1.44	0.81	2.56	1.20	0.62	2.30
E-cigarette use	14.7	0.89	0.60	1.30	0.76	0.51	1.14
Both	22.7	1.47	0.99	2.17	1.17	0.72	1.90
Family use of nicotine products							
Neither	15.8	1.00			1.00		
Cigarettes	15.5	0.93	0.62	1.41	0.90	0.60	1.35
E-cigarettes	28.2	1.99	0.79	5.04	1.72	0.69	4.31
Both	24.2	1.67	0.96	2.93	1.59	0.91	2.79
Friends use of nicotine products							
Neither	11.4	1.00			1.00		
Cigarettes	15.0	1.49	0.74	2.98	1.13	0.58	2.21
E-cigarettes	18.0	178	0.92	3.47	1.84	0.98	3.45
Both	19.6	1.90*	1.06	3.42	1.37	0.74	2.51
Societal approval							
Disapprove	13.9	1.00			1.00		
Neither approve nor disapprove	18.6	1.37	0.87	2.16	1.28	0.75	2.21
Approve	21.7	1.71**	1.00	2.91	1.40	0.71	2.76
Don´t know	16.3	1.18	0.72	1.94	1.23	0.69	2.19
Flavor e-cigarette							
Mint	10.0	1.00			1.00		
Fruit	20.0	2.41**	1.33	4.39	1.90*	1.04	3.50
Tobacco	9.1	0.84	0.40	1.73	0.64	0.25	1.64
Combined	22.7	2.32***	1.50	3.58	1.70*	1.07	2.71
Do not have favorite flavor	14.2	1.68	0.81	3.47	1.49	0.74	3.01
Other	28.1	3.75***	1.96	7.18	3.12**	1.57	6.24
Type of liquids							
Liquids without nicotine	15.6	1.00			1.00		
Liquids with nicotine	20.1	1.36**	1.03	1.80	1.30	0.96	1.76

*p value = < 0.05, **p value = < 0.005, ***p value = < 0.001.
 [a] Analytic sample excluded those who indicated "don't know" to the question on lifetime frequency (n = 119).

family members who smoked. About 60% of these students had friends who used both e-cigarettes and cigarettes, and 19% reported that society approved of e-cigarettes. Almost half of the students preferred fruit flavored e-cigarettes.

Table 3
E-cigarette frequency of use in the last month among current e-cigarette users (n = 951) among middle school students.

Mean days of use in the last month		PR	95 CI		APR	95 CI	
Sex							
Female	4.4	1.00			1.00		
Male	7.3	1.74***	1.37	220	1.93**	1.53	2.44
FAS (1-9) (mean ± SD)		1.04	0.99	1.09	1.03	0.97	1.08
Smoking status							
Never	5.7	1.00			1.00		
Trial	5.5	0.95	0.75	1.21	0.82	0.63	1.07
Occasional smoker	4.7	0.79	0.56	1.11	0.59**	0.43	0.81
Current smoker	8.1	1.58*	1.19	2.11	1.07	0.75	1.52
Alcohol use							
Neither	5.6	1.00			1.00		
Tried	5.4	0.95	0.64	1.42	0.93	0.62	1.40
Current	5.0	0.86	0.57	1.31	0.85	0.55	1.32
Binge	7.3	1.39	0.95	2.03	1.29	0.83	2.01
Drug use							
No	5.2	1.00			1.00		
Yes	8.0	1.74***	1.35	2.24	1.51*	1.11	2.06
Technophilia Index							
Quartile 1	4.8	1.00			1.00		
Quartile 2	5.3	1.12	077	1.61	1.15	0.80	1.63
Quartile 3	6.0	1.32	0.95	1.84	1.32	0.93	1.88
Quartile 4	7.4	1.73**	1.23	2.2	1.69**	1.23	2.31
Sensation seeking (1-5) (mean ± SD)		1.13	0.97	1.32	1.07	0.93	1.24
Internet advertising							
Neither	5.6	1.00			1.00		
Cigarettes	6.8	1.29	0.77	2.16	1.14	0.72	1.82
E-cigarette use	5.7	1.04	0.78	1.38	0.96	0.72	1.28
Both	6.3	1.17	0.88	1.56	1.02	0.75	1.39
Family use of nicotine products							
Neither	4.9	1.00			1.00		
Cigarettes	5.5	1.15	0.82	1.61	1.10	0.76	1.58
E-cigarettes	8.2	1.91	0.84	4.32	1.58	0.81	3.11
Both	7.4	1.65*	1.13	2.40	1.51*	1.03	2.20
Friends use of nicotine products							
Neither	5.0	1.00			1.00		
Cigarettes	6.2	1.30	0.78	2.16	1.29	0.75	2.22
E-cigarettes	4.7	0.94	0.55	1.62	1.03	0.58	1.82
Both	6.2	1.30	0.84	2.02	1.29	0.81	2.06
Societal approval							
Disapprove	5.1	1.00			1.00		
Neither approve nor disapprove	5.6	1.12	0.79	1.58	1.08	0.74	1.56
Approve	7.5	1.60*	1.10	2.34	1.36	0.88	2.09
Don´t know	5.7	1.14	0.77	1.67	1.10	0.72	1.67
Flavor e-cigarette							
Mint	5.3	1.00			1.00		
Fruit	5.4	1.03	0.72	1.48	0.92	0.64	1.33
Tobacco	7.5	1.54	0.88	2.71	1.36	0.75	2.45
Combined	7.4	1.52	0.94	2.46	1.33	0.81	2.21
Do not have favorite flavor	5.8	1.11	0.72	1.71	1.07	0.70	1.63
Other	7.4	1.52	0.91	2.56	1.41	0.85	2.34
Type of liquids							
Liquids without nicotine	5.9	1.00			1.00		
Liquids with nicotine	5.9	1.09	0.91	1.32	1.00	0.81	1.23

*P value = < 0.05, **p value = < 0.005, ***p value = < 0.0021.

3.1. Lifetime frequency of E-Cigarette use

In adjusted models predicting frequency of lifetime e-cigarette use (see Table 2), being male (Adjusted Prevalence Ratio or APR = 2.46, 95% CI 1.75–3.47), being a regular smoker (APR = 1.81, 95% CI 1.03–3.19), higher family affluence (APR = 1.13, 95% CI 1.03–1.24), drug use in the last year (APR = 1.89, 95% CI 1.25–2.86), higher technophilia (APR$_{quartile4\ vs.\ quartile1}$ = 1.84, 95% CI 1.06–3.19) and, higher sensation seeking (APR = 1.31 95% CI 1.02–1.68) were

positively associated with lifetime frequency. Finally, compared to those who preferred mint e-cigarette flavors, preference for fruit flavors (APR$_{fruit\ flavor\ vs\ mint\ flavor}$ = 1.90 95% CI 1.04–3.50) and combined flavors (APR$_{combined\ flavors\ vs.\ mint\ flavor}$ = 1.70 95% CI 1.07–2.71) were associated with greater frequency of lifetime e-cigarette use.

3.2. Frequency of E-Cigarette use in the last month

In fully adjusted models (see Table 3), males used e-cigarettes more frequently than females in the last month (APR = 1.93, 95% CI 1.53–2.44), as did students whose family members used both e-cigarettes and cigarettes (APR = 1.51 95% CI 1.03–2.20). Use of drugs in the last year (APR = 1.51, 95% CI 1.11–2.06) and higher technophilia (APR$_{quartile4\ vs.\ quartile1}$ = 1.69, 95% CI 1.23–2.31) were also positively associated with a higher frequency of use. On the other hand, occasional smokers used e-cigarettes less frequently than never smokers (APR = 0.59 95% CI 0.43–0.81). Results from the multinomial model (sensitivity analyses, see Appendix 1) were generally in the same direction as the findings reported here.

3.3. Motivations for E-cigarette use

The most common reason for using e-cigarettes (Table 4) was curiosity (about 70.0%), with those who endorsed this reason using an average of 4.6 days in the prior month and 13.4 sessions in their lifetime. Fewer students reported using e-cigarettes: in places where cigarettes were banned (9.6%); to smoke fewer cigarettes (16.6%); and to quit smoking (7.5%). However, students who reported these reasons used e-cigarettes more frequently in the last month (9.5, 7.7 and 10.5 days, respectively) and over their lifetimes (28.3, 25.0, and 36.4 sessions, respectively) relative to those who were motivated by curiosity.

4. Discussion

The results from this study of Mexican middle schoolers were somewhat consistent with prior studies. Being a regular current smoker was unassociated with frequency of use in the last month, which is not consistent with previous studies (Lee et al., 2017; McCabe et al., 2017); still, it was associated with higher lifetime frequency of e-cigarette use, perhaps because lifetime use allowed for more meaningful variation in our relatively young sample. Surprisingly, occasional smokers used e-cigarette less frequently in the last month compared to never smokers. This may be because never smokers use e-cigarettes instead of that cigarettes that they would have smoked had e-cigarettes not been available. Indeed, the introduction of e-cigarettes into the US market appears associated with declining prevalence of cigarette use among youth (Levy et al., 2018). However, it is also possible that e-cigarettes use among never smokers could lead to experimenting with cigarettes or becoming a regular cigarette user in the future (Best et al., 2018; Conner et al., 2018; Wills et al., 2017). Nevertheless, the strength of the association between exclusive e-cigarette use and subsequent smoking is substantially weaker in Mexico than found in other countries (Lozano et al., 2017). To better examine this issue, studies are needed with

longer follow up and surveillance is needed of population-level trends in the prevalence of cigarette and e-cigarette use.

Compared to students who had not used drugs in the last year, those who used them also used e-cigarettes more frequently, whether assessed for the last month or in their lifetimes, which is consistent with prior research (Dunbar et al., 2017). By contrast with this research, however, alcohol use was unassociated with a higher frequency of e-cigarette use. These findings suggest that e-cigarette users in Mexico are a relatively heterogeneous group.

Unlike prior studies (Morean et al., 2018; Vogel et al., 2018; Goldenson et al., 2017), we did not find any associations between the use of e-cigarettes with nicotine and higher frequency of use (in the last month and lifetime). This may be because we only queried ever rather than current use of e-cigarettes with nicotine. It is also possible that study participants incorrectly identified the nicotine content of e-liquids they used, as many adolescents hold incorrect knowledge of e-cigarette ingredients (Buettner-Schmidt et al., 2016) and some e-cigarettes are incorrectly labeled as not containing nicotine when they do (Gorukanti et al., 2017). This phenomenon may be amplified in a country where e-cigarette packaging and labeling are unregulated precisely because their sales are illegal.

Students who preferred e-cigarettes with fruit flavors or combined flavors were more frequent lifetime, but not current, e-cigarette users than students who preferred mint flavors. Similarly, US adolescents who preferred a greater number of flavors and fruit flavors consumed e-cigarettes more frequently in the last month (Morean et al., 2018). Furthermore, 45% of current e-cigarette users in our sample preferred e-cigarettes with fruit flavors, which indicates that sweet flavors appeal to Mexican youth. This suggests the potential importance of regulations that restrict sweet e-cigarette flavors in order to reduce e-cigarette appeal among youth (Morean et al., 2018; US Food and Drug Administration, 2016).

Reporting higher levels of technophilia was associated with a higher frequency of e-cigarette use in the last month and in one's lifetime. This finding contrasts somewhat with previous studies in Mexico, in which stronger technophilia was associated with trial of e-cigarettes, but not with current use (Barrientos-Gutierrez et al., 2018; Thrasher et al., 2016). However, among current e-cigarette users, higher levels of technophilia appears associated with greater frequency of use, as would be predicted by the theory of technophilia (Barrientos-Gutierrez et al., 2018; Martínez-Córcoles et al., 2017; Emelin et al., 2013). Hence, this theory may best characterize initial trial and subsequent intensity of engagement with new electronic devices.

Having family members who used both e-cigarettes and cigarettes was associated with higher frequency of e-cigarette use in the last month. Having family members who use e-cigarettes may have provided access to e-cigarettes, especially since e-cigarette sales are banned in Mexico. Even in the US, where e-cigarettes are legal and widely available, receipt of one's first e-cigarette from a family member was associated with more frequent use (Vogel et al., 2018). Future longitudinal research should assess the independent effects of perceived peer, parental, and societal approval of e-cigarettes on e-cigarette frequency of use.

Table 4

Reasons for use* and frequency of use** among middle school students who currently use e-cigarettes.

	%	Days of e-cigarette use Mean (95% CI	Lifetime number of e-cigarette sessions[a] Mean (95% CI)
Curiosity	68.1	4.6 (4.1–5.2)	13.4 (10.2–15.4)
To use it in places where smoking is banned	9.6	9.5 (7.4–11.6)	28.3 (20.1–36.7)
To smoke fewer cigarettes	16.6	7.7 (6.3–9.1)	25.0 (19.6–30.6)
To quit smoking cigarettes	7.5	10.5 (8.0–12.9)	36.4 (27.0–45.9)
Other reasons	14.1	10.4 (8.5–12.2)	30.0 (22.6–30.0)

*students could choose all responses that applied.

**mean frequency of use was estimated by using the midpoint for each response option.

[a] Analytic sample excluded those who indicated "don't know" to the question on lifetime frequency (n = 119).

Consistent with some prior research (Morean et al., 2018), males were more likely than females to use e-cigarettes more often in the last month and over their lifetimes. By contrast, among adults who smoke in Mexico, females are more likely than males to use e-cigarettes (Zavala-Arciniega et al., 2018). Research is needed to better understand the reasons for gender differences in the patterns of e-cigarette consumption, including transitions between cigarettes and e-cigarettes and cohort effects around adoption and regular use of this new technology.

Consistent with previous studies (Lee et al., 2017; Patrick et al., 2016), curiosity was the most common reason for using e-cigarettes in our study. As expected, those who reported this reason used e-cigarettes less frequently than those who reported using e-cigarettes for other reasons (*i.e.*, to smoke in places where smoking is banned, to smoke less, to quit combustible cigarettes). It is important to note that relatively few students used an e-cigarette to help them quit smoking (7.5%). Further longitudinal research is sorely needed to more closely examine whether youth who would have otherwise become smokers are using e-cigarettes instead of cigarettes, as has been suggested by some recent research in the US (Levy et al., 2018).

This study has several limitations, including the cross-sectional nature of the data. Reverse causality could account for some of the results found for time-varying covariates, such as drug use. To help minimize this possibility, only variables with a theoretical or empirical justification were included in the models. Future studies are needed to evaluate these associations using longitudinal samples, where changes in the frequency of different product use and transitions between products can also be evaluated. Also, different time frames were used when querying illegal drugs (past 12 months) than alcohol and tobacco products (past 30 days). Ideally, all behaviors would be queried with the same time frame. However, adolescent use of illegal drugs is quite low in Mexico, including use in the last year (3.1%) (Villatoro-Velázquez et al., 2017). Given the young age of our middle school sample (average of 13 years old) and concerns about adequate sample size for meaningful analyses, we believe our approach is justifiable for the Mexican context. Additionally, students were asked about ever using e-cigarettes with nicotine instead of current use, which may be more relevant for understanding frequency of use and its consequences. Nevertheless, asking ever use of e-cigarettes with nicotine is meaningful among middle school adolescents like those in our sample, because this may signify progression to heavier use in the future.

Our measurement of the lifetime frequency of e-cigarette use may be biased; however, we aimed to reduce this potential bias by excluding from the analytic sample the students who indicated that they don´t know the number of their lifetime e-cigarette sessions. We also limited our analytic sample to current e-cigarette users, who may be more likely than past users to provide more reliable responses about lifetime use. Still, it is unclear how any recall bias may have influenced our results. Finally, the results are not generalizable to the Mexican population as the sample was only representative of public middle school students in the three largest cities in Mexico. However, three-quarters of Mexicans live in urban areas (CONAPO, 2014), most adolescents attend public school, and our large sample allows for inferences regarding the main urban settings in Mexico.

Despite these limitations, this study provides valuable insights because it is the first of its type in Latin America, and the only study we know of to examine this issue in a country that bans e-cigarettes. Also, this study uses a novel statistical approach which allowed us to maintain the variation in the original response options that would have otherwise been lost if we had collapsed response categories. Results from the models were qualitatively and quantitatively consistent with the multinomial models that we conducted as sensitivity analyses, although our approach allowed for greater parsimony because we modeled variation across all response options instead of comparing more than two dependent variable categories. Furthermore, we evaluated most previously studied risk factors for e-cigarette use frequency, so omitted variable bias is unlikely to seriously threaten our conclusions.

4.1. Conclusions

Overall, our study shows that some correlates for e-cigarette frequency use, both across one's lifetime and in the last month, are different among Mexican adolescents compared to youth in other countries. In particular, we found a novel association between higher technophilia and greater frequency of e-cigarette use, which should be subject to future studies, including different populations and countries. Also, the use of e-cigarettes with nicotine was unassociated with use frequency, which contrasts with prior studies (Vogel et al., 2018; Goldenson et al., 2017). On the other hand, some risk factors appear common with other studies (*i.e.*, being male (Morean et al., 2018); drug use (Dunbar et al., 2017); having a family member who uses e-cigarettes and cigarettes (Vogel et al., 2018)), and are likely to be important determinants across sociocultural and regulatory contexts.

Contributors

LZ wrote the draft, conducted the statistical analyses and revised the manuscript. PL and DSG assisted with the statistical analyses and revised the manuscript. JWH develops new commands in Stata that allowed to perform a novel statistical approach and revised the manuscript. JFT conceived the research and analysis plan, designed the study and provided important revisions to the manuscript. IB, EA, and CK provided a critical revision to the manuscript. All authors approved the final version of this manuscript

Declaration of Competing Interest

No conflict declared.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2019.107585.

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