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# E-Cigarette, Cannabis and Combustible Tobacco Use: Associations with Xerostomia Among California Adolescents

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## Abstract

**Objective:** Xerostomia (subjective experience of dry mouth), while less common in younger populations, can contribute to caries and oral discomfort. Use of e-cigarettes and cannabis among adolescents is increasing and may be a xerostomia risk factor. This study evaluates xerostomia prevalence in an adolescent population, overall and by e-cigarette, cannabis, and combustible tobacco use.

**Methods:** Cross-sectional analyses of 12-month follow-up data (N=976; collected 2020–2021) from a cohort of adolescents recruited from public high schools in Northern California (USA) compared self-reported past 30-day e-cigarette, cannabis, and other tobacco use and dry mouth (overall dry mouth experience; Shortened Xerostomia Inventory, SXI). Dry mouth experience (never, occasionally, frequently/always) was modeled using ordered logistic regression with school-level clustering and adjustment for gender, race/ethnicity, alcohol use, asthma, physical activity, and mutually for e-cigarette, cannabis, and tobacco use.

**Results:** Past 30-day use prevalence was 12% for e-cigarettes, 16% for cannabis, and 3% for combustible tobacco. Occasional dry mouth experience (54%) was more common than frequent/always experience (5%). Frequent/always dry mouth was more prevalent among frequent (>5 days/month) e-cigarette (14%) and cannabis (19%) users and combustible tobacco users (19%) than non-users of those respective products (all comparisons $P<0.001$). In covariable adjusted models, frequent e-cigarette use was no longer significantly associated with dry mouth experience (OR: 1.40; 95% CI: 0.69, 2.84), while frequent cannabis use (OR: 3.17; 95% CI: 1.47, 6.82) and combustible tobacco use (OR: 1.92; 95% CI: 1.38, 2.68) were associated with greater odds of reporting more frequent dry mouth. Findings were qualitatively similar using the SXI.

**Conclusions:** In this study, xerostomia was not independently associated with e-cigarette use but was one potential health concern of adolescent cannabis and combustible tobacco use.

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**Author Contributions**:

BWC: Conceptualization, Methodology, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Supervision, Funding acquisition. BHF: Conceptualization, Investigation, Writing - Review & Editing, Supervision, Funding acquisition. JC: Methodology, Investigation, Writing - Review & Editing, Funding acquisition.

**Conflicts of Interest Statement**: Dr. Halpern-Felsher is a paid expert scientist in some litigation against JUUL and has been an unpaid expert scientist regarding tobacco-related regulation in California, Alaska, Rhode Island, and Idaho. The remaining authors report no conflicts of interest related to this research.

**Keywords**

Adolescent Health; Marijuana Use; Tobacco Use; Vaping; Xerostomia

## Introduction

Xerostomia, the subjective experience of a dry mouth, may be associated with diminished ability to swallow, chew, and speak, leading to reduced quality of life.[1–3] While more common among older adults,[4] in part due to xerogenic effects of common medications,[5,6] xerostomia is also reported among younger populations, including 9% of Australians ages 15–34.[7] Dry mouth may have adverse consequences for younger populations. In a study of adults in their early 30s, the presence of xerostomia was negatively associated with oral health-related quality of life.[8] In addition to oral discomfort, patients with deficits in saliva are at elevated risk of oral infection and dental caries.[9] Among potential factors contributing to dry mouth, use of tobacco may be particularly salient for younger populations.

Tobacco and other substance use patterns have shifted considerably over the last decade, especially among adolescents. In the United States, recent trends include declining levels of cigarette smoking but increasing use of electronic cigarettes (e-cigarettes) and cannabis (marijuana).[10–12] Among serious health implications are risks of nicotine addiction and potential harm to brain development from e-cigarette use,[13] as well as potential respiratory and cardiovascular harm associated with cannabis use.[14,15] The potential associations of tobacco, nicotine, and cannabis use with xerostomia among adolescents have been underexplored.

Some existing evidence implicates tobacco and cannabis use as potential xerogenic factors. Cigarette smoking has been positively associated with xerostomia in population-based studies of older adults.[16,17] Dry mouth or throat has been reported as a side effect of e-cigarette use among adults[18,19] and youth[20] and as an adverse event connected to e-cigarette use in smoking cessation trials,[21] possibly from inhaling propylene glycol or glycerin components of the aerosol. Xerostomia has also been reported among adult cannabis users and as an adverse side effect of medical cannabis treatments.[22,23] Parasympatholytic action of tetrahydrocannabinol (THC), the psychoactive chemical in cannabis, could inhibit salivary flow.[24]

The present investigation examines the associations between xerostomia and tobacco, e-cigarette, and cannabis use in an adolescent population. Specifically, because xerostomia measures have primarily been used with older adults, we first assess the validity of a brief self-reported xerostomia questionnaire for adolescents. Next, we compare the prevalence of dry mouth and frequency of xerostomia symptoms according to tobacco and other substance use behaviors, including statistical adjustment for product co-use and other confounders.

## Methods

This investigation is a cross-sectional analysis of data collected during the 12-month follow-up wave of an ongoing cohort study in Northern and Central California, United States.

Further cohort information is published elsewhere.[25,26] Briefly, the overall study aimed to evaluate tobacco-related behaviors, perceptions, and health outcomes among students recruited from 8 rural high schools (municipal populations <50,000; county population densities <1000/square-mile). Ninth and tenth grade students at each participating school were invited to enroll in the study in-person during visits to required classes from March 2019 to February 2020. Investigators administered in-school electronic surveys on tablet computers to students with signed parental consent and participant assent (N=1423). An Institutional Review Board at the University of California San Francisco approved all study procedures. Students received a $10 gift card to an online retailer for each survey wave completed. Participating schools received $300 at enrollment.

Follow-up surveys were administered online via email and/or text message invitations at 6-month intervals from enrollment. Due to the COVID-19 pandemic, in-person return visits to schools were infeasible. Twelve-month follow-up surveys were completed from March 2020 to March 2021 and included 976 participants (69% retention from baseline). Survey measures related to xerostomia were introduced in the 12-month follow-up wave.

To assess concurrent validity, two existing xerostomia measures were included: a global measure of dry mouth frequency ("How often does your mouth feel dry?" Options: never, occasionally, frequently, always) and the Shortened Xerostomia Inventory (SXI).[27] The SXI asks respondents to choose from never, hardly ever, occasionally, fairly often, and very often (scored 1 to 5, respectively) to five items: My mouth feels dry when eating a meal; My mouth feels dry; I have difficulty eating dry foods; I have difficulties swallowing certain foods; My lips feel dry. Items were presented to participants in random order following the prompt "How often did you experience the following in the PAST 30 DAYS?" Scores are summed across items (total score range: 5 to 25).

For items related to tobacco, e-cigarette, and cannabis, participants were given a brief description with example images and asked if they had ever used the product; ever-users were then asked how many days they used in the past 30 days. Combustible tobacco products included cigarettes, cigars, and hookah. Smokeless tobacco products were moist snuff, chewing tobacco, snus, nicotine pouches, and nicotine tablets/lozenges. E-cigarettes were presented separately as cigalike, pen/tank, mod, pod, and disposable pod device types. Cannabis included smoked (e.g., joint or blunt), vaped or dabbed, and edible products. For this analysis, use frequency of e-cigarettes and cannabis were specified as 0, 1–5, or 6–30 days in the past 30-days. Cut-points for frequency categories were chosen to separate experimental from routine use. However, given overall low use prevalence, combustible tobacco was specified as past 30-day use (any vs. none). Smokeless tobacco use was uncommon (n=6 past 30-day users) and not included in models.

Other covariables, as specified in Table 1, included self-identified gender, race/ethnicity, asthma, physical activity, and past 30-day alcohol use. Xerostomia is common among asthma patients, particularly those using inhaled corticosteroids.[28] Specified asthma categories were: never been told by a doctor or health professional as having asthma, ever having asthma but without recent symptoms, or experiencing symptom (e.g., wheeze, asthma attack, medication use) in the past 12 months.

Validity checks of the SXI followed an earlier approach.[27] Principal components analysis was conducted to assess whether the SXI is unidimensional, meaning that a single latent construct underlies the score on the questionnaire and that the SXI total score appropriately summaries a participant's questionnaire response. The discriminatory power of each item of the SXI was examined by the polychoric correlation between the item score and the total SXI score, excluding the item under consideration. The internal consistency and reliability of the SXI was assessed using Cronbach's alpha. Convergent validity of the SXI questionnaire was examined by comparing scores with the dry mouth frequency measure. If the SXI is a valid measure of dry mouth, we expect to see at least a moderate association between SXI scores and the levels of the global measure of dry mouth frequency.

The prevalence of reporting dry mouth "frequently" or "always" (combined) and mean SXI scores were compared according to tobacco, e-cigarette, and cannabis use. To adjust for covariables, two multivariable regression models were fitted: ordered logistic regression was used to model dry mouth frequency and negative binomial regression for SXI scores. Past 30-day combustible tobacco use, e-cigarette use frequency, and cannabis use frequency were included as independent variables in all models. Model fit tests indicated no evidence of violations of the proportional odds assumption for dry mouth frequency (Brant test to compare the slope coefficients of the binary logits implied in the ordered model[29]). Negative binomial models were chosen for SXI score because outcome distributions fit poorly to linear models (residual vs. fitted plots). Although missing data were uncommon (<1% of observations), to maintain all possible observations in multivariable models and have less stringent assumption than missing completely at random in complete case analysis, missing values were multiply imputed (20 imputations) by chained equations using the mi: command suite in Stata 16.1. Outcome variables (dry mouth frequency, SXI score) were not imputed. Predictor variables for imputation included all covariables used in the main analysis and additional markers of socioeconomic position (home computer ownership, federal school lunch program participation). In the main analysis, model coefficients were considered statistically significant if 95% confidence intervals excluded the null value. Exploratory analyses assessed dry mouth outcomes by use past 30-day use of e-cigarettes and/or cannabis (i.e., neither, either, or both as a check for interaction) and by mode of cannabis consumption (i.e., smoked, vaped, both, or other).

## Results

Table 1 presents the population characteristics of the 976 adolescent participants included in this analysis of the cohort's 12-month follow-up wave. The mean age of participants was 16.1 years (standard deviation: 0.7 years). Participants included in the analytic sample were more likely than participants without 12-month follow-up to have reported at baseline being female (61% vs. 45%) and having ≥2 computers in their home (40% vs. 32%) but less likely to have reported past 30-day use of alcohol (19% vs. 26%), e-cigarettes (19% vs. 26%), and cannabis (19% vs. 26%). In the analytic sample, reported past 30-day use prevalence was 12% for e-cigarettes, 16% for cannabis, and 3% for combustible tobacco (Table 1). Among all participants, the majority (60%) reported experiencing dry mouth at least "occasionally" but few (6%) reported dry mouth "frequently" or "always" (Table 1).

Validity testing suggested adequate performance of the xerostomia measures. Mean SXI scores were higher in each successive category of the global measure of dry mouth frequency (Table 2). Positive correlation between these two measures was consistent across statistical tests (Kruskal-Wallis: $P<0.001$; linear trend: $P<0.001$; Spearman correlation: rho=0.553, $P<0.001$). The SXI demonstrated good internal consistency (Cronbach's alpha=0.645). Principal components analysis indicated one retained factor explained 44% of the observed variance (Table 3). Of the five items comprising the SXI, feeling dry lips was endorsed most frequently, whereas dryness when eating, difficulty eating dry foods, and difficulty swallowing were uncommonly endorsed (Table 3).

In unadjusted analyses, dry mouth was positively associated with use of e-cigarettes, cannabis, and combustible tobacco (Table 4). Use ≥6 days in the past 30-days (vs. 0 days) was associated with greater report of experiencing dry mouth frequently or always for e-cigarettes (14% vs. 5%) and cannabis (19% vs. 4%), as well as for any past 30-day use of combustible tobacco (19% vs. 5%). Likewise, mean SXI scores were higher than among non-users for frequent users of cannabis (7.6 vs. 6.5) and combustible tobacco users (7.8 vs. 6.5).

In covariable-adjusted models mutually adjusted for use of each type of product (Table 5), use of cannabis and combustible tobacco maintained positive associations with reported dry mouth frequency, but e-cigarette use did not. In adjusted models for SXI score, frequent cannabis use remained positively and statistically significantly associated with higher SXI scores (Table 5).

In exploratory analyses, past 30-day use of both cannabis and e-cigarettes together was associated with greater dry mouth frequency, and use of both and use of cannabis alone (i.e., without e-cigarettes) were associated with higher SXI score; however, use of e-cigarettes alone was not associated with either dry mouth measure (Table 6). Modes of cannabis consumption that included combustion were positively associated with dry mouth frequency (Table 7). However, wide confidence intervals for some cannabis consumption categories and greater use frequency among dual-users than single-product users (not shown) complicated interpretation.

## Discussion

In this study of adolescents, self-report of occasional dry mouth was common, although experiencing frequent and severe dry mouth was rare. Use of combustible tobacco was also uncommon but was positively associated with reported symptoms of xerostomia. Cannabis use was similarly associated with xerostomia and, given its much greater use prevalence, could be one of the most important contributors to dry mouth in this age group. In contrast to combustible tobacco and cannabis, and contrary to expectations, e-cigarette use was not statistically or meaningfully associated with xerostomia after accounting for potential confounding by concurrent cannabis and/or tobacco use, as well as other factors.

Among strengths of the present study was the application of two measures of xerostomia, allowing an examination of convergent validity; indeed, the SXI and global dry mouth

frequency measure were highly correlated. While these measures have been previously validated among older adults in multiple settings,[27] to our knowledge, they have not been extensively tested among adolescents. The present study also aimed to account for concurrent use of three types of products (i.e., combustible tobacco, cannabis, and e-cigarettes), which is particularly important for untangling potential health effects given the prevalence of dual- and poly-substance use behaviors in younger populations.[10,30]

Among study limitations, results from this Northern California study sample may not generalize to adolescent populations elsewhere. Likewise, results may not apply to adults. Individuals at the age of this sample tend to use tobacco products less frequently than older adolescents or young adults;[12] associations with xerostomia could be stronger with heavier use. Also a limitation was the relatively high level of attrition, which was due in part to challenges posed by the COVID-19 pandemic, resulting in a follow-up sample more likely to own computers and less likely to report substance use than the baseline population. However, we do not expect attrition to affect the internal validity of the observed xerostomia and substance use associations, as such a bias would require one or more unmeasured factors that are strong causes of both xerostomia and study retention.

Among other limitations, self-reported substance use could not be biochemically verified. Likewise, salivary flow was not objectively measured. Subjective dry mouth (xerostomia) and measured low salivary flow (hyposalivation) are correlated and have led to similar conclusions when used as research study endpoints.[31] Also, unmeasured confounding is possible; although, potential unmeasured causes of dry mouth, such as diabetes and xerogenic medication use for conditions other than asthma, are likely to be uncommon among adolescents. Additionally, use of combustible tobacco was uncommon, precluding examination of associations by product (e.g., cigarettes vs. cigars). While exploratory data were presented, use of cannabis via multiple modalities or in combination with e-cigarettes presented a challenge in teasing out potential independent contributions.

Compared to existing studies of older populations,[27] xerostomia was less common and less severe in this population of adolescents. Individual SXI items related to difficulties eating and swallowing were rarely endorsed, leading to a limited range of SXI scores within the population and small relative differences between comparison groups. Nonetheless, psychometric properties of the SXI were adequate, albeit at a lower Cronbach's alpha (0.65) than reported for six older adult populations (range: 0.72 to 0.80).[27] We speculate that a better performing short xerostomia instrument for adolescences would utilize prompts that differ from those included in the SXI. Pending the availability of an age-specific SXI, studies of younger populations might prefer to rely on the single global measure of dry mouth experience, as done elsewhere.[8] This could afford greater statistical power than a range-limited SXI, as seen in our study sample.

The present findings are consistent with reported associations between tobacco smoking and dry mouth in older adults in Sweden[16] and Republic of Korea.[17] In regional studies including older and younger adults, however, smoking was not associated with dry mouth among dental patients in Italy[32] but was among US men (albeit not women).[33] Present findings support an association among adolescents. Xerostomia has been reported as a

potential oral health side effect of cannabis use in a number of review articles focused on clinical dental settings;[34,35] however, population-based data demonstrating this association are sparse. In a study of behavioral health center clients, adults who smoked cannabis, tobacco, and methaqualone were compared to tobacco-only smokers from nearby dental clinics, with a greater prevalence of reporting “dry mouth after smoking” among the cannabis, tobacco, and methaqualone group.[36] The present study corroborates associations with use of combustible tobacco or cannabis using data from a single community-based sample and validated xerostomia measures.

An association between e-cigarette use and xerostomia did not persist after we accounted for concordant use with cannabis and/or combustible tobacco. While dry mouth has been reported in the literature as possible result of e-cigarette use,[18–21] some studies have combined mouth dryness with mouth and throat irritation,[19,20,37] potentially muddying the distinction between xerostomia and other sensations related to e-cigarette use. Other potential reasons for discordant findings in the present study may be use of validated xerostomia measures and recent changes in e-cigarette design. Specifically, the pod-based e-cigarettes most commonly used in the present study may be capable of delivering nicotine in lower volumes of aerosolized carrier solution (a possible mouth and throat irritant) than the devices most commonly used only a few years earlier.[38,39]

The clinical, policy, and tobacco regulatory implications of the present findings must be contextualized by acknowledging that any potential contribution of xerostomia to total morbidity burden of tobacco use will be small given the severe consequences of the tobacco epidemic on chronic disease.[40] Nonetheless, dry mouth has meaningful implications for oral health and quality of life, especially if leading to greater risk for dental caries and oral infection.[2,9] Association between cannabis, tobacco, and xerostomia is one additional motivation for dental professionals to inquire about all forms of tobacco and cannabis use with their patients and offer evidence-based cessation support for those patients willing and ready to quit.[41,42]

Among open questions for future research is whether dry mouth symptoms associated with tobacco and cannabis use in this and similar populations reflect transient experiences connected to an episode of tobacco or cannabis consumption and/or more durable diminutions in salivary flow. Mechanistically, the present study does not fully answer whether potential xerogenic effects are specific to combustible products, THC, nicotine, or other constituents of cannabis or tobacco smoke. Such questions are likely better answered in clinical investigations. However, the present findings do help to underscore that adverse oral health effects are one of many reasons to emphasize tobacco and cannabis use prevention and cessation for adolescents.

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**Table 1.**

Population Characteristics, California Adolescents

| Characteristic | n[1] | % |
|---|---|---|
| Gender | | |
| Male | 357 | 36.6 |
| Female | 594 | 60.9 |
| Other | 25 | 2.6 |
| Race/Ethnicity | | |
| Hispanic/Latinx | 486 | 49.8 |
| Non-Hispanic White | 342 | 35.0 |
| Other | 148 | 15.2 |
| Asthma status | | |
| Never diagnosed | 780 | 79.9 |
| Ever diagnosed, without symptoms | 63 | 6.5 |
| Symptoms in the past 12 months | 133 | 13.6 |
| Physical activity in the past 7 days | | |
| 0–1 days | 156 | 16.0 |
| 2–4 days | 447 | 45.8 |
| 5–7 days | 367 | 37.6 |
| Past 30-day use alcohol | | |
| 0 days | 795 | 81.8 |
| 1–30 days | 177 | 18.2 |
| Past 30-day use smokeless tobacco[2] | | |
| 0 days | 970 | 99.4 |
| 1–30 days | 6 | 0.6 |
| Past 30-day use e-cigarettes | | |
| 0 days | 859 | 88.1 |
| 1–5 days | 58 | 5.9 |
| 6–30 days | 58 | 5.9 |
| Past 30-day use cannabis | | |
| 0 days | 816 | 83.7 |
| 1–5 days | 92 | 9.4 |
| 6–30 days | 67 | 6.9 |
| Past 30-day use combustible tobacco[3] | | |
| 0 days | 945 | 96.8 |
| 1–30 days | 31 | 3.2 |
| Dry Mouth Frequency | | |
| Never | 390 | 40.0 |
| Occasionally | 529 | 54.2 |
| Frequently | 53 | 5.4 |
| Always | 4 | 0.4 |

[1] Total analytic sample size: N=976; Sample size may be smaller for some variables due to missing data

[2] Includes moist snuff, chewing tobacco, snus, nicotine pouches, and nicotine tablets/lozenges

[3] Includes cigarettes, cigars, and/or hookah

**Table 2.**

Shortened Xerostomia Inventory Scores by Reported Frequency of Dry Mouth

| | | Shortened Xerostomia Inventory | |
|---|---|---|---|
| | **n** | **Mean Score (SD)** | **Median Score (IQR)** |
| **Dry Mouth Frequency** | | | |
| Never | 385 | 5.7 (0.9) | 6 (5, 6) |
| Occasionally | 523 | 7.0 (1.4) | 7 (6, 8) |
| Frequently | 52 | 8.9 (1.7) | 8 (8, 10) |
| Always | 4 | 10.5 (3.4) | 10 (8, 13) |
| Total | 964 | 6.6 (1.5) | 6 (5, 7) |

Abbreviations: IQR = interquartile range; SD = standard deviation

**Table 3.**

Shortened Xerostomia Inventory, Principal Components Analysis

| | Response Distribution, % | | | Eigenvectors |
|---|---|---|---|---|
| | Never | Occasionally | Often | |
| **Shortened Xerostomia Inventory Items** | | | | |
| My mouth feels dry when eating a meal | 87.9 | 11.1 | 1.0 | 0.469 |
| My mouth feels dry | 59.0 | 38.3 | 2.7 | 0.459 |
| I have difficulty in eating dry foods | 89.9 | 8.8 | 1.2 | 0.467 |
| I have difficulties swallowing certain foods | 90.8 | 7.5 | 1.8 | 0.450 |
| My lips feel dry | 32.8 | 55.1 | 12.1 | 0.386 |

Meta-data:

Number of complete observations: 964

Number of factors retained: 1

Percent variance explained: 43.6

Eigenvalue: 2.18

Cronbach alpha: 0.645

**Table 4.**

Dry mouth experience according to use of e-cigarettes, cannabis, and combustible tobacco

| | Dry Mouth Frequency | | | | | Shortened Xerostomia Inventory | | |
|---|---|---|---|---|---|---|---|---|
| | n | Never, % | Occasionally, % | Frequently or Always, % | P-Value[1] | n | Mean Score (SD) | P-Value[2] |
| E-Cigarette Use | | | | | <0.001 | | | 0.05 |
| 0 days in past 30 | 859 | 42.1 | 52.7 | 5.1 | | 851 | 6.5 (1.5) | |
| 1–5 days in past 30 | 58 | 31.0 | 60.3 | 8.6 | | 57 | 7.0 (2.0) | |
| 6–30 days in past 30 | 58 | 17.2 | 69.0 | 13.8 | | 55 | 6.9 (1.6) | |
| Cannabis Use | | | | | <0.001 | | | <0.001 |
| 0 days in past 30 | 816 | 43.3 | 52.6 | 4.2 | | 808 | 6.5 (1.4) | |
| 1–5 days in past 30 | 92 | 30.4 | 58.7 | 10.9 | | 91 | 6.7 (1.5) | |
| 6–30 days in past 30 | 67 | 13.4 | 67.2 | 19.4 | | 64 | 7.6 (1.8) | |
| Combustible Tobacco Use[3] | | | | | <0.001 | | | <0.001 |
| 0 days in past 30 | 945 | 41.0 | 53.7 | 5.4 | | 934 | 6.5 (1.5) | |
| 1–30 days in past 30 | 31 | 9.7 | 71.0 | 19.4 | | 30 | 7.8 (2.1) | |

1. Chi-square test

2. Kruskall-Wallis test (e-cigarettes and cannabis); Wilcoxon rank-sum test (combustible tobacco)

3. Includes cigarettes, cigars, and/or hookah; Categories of use 1–5 days and 6–30 days collapsed due to small cell sizes

Abbreviation: SD = standard deviation

**Table 5.**

Dry mouth experience according to use of e-cigarettes, cannabis, and combustible tobacco, multivariable models

| | Dry Mouth Frequency | | | Shortened Xerostomia Inventory | | |
|---|---|---|---|---|---|---|
| | Adjusted OR[1,2] | 95% Confidence Interval | P-Value | Adjusted Ratio[1,3] | 95% Confidence Interval | P-Value |
| E-Cigarette Use | | | | | | |
| 0 days in past 30 | reference | | | reference | | |
| 1–5 days in past 30 | 1.22 | 0.84, 1.78 | 0.30 | 1.05 | 0.99, 1.11 | 0.13 |
| 6–30 days in past 30 | 1.40 | 0.69, 2.84 | 0.35 | 0.96 | 0.90, 1.01 | 0.12 |
| Cannabis Use | | | | | | |
| 0 days in past 30 | reference | | | reference | | |
| 1–5 days in past 30 | 1.57 | 1.06, 2.33 | 0.03 | 1.02 | 1.00, 1.04 | 0.06 |
| 6–30 days in past 30 | 3.17 | 1.47, 6.82 | 0.003 | 1.14 | 1.09, 1.19 | <0.001 |
| Combustible Tobacco Use[4] | | | | | | |
| 0 days in past 30 | reference | | | reference | | |
| 1–30 days in past 30 | 1.92 | 1.38, 2.68 | <0.001 | 1.13 | 0.99, 1.29 | 0.07 |

1. Multivariable adjusted models included all exposures in the table, as well as gender, race/ethnicity, asthma, physical activity, and past 30-day alcohol use; missing values multiply imputed

2. Ordered logistic regression; adjusted odds ratio represents the ratio (relative to reference) of odds of being in a more frequent category of dry mouth, holding all covariables constant

3. Negative binomial regression; adjusted ratio represents ratio of Shortened Xerostomia Inventory score in the category of interest relative to reference, holding all covariables constant

4. Includes cigarettes, cigars, and/or hookah; Categories of use 1–5 days and 6–30 days collapsed due to small cell sizes

Abbreviation: OR = odds ratio

**Table 6.**

Dry mouth experience according to use of e-cigarettes and/or cannabis

| | Dry Mouth Frequency | | | Shortened Xerostomia Inventory | | |
|---|---|---|---|---|---|---|
| | Adjusted OR[1,2] | 95% Confidence Interval | P-Value | Adjusted Ratio[1,3] | 95% Confidence Interval | P-Value |
| Past 30-Day Use Category | | | | | | |
| Neither product | reference | | | reference | | |
| E-cigarettes alone | 1.00 | 0.55, 1.80 | 0.99 | 0.99 | 0.93, 1.06 | 0.86 |
| Cannabis alone | 1.65 | 0.96, 2.83 | 0.07 | 1.05 | 1.00, 1.09 | 0.05 |
| Both products | 3.34 | 1.43, 7.80 | 0.01 | 1.09 | 1.05, 1.13 | <0.001 |

1. Multivariable adjusted models included past 30-day combustible tobacco use, gender, race/ethnicity, asthma, physical activity, and past 30-day alcohol use; missing values multiply imputed

2. Ordered logistic regression; adjusted odds ratio represents the ratio (relative to reference) of odds of being in a more frequent category of dry mouth, holding all covariables constant

3. Negative binomial regression; adjusted ratio represents ratio of Shortened Xerostomia Inventory score in the category of interest relative to reference, holding all covariables constant

Abbreviation: OR = odds ratio

**Table 7.**

Dry mouth experience according to mode of cannabis consumption

| | Dry Mouth Frequency | | | Shortened Xerostomia Inventory | | |
|---|---|---|---|---|---|---|
| | Adjusted OR[1,2] | 95% Confidence Interval | P-Value | Adjusted Ratio[1,3] | 95% Confidence Interval | P-Value |
| Past 30-Day Cannabis Use | | | | | | |
| No use in past 30 days | reference | | | reference | | |
| Smoked, not vaped | 5.93 | 2.85, 12.3 | <0.001 | 1.04 | 0.99, 1.10 | 0.12 |
| Vaped, not smoked | 1.44 | 0.19, 11.2 | 0.73 | 0.99 | 0.96, 1.03 | 0.70 |
| Smoked and vaped | 3.13 | 1.09, 8.97 | 0.03 | 1.12 | 1.06, 1.18 | <0.001 |
| Other[4] | 0.98 | 0.23, 4.08 | 0.98 | 1.11 | 1.05, 1.18 | <0.001 |

1. Multivariable adjusted models included past 30-day frequency of e-cigarette use, past 30-day combustible tobacco use, gender, race/ethnicity, asthma, physical activity, and past 30-day alcohol use; missing values multiply imputed

2. Logistic regression; adjusted odds ratio represents the ratio (relative to reference) of odds of reporting dry mouth frequently or always, holding all covariables constant; Ordered logistic models demonstrated evidence of violating the proportional odds assumption

3. Negative binomial regression; adjusted ratio represents ratio of Shortened Xerostomia Inventory score in the category of interest relative to reference, holding all covariables constant

4. Includes edible products, balms, and tinctures

Abbreviation: OR = odds ratio