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# Retail Access is Associated with Multiple Tobacco Product Use among Adolescent

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## Acknowledgements

## INTRODUCTION

In 2018, approximately 40% of adolescent tobacco users (3.3 million middle and high school students) reported using two or more products in the past 30 days.[1] The use of multiple tobacco products among adolescents presents a number of public health concerns. For example, multiple tobacco product users, relative to single product users, report greater rates of nicotine dependence[2-4] and heavier use of each tobacco product.[5,6] Consequently, multiple tobacco use places adolescents at greater risk for long-term tobacco use, and subsequent tobacco-induced diseases, which tracks into adulthood.[2,3,3] Given these behavioral and epidemiological concerns, it is vital to explore risk factors for multiple tobacco product use among adolescents.

Multiple tobacco product use among adolescents is a complex behavior with several known correlates and risk factors. For example, prevalence varies significantly across socio-demographic factors. Specifically, males, non-Hispanic whites, and high school (relative to middle school) students are more likely to be multiple tobacco product users.[1,7,8] However, studies also point to distinct risk factors for dual (two products) tobacco use, relative to poly (three or more products) tobacco use.[9-14] The total number of tobacco products used may ultimately be influenced by psycho-social (e.g., harm perceptions; sensation seeking), behavioral (e.g., marijuana/alcohol use; flavored tobacco use), and environmental (e.g, tobacco marketing exposure) risk factors.[9-14] As such, it is critical to not only explore risk factors for multiple tobacco products use but also examine differences across dual and poly users.

Retail access to tobacco is a potential risk factor for multiple tobacco product use. Specifically, Social Cognitive Theory (SCT) postulates that a person's behavior influences, and is influenced by, individual and environmental factors (the construct of reciprocal

determinism).[15] According to SCT, retail access to tobacco products can enhance self-efficacy (i.e., perceived ability to purchase tobacco product), which may influence/increase tobacco use among youth.[15] Furthermore, retail access may be perceived as an indicator of social and environmental acceptance of adolescent tobacco use, thus encouraging use.[15] This theory is supported by research that has consistently found retail access (the environment) to be a strong determinant of adolescent tobacco use (the behavior)[16,17] However, previous research demonstrating this association has been predominantly product specific (i.e., cigarette only; e-cigarette only). [16-20] As such, the relationship between retail access and the use of multiple tobacco products is not well understood.

As of December 20, 2019,[21] federal law prohibited the sale of tobacco products to individuals under the age of 21, an increase from the previous age restriction of 18 years old.[22] Prior to this federal level regulatory change, a total of 18 states, the District of Columbia, and nearly 500 local municipalities had restricted the sale of tobacco to individuals under 21.[23,24] Despite these age restrictions, retail access to tobacco products among adolescents remains high,[16-20] with youth frequently reporting purchasing tobacco products in-person (e.g., convenience stores; "vape shops")[18,20] and online.[18,20] Online tobacco sales present a particularly challenging situation from an oversight and compliance perspective, with several retailers failing to install rigorous age verification mechanisms.[25-27] As such, it is reasonable to consider that these gaps in the enforcement of tobacco retail access laws may contribute to the high rate of multiple tobacco product use among youth.

*Study Aims & Hypotheses*

This study aims to examine the relationship between self-reported tobacco retail access and self-reported multiple tobacco product use among a nationally representative sample of

adolescent tobacco users. This study has two hypotheses. First, self-reported tobacco retail access will be associated with greater risk of dual (two products) and poly (three or more products) tobacco use, relative to single tobacco product use. Second, we hypothesize that self-reported tobacco retail access will be associated with greater risk of poly tobacco use, relative to dual tobacco use. Understanding the relationship between self-reported tobacco retail access and multiple tobacco product use behaviors among youth will help inform tobacco regulatory policy and enforcement as well as public health research.

## METHODS

*Data Source & Procedures*

This study analyzed data from the 2018 National Youth Tobacco Survey (NYTS), an annual survey that utilizes a stratified, three-stage cluster sample design to obtain a representative sample of middle and high school students in the United States. Further, the NYTS sample procedures are probabilistic and conducted without replacement at all stages. The stages of the three-stage cluster sample design were primarily sample within each stratum, school within each primary sampling unit, and class within each school. Participation in the 2018 NYTS was voluntary and confidential for schools and students. The 2018 NYTS surveyed 20,189 participants attending 238 public and private schools. Additional information on the sample and procedures of the 2018 NYTS is available elsewhere.[28]

*Study Sample*

Participants included in this study were required to meet four eligibility criteria. First, they had to have self-reported obtaining a tobacco product in the past 30 days (n=3,223). Second, participants that did not self-report using a tobacco product in the past 30 days were excluded

(n=863). Third, participants that were 18 years or older were excluded (n=40), as federal law at the time of data collection did not prohibit the sale of tobacco products to these individuals.[22,29] And fourth, this study excluded participants with missing data across other study variables (n=121). These criteria resulted in a final sample of n=2,199 adolescent tobacco users. Sample selection is further detailed in Figure 1.

*Measures*

*Multiple Tobacco Product Use.* Self-reported number of tobacco products used in the past 30 days was the outcome variable of this study. Self-reported tobacco use was individually assessed for the following 10 product groups: cigarettes, e-cigarettes, cigar products (i.e., cigars, cigarillos, little cigars), hookah/waterpipe, smokeless tobacco (i.e., chewing tobacco, snuff, dip), snus, dissolvables, pipe tobacco, roll-your-own tobacco, and bidis. Participants were asked "during the past 30 days, on how many days did you [smoke]/[use] [product]?" Participants that self-reported past 30-day use of only one tobacco product were considered single tobacco product users. Participants that self-reported past 30-day use of only two tobacco products were considered dual tobacco product users. And participants that self-reported past 30-day use of three or more tobacco products were considered poly tobacco product users.

*Tobacco Retail Access.* The independent variable for this study was self-reported retail access to tobacco products. Participants were asked "During the past 30 days, how did you get your own tobacco products? (Select one or more)". Participants that responded "I bought them myself" were considered to self-report retail access to tobacco (coded as 1), even if they reported additional sources of obtaining tobacco other than retail access. Participants that self-reported any additional sources of obtaining tobacco but did not self-report retail access were treated as the referent group (coded as 0). Other possible methods of obtaining tobacco products were:

1. I had someone else buy them for me

2. I asked someone to give me some

3. Someone offered them to me

4. I bought them from another person

5. I took them from a store or another person

6. I got them some other way

*Covariates.* This study controlled for the following socio-demographic variables: sex, race/ethnicity, and grade level. Sex is a dichotomous variable; males served as the referent group. Race/ethnicity was categorized as follows: non-Hispanic white (referent group); Hispanic/Latino; non-Hispanic black; and "other." For the purposes of this study, "other" included non-Hispanic Asian, non-Hispanic Multiracial, and any other race/ethnicity. Grade level was categorized as middle school (6th – 8th grade) and high school (9th – 12th grade). Middle school served as the referent group.

This study also controlled for self-reported exposure to tobacco and e-cigarette marketing.[9] First, participants self-reported exposure to tobacco marketing via four channels: internet, print media (e.g., newspapers, magazines), the retail setting (e.g., gas station, grocery story), and television/movies. Next, participants were asked to self-report exposure to e-cigarette marketing via the same four channels. Marketing exposure via internet, print media, and the retail setting were assessed with similarly phrased questions across product type: (1) "When you are using the Internet, how often do you see ads or promotions for [cigarettes or other tobacco products] / [electronic cigarettes or e-cigarettes]?" (2) "When you read newspapers or magazines, how often do you see ads or promotions for [cigarettes or other tobacco products] / [electronic cigarettes or e-cigarettes]?" (3) "When you go to a convenience store, supermarket, or

gas station, how often do you see ads or promotions for [cigarettes or other tobacco products] / [electronic cigarettes or e-cigarettes]?" However, due to differences in regulation and marketing restrictions for e-cigarettes relative to other tobacco products,[29] TV/ movie marketing exposure questions differed by product: (4.1) "When you watch TV or go to the movies, how often do you see actors using cigarettes or other tobacco products?" and (4.2) "When you watch TV or go to the movies, how often do you see ads or promotions for electronic cigarettes or e-cigarettes?"

Possible responses to all eight marketing questions included: never, rarely, sometimes, most of the time, and always. Based on previous literature,[30,31] responses to each channel were dichotomized. Specifically, participants that reported "never" or "rarely" were considered unexposed to marketing via that particular channel (coded as 0), while those that reported "sometimes", "most of the time", or "always" were considered exposed to marketing via that particular channel (coded as 1). A cumulative marketing exposure index was developed, tallying the number of channels of exposure. As such, possible values for self-reported recall of tobacco and e-cigarette marketing exposure ranged from 0 to 8 total channels.

*Statistical Analyses*

Data were weighted to be nationally representative of middle and high school tobacco users in the United States, adjusting for nonresponse and probability of selection. Prior to testing study hypotheses, chi-squared analyses were used to test for statistical differences in self-reported tobacco retail access and multiple tobacco product use across study covariates.

Two weighted multivariate, multinomial logistic regression models were used to test study hypotheses. These models examined the association between self-reported tobacco retail access and multiple tobacco product use, controlling for sex, race/ethnicity, grade level, and cumulative tobacco/e-cigarette marketing exposure. In the first multivariate, multinomial logistic

regression model, single tobacco product users served as the referent group and were thus compared to dual and poly tobacco product users. In the second multivariate, multinomial logistic regression model, dual tobacco products served as the referent group and were thus compared to poly tobacco product users. These iterations of the statistical models allowed for the following comparisons: single to dual tobacco product users, single to poly tobacco product users, and dual to poly tobacco product users. Logit coefficients for each multivariate multinomial logistic regression were exponentiated and reported as Relative Risk Ratios (RRR). All analyses were weighted to be nationally representative and conducted using STATA 14.2 (College Station, TX).

## RESULTS

*Descriptive Statistics*

Among the full sample, 42.6% were single tobacco product users, 23.8% were dual tobacco product users, and 33.6% were poly tobacco product users. Further, 27.9% self-reported retail access to tobacco products. Prevalence of self-reported retail access to tobacco products was greater among dual (29.9%) and poly (35.5%) tobacco product users, compared to single tobacco product users (19.3%). Chi-squared tests revealed this difference in prevalence of self-reported retail access to tobacco products across single, dual, and poly tobacco use was statistically significant (p < 0.001).

Self-reported tobacco retail access differed significantly by socio-demographic characteristics. Non-Hispanic whites (31.0%) had the greatest prevalence of self-reported tobacco retail access and non-Hispanic African Americans (13.6%) reported the lowest prevalence of self-reported tobacco retail access (p < 0.001). Similarly, males (32.8%) and high

school students (30.4%) reported significantly greater prevalence of self-reported tobacco retail access than females (20.3%; p < 0.001) and middle school students (11.2%; p < 0.001). There was no statistical difference in mean exposure to tobacco/e-cigarette marketing by self-reported tobacco retail access (p = 0.776).

Prevalence of single, dual, and poly tobacco use differed significantly by sex (p = 0.003). Among males, 39.2% were single tobacco product users, 23.3% were dual tobacco product users, and 37.4% were poly tobacco product users. Among females, 46.9% were single tobacco product users, 24.4% were dual tobacco product users, and 28.8% were poly tobacco product users. Additionally, poly tobacco users reported significantly greater exposure to tobacco/e-cigarette marketing (mean = 3.44 channels) than single (mean = 2.76 channels; p < 0.001) or dual (mean = 2.91 channels; p = 0.002) tobacco users. Prevalence of single, dual, and poly tobacco use did not differ statistically by race/ethnicity (p = 0.985) or grade level (p = 0.200). Further detail of these figures is available in Table 1.

As seen in Table 2, the majority of cigarette (65.4%), cigar (66.1%), and hookah/waterpipe smokers (67.8%) as well as smokeless tobacco users (65.3%) were poly tobacco product users. Similarly, approximately 4 out of 5 pipe tobacco (81.7%), roll-your-own (84.2%), and bidis smokers (84.2%) as well as snus (83.2%) and dissolvables (81.4%) users were poly tobacco product users. Further, about two-thirds of all e-cigarettes were either dual (23.3%) or poly (38.5%) tobacco product users.

*Study Hypotheses*

As seen in Table 3, self-reported tobacco retail access was associated with an increased relative risk of dual tobacco product use (RRR: 1.78; 95% CI: 1.33 – 2.38) relative to single tobacco product use, controlling for covariates. Similarly, self-reported tobacco retail access was

associated with an increased relative risk of poly tobacco product (RRR: 2.25; 95% CI: 1.62 – 3.11) relative to single tobacco product use, controlling for covariates. Self-reported tobacco retail access was not associated with differing relative risk of poly tobacco product use (RRR: 1.27; 95% CI: 0.89 – 1.80) relative to dual tobacco product use, controlling for covariates.

## DISCUSSION

In line with study hypotheses, self-reported tobacco retail access was found to be associated with increased risk of multiple tobacco product use in a nationally representative sample of adolescents. Specifically, youth that reported purchasing tobacco products were more likely to be dual or poly tobacco product users than single tobacco product users. This relationship was observed even when controlling for established correlates of multiple tobacco product uses.[1,7-9] To our knowledge, this is the first study to explore the relationship between tobacco retail access and multiple tobacco product use among a nationally representative sample of adolescents.

This study has several regulatory implications. Descriptive statistics reveal a gap in enforcement of retail access laws that prohibit the sale of tobacco products to individuals under the age of 18.[22,29] Specifically, it was highly concerning that more than one in four adolescent tobacco users (27.9%) reported purchasing tobacco products from a retail outlet. Considering the main associative finding of this study, it is plausible that ineffective enforcement of retail access laws may promote the use of multiple tobacco products among adolescents. These findings are consistent with previous research that showed retail access to tobacco products is common and associated with greater odds of tobacco use.[16-20] Overall, these findings are indicative of a need

for greater enforcement of tobacco retailer compliance with tobacco retail access laws, as a method of reducing tobacco use among adolescents.[32-35]

Another notable finding includes the high prevalence of dual (23.8%) and poly (33.6%) tobacco product use. Further, these findings indicate that the proportion of adolescent tobacco users that report poly tobacco use may be growing, compared to nationally representative figures from 2014-2017.[7-10] These findings are alarming given that multiple tobacco product use is a risk factor for heavy tobacco use,[5,6] as well as nicotine dependence.[2-4]

This study also found descriptive differences in tobacco retail access by socio-demographic characteristics. For example, tobacco retail access prevalence was more than twice as high among non-Hispanic whites (31.0%) than non-Hispanic African Americans (13.6%). Similar differences were observed by sex, with males (32.8%) having significantly greater prevalence of tobacco retail access than females (20.3%). This study also found poly tobacco product users self-reported greater exposure to tobacco and e-cigarette marketing, relative to both single and dual tobacco product users. These findings support the SCT construct of reciprocal determinism, where environmental factors (exposure to tobacco and e-cigarette marketing) and the individual (poly tobacco user) influence each other.[15,36] Further research is needed to determine if poly tobacco users are mediators (i.e., reasons for tobacco use) to the environment (i.e., normalizing tobacco use) of non-users, single, and dual tobacco product users, given that enforcement of retail access regulations are lacking.[24]

*Limitations*

This study has limitations. First, data were cross-sectional and thus temporal relationships cannot be determined. Second, participants self-reported retail access and tobacco use behaviors

and thus findings are subject to recall bias. And third, this study was unable to account for variance in tobacco retail access policies and enforcement on the state and local level.

*Conclusion*

Despite these limitations, this study contributes to existing literature of tobacco retail access among adolescents. Specifically, this study found retail access was highly prevalent among adolescent tobacco users. Further, this retail access was associated with increased risk for multiple tobacco product use, even controlling for socio-demographic variables and tobacco marketing exposure. Greater efforts should be made toward compliance and enforcement of tobacco retail access laws in order to reduce adolescent tobacco use, including the use of multiple tobacco products.

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**Table 1: Descriptive Statistics by Tobacco Use Category (NYTS 2018, n=2,199; N=2,900,794)**

| | Tobacco Retail Access[a] (n=2,199; N=2,900,794)[c] | | Tobacco Use Categories[b] (n=2,199; N=2,900,794)[c] | | |
| --- | --- | --- | --- | --- | --- |
| | No | Yes | Single Users[b] | Dual Users[b] | Poly Users[b] |
| **Percent of Sample** | 72.1% (69.8 – 75.5) | 27.9% (24.5 – 30.2) | 42.6% (38.9 – 46.5) | 23.8% (21.3 – 26.4) | 33.6% (30.3 – 37.0) |
| **Sex** | | | | | |
| Male | 67.2% (63.6 – 70.6) | 32.8% (29.4 – 36.4) | 39.2% (35.3 – 43.3) | 23.3% (20.4 – 26.6) | 37.4% (33.8 – 41.2) |
| Female | 79.7% (75.8 – 83.2) | 20.3% (16.8 – 24.2) | 46.9% (41.3 – 52.6) | 24.4% (21.3 – 27.7) | 28.8% (24.2 – 33.8) |
| | **p<0.001** | | **p=0.003** | | |
| **Grade** | | | | | |
| Middle School | 88.8% (84.1 – 92.2) | 11.2% (7.8 – 15.9) | 42.4% | 23.5% | 34.1% |
| High School | 69.9% (66.6 – 73.0) | 30.1% (27.0 – 33.4) | 42.7% | 23.8% | 33.5% |
| | **p<0.001** | | p=0.985 | | |
| **Race/Ethnicity** | | | | | |
| Non-Hispanic White | 69.0% (65.4 – 72.5) | 31.0% (27.5 – 34.6) | 42.3% (37.6 – 47.2) | 23.9% (20.9 – 27.1) | 33.8% (29.7 – 38.2) |
| African American | 86.3% (79.3 – 91.4) | 13.6% (8.6 – 20.7) | 50.1% (40.0 – 60.0) | 19.8% (13.1 – 28.7) | 30.1% (22.0 – 39.8) |
| Hispanic/Latino | 78.1% (72.9 – 82.5) | 21.9% (17.5 – 27.1) | 39.0% (33.5 – 44.7) | 23.1% (19.2 – 27.5) | 37.9% (32.5 – 43.8) |
| Other | 75.4% (69.5 – 80.6) | 24.6% (19.4 – 30.6) | 46.5% (36.8 – 56.4) | 28.0% (20.5 – 37.1) | 25.5% (17.8 – 35.0) |
| | **p<0.001** | | p=0.200 | | |
| **Marketing Exposure[e]** | | | | | |
| Mean (SD) | 3.03 (2.3) | 3.00 (2.3) | 2.76 (2.2) | 2.91 (2.2) | 3.44 (2.5) |
| | F=0.08; p=0.776 | | Single vs Dual: F=1.07; p=0.305 **Single vs Poly: F=26.0; p<0.001** **Dual vs Poly: F=10.2; p=0.002** | | |
| **Tobacco Retail Access** | | | | | |
| No | --- | | 80.7% (76.8 – 84.1) | 70.1% (64.8 – 74.9) | 64.5% (59.2 – 69.5) |
| Yes | --- | | 19.3% (15.9 – 23.2) | 29.9% (25.1 – 35.2) | 35.5% (30.5 – 40.8) |
| | --- | | **p<0.001** | | |

a Self-Reported "I bought [tobacco products] myself"
b Reflects number of tobacco products used in the past 30 days
c Lower case "n" reflects unweighted sample size; Capital "N" reflects weighted sample size. All data presented are weighted.
d "Other" is where a response was "non-Hispanic, Asian", "non-Hispanic-American Indian/Alaska Native" or "native Hawaiian and other Pacific Islanders, non-Hispanic"
e Cumulative self-reported exposure to tobacco and e-cigarette marketing (0–8).

**Table 2: Single, Dual, and Poly Use by Tobacco Product among Past 30-Day Tobacco Users (NYTS 2018, n=2,199; N=2,900,794)**

|  | Prevalence among Full Sample | Single Product Users[a] | Dual Product Users[a] | Poly Product Users[a] |
|---|---|---|---|---|
| **Tobacco Product** |  |  |  |  |
| E-Cigarettes | 73.2% (69.3 – 76.8) | 38.1% (33.6 – 42.9) | 23.3% (20.7 – 26.2) | 38.5% (34.2 – 43.1) |
| Cigarettes | 41.1% (37.7 – 44.6) | 8.3% (6.2 – 11.1) | 26.3% (22.6 – 30.3) | 65.4% (61.2 – 69.4) |
| Cigar Products | 32.5% (29.5 – 35.6) | 13.1% (10.0 – 16.9) | 20.9% (17.3 – 25.0) | 66.1% (61.3 – 70.5) |
| Smokeless | 20.9% (17.3 – 25.0) | 14.8% (10.8 – 20.0) | 19.9% (15.1 – 25.8) | 65.3% (57.8 – 72.1) |
| Hookah | 18.6% (16.0 – 21.5) | 11.5% (7.4 – 17.6) | 20.7% (16.4 – 25.8) | 67.8% (61.1 – 73.8) |
| Roll-Your-Own | 14.0% (12.0 – 16.3) | 3.0% (1.6 – 5.7) | 12.8% (8.7 – 18.3) | 84.2% (78.6 – 88.6) |
| Snus | 12.5% (10.7 – 14.7) | 4.4% (1.9 – 9.7) | 12.4% (8.6 – 17.7) | 83.2% (77.0 – 87.9) |
| Pipe | 5.8% (4.6 – 7.3) | 2.5% (1.0 – 7.0) | 15.8% (9.7 – 24.6) | 81.7% (72.4 – 88.3) |
| Bidis | 4.1% (3.2 – 5.2) | 8.1% (3.7 – 16.8) | 7.7% (2.9 – 18.9) | 84.2% (72.6 – 91.5) |
| Dissolvables | 4.1% (3.2 – 5.1) | 8.7% (3.9 – 18.5) | 8.9% (4.4 – 17.3) | 82.4% (71.9 – 89.5) |

**NOTE:** Rows of last three columns (i.e. single, dual, and poly users) should equal 100%

a Corresponds to the number of tobacco products used in past 30 days. Single users are exclusive users of the corresponding product.

**Table 3: Multinomial Logistic Regression Models of Self-Reported Tobacco Retail Access and Number of Tobacco Products Used in the Past 30 Days (NYTS, 2018, n=2,199; N=2,900,794)**

|  | Single Product Users[a] | Dual Product Users[a] | Poly Product Users[a] |
|---|---|---|---|
|  | Relative Risk Ratio 95% Confidence Interval | Relative Risk Ratio 95% Confidence Interval | Relative Risk Ratio 95% Confidence Interval |
| **Single Product Users as Referent** |  |  |  |
| Tobacco Retail Access[b] | 1.00 (Ref) | **1.78*** (1.33 – 2.38)** | **2.25*** (1.62 – 3.11)** |
| **Dual Product Users as Referent** |  |  |  |
| Tobacco Retail Access[b] | --- | 1.00 (Ref) | 1.27 (0.89 – 1.80) |

All models adjusted for grade level, sex, race/ethnicity, and self-reported recall of tobacco/e-cigarette marketing exposure
**Bold** indicates statistical significance; ***p < .001.
a Corresponds to the number of tobacco products used in past 30 days
b Self-Reported "I bought [tobacco products] myself"

Figure 1: Sample Selection and Exclusion Criteria