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Original investigation

# Trends and Racial Disparities in Mono, Dual, and Poly Use of Tobacco Products Among Youth

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## Abstract

**Introduction:** We examined racial disparities in mono, dual, and poly use of tobacco products including whether racial disparities changed over time.

**Methods:** We analyzed data on high school students from the North Carolina Youth Tobacco Survey collected in 2011, 2013, and 2015. Dual and poly use included use of two and three or more tobacco products, respectively, in the past month. Multinomial regression models assessed racial differences and changes over time in mono, dual, and poly use. Data include product combinations most commonly used by youth from different racial groups.

**Results:** In total, 24% (in 2011) and 26% (in 2013 and 2015) of students used tobacco products. No significant changes over time were observed in mono (12%) or dual use (6%). Poly use was 6%, 8%, and 7% in 2011, 2013, and 2015, respectively. Relative to nonuse of tobacco, White students had a higher relative risk than Blacks for mono use. Whites and Hispanics had a higher relative risk than Blacks for dual and poly use. Observed racial differences in tobacco use did not change over time. Types of tobacco products used varied by year and race. In 2015, e-cigarette was the most commonly used product among mono users from all racial groups.

**Conclusions:** Substantial racial variation persists over time in mono and multiple tobacco product use among North Carolina youth, including racial variation in the types of tobacco products used. Research and policy efforts should examine and eliminate factors that drive multiple tobacco use and racial disparities in use among youth.

**Implications:** This study reports on racial disparities in mono and multiple tobacco product use among youth. White and Hispanic youth have higher relative risk for dual and poly use of tobacco products than Black youth. In addition, significant racial variation exists in the types of tobacco products used among youth mono, dual, and poly users, with cigarettes, cigars, smokeless tobacco, and e-cigarettes being the most commonly used products. Patterns of multiple tobacco product use vary by race and may warrant tailored prevention efforts. Strengthening tobacco control regulations for other tobacco products than cigarettes is critical to reduce multiple tobacco product use among youth.

## Introduction

Tobacco use remains the leading preventable cause of disease and mortality in the United States.[1] In recent years, as other tobacco products than cigarettes (OTPs; eg, cigars and electronic cigarettes) have become more widely available, concurrent use of multiple tobacco products (ie, use of two or more tobacco products simultaneously) has also increased. At a global level, it is estimated that more than 20% of cigarette smokers, aged 15 or older, across more than 2 dozen countries worldwide, use cigarettes and at least one other tobacco product, simultaneously.[2] With increasing availability of new and emerging tobacco products, multiple product use is a growing public health concern, particularly among youth. In the United States, an estimated 4.6 million middle and high school students were current users of a tobacco product in 2014 (ie, have used a tobacco product in the past month), of which an estimated 2.2 million students were current users of at least two products.[3] The availability of a wider range of OTPs including new combustible and noncombustible tobacco products,[4] as well as changing product characteristics with regard to flavors, colors, and packaging, make tobacco products appealing to youth.[5–8] These factors may encourage experimentation and initiation among susceptible youth, and continued use among current users, including dual (ie, use of two tobacco products) and poly (ie, use of three or more tobacco products) use.[9] Monitoring trends and patterns of multiple tobacco product use at the state, national, and international levels is critical to support policy and intervention efforts to curb tobacco use among youth.

Multiple tobacco product use during adolescence is especially detrimental. Nicotine exposure during adolescence harms the developing adolescent brain and can cause addiction.[10] Dual and poly use may exacerbate the risk for addiction due to greater exposure to nicotine.[11] Available evidence suggests that dual users of tobacco products are more nicotine dependent[12,13] and less likely to quit than those who use a single product.[11,14–16] Moreover, health risks posed by dual and poly use of tobacco products may be greater than those posed by use of a single product (mono use). Dual and poly use in early age increase exposure to harmful and potentially harmful constituents that are known to have adverse health effects.[17] Furthermore, combustible, noncigarette tobacco products that are common among youth dual and poly users (eg, cigars and hookah) pose health risks that may be similar or greater than those of cigarettes.[18–20] For example, cigar products that are commonly used by youth contain higher concentrations of toxic and carcinogenic compounds than cigarettes and are known to cause cancers of the lung and the upper aero-digestive tract.[18] To evaluate potential population health effects of dual and poly use, research should determine over time concurrent use patterns of cigarettes and noncigarette tobacco products among dual and poly users.

Patterns of tobacco use among youth vary by race. Whereas prior studies support that racial disparities exist in cigarette use in adolescence,[21–23] less is known about racial disparities in multiple tobacco product use among adolescents aged 14–17. Evidence supports that cigarette smoking is significantly lower among non-Hispanic Black youth compared with Whites.[3,24,25] Such racial variations in use are particularly important to monitor given accumulating evidence that Blacks start smoking cigarettes at an older age than Whites.[26,27] Further, despite lower cigarette consumption among adult Black smokers compared with White smokers,[26,27] Black smokers are more likely to die from smoking-related diseases than Whites.[28–30] With the changing landscape of tobacco products, however, racial differences may shift over time. Moreover, national data show that, in 2013, cigarettes were the product most commonly used by non-Hispanic White and Hispanic youth, whereas cigars were more commonly used by all other racial groups.[31] In 2014, however, e-cigarettes became the most commonly used product among Whites and Hispanics, whereas cigars continued to be most commonly used by Black youth.[3] Subsequently, racial patterns of dual and poly use of tobacco products may also vary over time suggesting that youth from some racial groups may be more vulnerable than others to addiction and to the negative health effects associated with dual and poly use.

In this study of high school students, we examined racial disparities in mono, dual, and polytobacco product use over time (between 2011 and 2015) and trends in tobacco product types that are most commonly used by mono, dual, and polytobacco users from different racial groups.

## Materials and Methods

### Sample and Data

We use data from the North Carolina Youth Tobacco Survey (NCYTS), a repeat cross-sectional public and charter school-based survey of students in grades 6–12, that has been collected every 2 years since 1999 by the Tobacco Prevention and Control Branch of the North Carolina Department of Health and Human Services. A multistage cluster sampling design in three regions of North Carolina (west, central, and east) was used. Within each region, schools were first selected with probability for selection proportional to the school's enrollment size for the survey year. Classes were then randomly selected within each school, excluding special populations (ie, classes that consist of >50% English as second language and/or Special Education students).[32,33] Participation in the survey was voluntary and anonymous. Passive consent forms were utilized, unless an active consent form was required according to a specific school district policy. Overall response rates for each survey year were 78.2% in 2011, 67.8% in 2013, and 74.4% in 2015.

For this study, we utilized data from high school students in grades 9–12 collected across three waves (2011: $n$ = 4791; 2013: $n$ = 4092; and 2015: $n$ = 3420). Missing data on study variables were small; less than 1% on demographic variables and 1%–3% on tobacco use variables, except for smokeless tobacco (SLT) use for which missing responses reached 6%. Excluding those with any missingness on demographics or tobacco use variables, our final analytic sample included 11 485 students (2011: $n$ = 4572; 2013: $n$ = 3859; and 2015: $n$ = 3054).

## Measures

### Dependent Variables

**Nonuse, Mono, Dual, and Poly Use of Tobacco Products**

For each survey year, past 30-day use of 10 tobacco products was assessed: cigarettes (including roll your own and flavored cigarettes, such as Camel crush), cigars (including cigars, little cigars, flavored cigars, and cigarillos), hookah (ie, waterpipe), pipe tobacco, bidis, clove cigarettes (kreteks) or clove cigars, e-cigarettes, SLT (including chewing tobacco, snuff, or dip), snus, and dissolvable tobacco. Students were classified as current users of that product if they indicated using it on at least 1 day in the past 30 days. For each student, we created an index of tobacco product use by summing up the number of tobacco products they had used in the past 30 days

(minimum = 0, maximum = 10). Students were then classified as (1) nonusers of tobacco products if they did not use any of these tobacco products, (2) mono users if they used only one tobacco product, (3) dual users if they used two tobacco products, and (4) poly users if they used three or more tobacco products within the past 30 days.

### Independent Variables

#### Racial Group

Students were asked whether they are Hispanic/Latino or not and what race or races they consider themselves to be and were classified into (1) non-Hispanic White, (2) non-Hispanic Black, (3) Hispanic/Latino, and (4) non-Hispanic other race (including American Indian or Alaska Native, Asian, Native Hawaiian, or Other Pacific Islander). Hereafter, we refer to these ethnic groups as Whites, Blacks, Hispanics, and other race. Since Black youth exhibit lower rates of tobacco use than other racial groups,[3,24,25] they were treated as the racial reference group.

#### Year of Survey Administration

We used data from three surveys conducted in years 2011, 2013, or 2015. In all models, 2011 was treated as the reference year.

#### Control Variables

Age (14 or less, 15, 16, 17 or higher) and sex (0 = male, 1 = female) were modeled as control variables.

### Statistical Analysis

We began with descriptive statistics to understand the data distribution. Then, bivariate and main effect multinomial regression models were estimated to examine the association of racial group and survey year to "nonuse," "mono use," "dual use," and "poly use" of tobacco products. Next, an interaction term between "racial group × survey year" was included in the multivariate model to assess possible changes over time in racial disparities in mono, dual, and poly use of tobacco products. We estimated the models twice: once with "nonuse" as the reference category and once with "mono use" as the reference category. We report relative risk ratios (RRR) and their associated 95% confidence intervals. We also estimated weighted marginal percentages of nonuse, mono, dual, and poly use by race and survey year using results from the fully adjusted models. Lastly, we estimated weighted percentages of tobacco product types and product combinations that are most commonly used by mono, dual, and poly users by race and survey year. All multivariate models adjusted for students' age and sex. All analyses were weighted to account for the complex survey design and sampling weights using STATA 13.0.

## Results

### Sample Characteristics

Participants were high school students in grades 9–12 (Table 1). Across survey years, slightly over half of students were White, about a third were Black, between 8% (in 2011) and 13% (in 2015) were Hispanic, and between 4% and 7% were from other race (including American Indian or Native American, Native Hawaiian or Pacific Islander, or Asian). Fifty percent were male at each survey year. Over 70% of students reported nonuse of tobacco products: 76% in 2011, and 74% in 2013 and 2015. Prevalence of mono use was 12% in 2011 and 2013 and 13% in 2015. Dual use was 6% across all three survey years, and poly use was 6%, 8%, and 7%, respectively, in years 2011, 2013 and 2015.

### Racial Disparities

Table 2 displays results from main effect multinomial regression models using data pooled across all three survey years ($n$ = 11 485). Compared with Black students, White students had a higher relative

**Table 1.** Sample Characteristics of High School Students, NC Youth Tobacco Survey (NCYTS), Weighted Estimates

| | Overall sample | Sample stratified by survey year | | |
|---|---|---|---|---|
| | 2011–2015 (n = 11 485) | 2011 (n = 4572) | 2013 (n = 3859) | 2015 (n = 3054) |
| | % | % | % | % |
| Race | | | | |
| Non-Hispanic Black | 28 | 31 | 27 | 26 |
| Non-Hispanic White | 55 | 57 | 55 | 54 |
| Hispanic/Latino | 11 | 8 | 11 | 13 |
| Non-Hispanic Other | 6 | 4 | 7 | 7 |
| Age | | | | |
| 14 or less | 20 | 21 | 20 | 20 |
| 15 | 26 | 25 | 25 | 27 |
| 16 | 25 | 25 | 24 | 24 |
| 17 or older | 29 | 28 | 30 | 29 |
| Sex | | | | |
| Male | 50 | 50 | 50 | 50 |
| Female | 50 | 50 | 50 | 50 |
| No. of tobacco products used in past 30 days | | | | |
| None—nonuse | 75 | 76 | 74 | 74 |
| One—mono use | 12 | 12 | 12 | 13 |
| Two—dual use | 6 | 6 | 6 | 6 |
| Three or more—poly use | 7 | 6 | 8 | 7 |

Non-Hispanic Other includes American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander.
Overall sample = sample pooled across all survey years.

**Table 2.** Adjusted Main Effect Multinomial Regression Models Examining Trends and Ethnic Disparities in Tobacco Product Use Among High School Students, North Carolina Youth Tobacco Survey (NCYTS) 2011–2015, Weighted Estimates ($n$ = 11 485)

| | Mono vs. Nonuse | Dual vs. Nonuse | Poly vs. Nonuse | Dual vs. Mono use | Poly vs. Mono use |
|---|---|---|---|---|---|
| | RRR (95% CI) | RRR (95% CI) | RRR (95% CI) | RRR (95% CI) | RRR (95% CI) |
| Race | | | | | |
| Non-Hispanic Black | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Non-Hispanic White | 1.21* | 1.85*** | 3.11*** | 1.53** | 2.57*** |
| | (1.04 to 1.41) | (1.42 to 2.41) | (2.39 to 4.05) | (1.17 to 1.99) | (1.95 to 3.39) |
| Hispanic/Latino | 1.01 | 1.41* | 2.12*** | 1.39 | 2.10*** |
| | (0.79 to 1.29) | (1.04 to 1.90) | (1.50 to 3.00) | (0.94 to 2.06) | (1.45 to 3.04) |
| Non-Hispanic Other | 1.10 | 1.52 | 1.56 | 1.38 | 1.42 |
| | (0.73 to 1.64) | (0.91 to 2.52) | (0.93 to 2.61) | (0.77 to 2.49) | (0.77 to 2.60) |
| Survey year | | | | | |
| 2011 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2013 | 1.09 | 0.97 | 1.48*** | 0.89 | 1.35* |
| | (0.90 to 1.32) | (0.75 to 1.26) | (1.18 to 1.85) | (0.69 to 1.14) | (1.04 to 1.76) |
| 2015 | 1.10 | 0.93 | 1.14 | 0.85 | 1.04 |
| | (0.88 to 1.35) | (0.71 to 1.22) | (0.88 to 1.47) | (0.65 to 1.11) | (0.77 to 1.40) |

Models adjusted for age and sex; interactions between race and survey year were estimated and found not significant.
Nonuse and mono use were treated as the reference categories: *$p$ < .05, **$p$ < .01, ***$p$ < .001.

risk for mono ($RRR_{\text{mono use vs. nonuse}}$ = 1.21, 95% CI 1.04 to 1.41), dual ($RRR_{\text{dual use vs. nonuse}}$ = 1.85, 95% CI 1.42 to 2.41), and poly use ($RRR_{\text{poly use vs. nonuse}}$ = 3.11, 95% CI 2.39 to 4.05) relative to nonuse of tobacco products. Hispanics did not statistically differ from Black student in their relative risk for mono use, but had a higher relative risk than Blacks for dual ($RRR_{\text{dual use vs. nonuse}}$ = 1.41, 95% CI 1.04 to 1.90) and poly use ($RRR_{\text{poly use vs. nonuse}}$ = 2.12, 95% CI 1.50 to 3.00) relative to nonuse. Students from "other race" did not statistically differ from Black students in their relative risk for mono, dual, or poly use relative to nonuse of any product.

We re-estimated the same model with mono use treated as the reference category (Table 2). White students had a higher relative risk for dual ($RRR_{\text{dual use vs. mono use}}$ = 1.53, 95% CI 1.17 to 1.99) and poly use ($RRR_{\text{poly use vs. mono use}}$ = 2.57, 95% CI 1.95 to 3.39) than Black students. Neither Hispanics nor students from other race significantly differed from Blacks in their relative risk for dual use relative to mono use. Hispanic students, however, had a higher relative risk than Blacks for poly use ($RRR_{\text{poly use vs. mono use}}$ = 2.10, 95% CI 1.45 to 3.04) compared with mono use.

## Trends Over Time

Relative to nonuse of tobacco products, there was no statistically significant change in mono or dual use of tobacco products over time (Table 2). There was a statistically significant increase in the relative risk for poly use in 2013 relative to 2011 (RRR = 1.48, 95% CI 1.18 to 1.85) but no significant change in 2015 (RRR = 1.14, 95% CI 0.88 to 1.47). Post hoc multiple comparisons using Bonferroni's adjustment show a statistically significant increase in poly use in 2013 (8%) compared with 2011 (6%), but no significant change in poly use prevalence in 2015 (7%) compared with 2013. Similar time trends in dual and poly use were observed when we treated mono use as the reference category.

## Changes in Racial Disparities Over Time—Interaction Effects

Interactions between racial group and survey year were estimated to examine changes in racial disparities over time in mono, dual, and polytobacco use. No statistically significant interactions were observed indicating no statistically significant changes in racial disparities in mono or multiple tobacco product use between 2011 and 2015 (results not shown in Tables).

Figure 1 presents weighted prevalence and associated 95% confidence intervals of mono, dual, and poly use by race and survey year. Across all survey years, Black students had the lowest prevalence of dual and poly use, whereas White students had the highest prevalence of dual and poly use. Except for Blacks in 2011 where poly use prevalence (2.9%) was considerably lower than dual use (4.5%), across all racial groups in all survey years, poly use prevalence was similar to or, in most cases, greater than dual use prevalence.

## Racial Variations in Types of Tobacco Products Used by Youth

Time and racial variations were observed in the types of tobacco products most commonly used by mono, dual, and poly users. Among mono users (Table 3), cigarettes and SLT were the most commonly used products among Whites in 2011, whereas cigarettes and cigars were most commonly used among Blacks, Hispanics, and youth of other races. In 2013, cigarettes and cigars were most commonly used by youth of all racial groups. In 2015, e-cigarettes became the most commonly used product among all racial groups (58%, 43%, 52%, and 34% for Whites, Blacks, Hispanics, and other race, respectively), followed by cigarettes among Whites (21%), Blacks (26%), and Hispanics (25%), and by pipe tobacco among youth from other race (30%). While SLT was the third most common product used by White mono users in 2015 (13%), cigars were the third most commonly used product among Black (18%) and Hispanic (10%) mono users.

Among dual users, 24 different combinations of products used emerged. Table 3 presents the most common of these combinations. In 2011 and 2013, cigarettes and cigars was the most common combination of two products used by dual users from all racial groups. In 2015, cigarettes and e-cigarettes was the most common combination used among Whites (34%), e-cigarettes and cigars was the most common combination used among Blacks (35%), cigarettes and

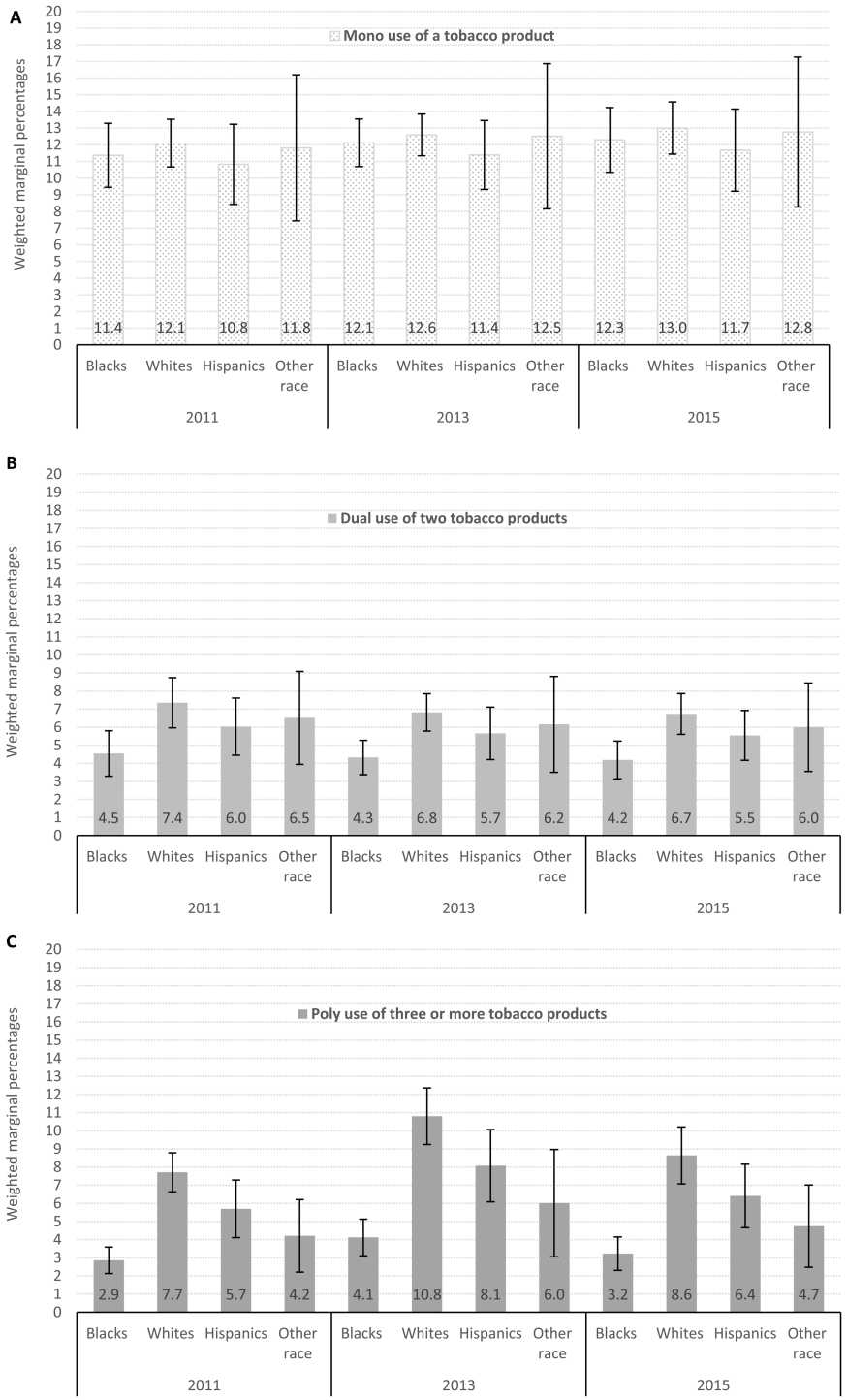


**Figure 1.** Weighted marginal predictions (%) of (A) mono, (B) dual, and (C) poly use of tobacco products by race and survey year, estimated based on results from adjusted multinomial regression models using the full sample. Error bars represent 95% confidence intervals.

cigars was the most common combination used among Hispanics (36%), and e-cigarettes and SLT was the most common combination used by other race students (27%).

There were 184 different combinations of products used among youth poly users. Table 3 presents weighted percentages of the most common combinations of three products used together with or without OTPs among poly users. A combination of cigarettes, cigars, and SLT was most commonly used by White poly users in 2011 (44%) and 2013 (37%). In 2013, a combination of cigarettes, cigars, and e-cigarettes was equivalently common among Whites (37%), and in 2015, this combination became the most commonly used combination by White poly users (53%). For Black and Hispanic poly users, a combination of cigarettes, cigars, and pipe tobacco was most common in 2011, whereas the combination of cigarettes, cigars, and e-cigarettes

**Table 3.** Most Common Tobacco Product Types and Product Combinations Used by Youth Mono, Dual, and Poly Users by Race and Survey Year, Weighted Estimates

| | 2011 | | | | 2013 | | | | 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | White | Black | Hispanic | Other | White | Black | Hispanic | Other | White | Black | Hispanic | Other |
| Mono users (*n* = 1387) | | | | | | | | | | | | |
| Cigarettes | 56 | 48 | 53 | 50 | 34 | 33 | 37 | 52 | 21 | 26 | 25 | 23 |
| Cigars | 15 | 41 | 18 | 25 | 25 | 35 | 23 | 20 | 6 | 18 | 10 | 9 |
| SLT | 18 | 4 | 7 | | 18 | 12 | 4 | 9 | 13 | 4 | 3 | 2 |
| Pipe | 2 | 2 | 3 | 11 | 2 | 10 | 8 | 3 | 1 | 5 | 4 | 30 |
| E-cigarettes | 2 | | 3 | 2 | 15 | 7 | 14 | 5 | 58 | 43 | 52 | 34 |
| Clove | | 1 | 5 | | 1 | | 2 | | | 2 | | |
| Hookah | 6 | 1 | 11 | 9 | 5 | 4 | 13 | 12 | 1 | 2 | 7 | 2 |
| Other products[a] | 2 | 2 | 1 | 2 | | | | | 1 | | | |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Dual users (*n* = 728) | | | | | | | | | | | | |
| Cigarettes, Cigars | 38 | 85 | 65 | 72 | 20 | 47 | 40 | 25 | 8 | 10 | 36 | 9 |
| Cigarettes, SLT | 17 | | 8 | 11 | 13 | 3 | | | 10 | 3 | | 15 |
| Cigarettes, Pipe | 4 | 3 | | | 4 | 1 | 4 | | | 2 | | |
| Cigarettes, E-cigarettes | 2 | | | | 19 | 4 | 13 | 8 | 34 | 9 | 19 | 25 |
| Cigarettes, Hookah | 6 | 3 | 2 | | 6 | 7 | 11 | | | 7 | | 11 |
| Cigarettes, Dissolvables | 1 | | | 8 | | | | | | | | |
| Cigars, SLT | 6 | 2 | | | 7 | 4 | 3 | 15 | | | 9 | |
| Cigars, Pipe | 3 | | 14 | | 3 | 2 | | | | 5 | | |
| Cigars, E-cigarettes | | | | | 9 | 8 | | 1 | 19 | 35 | 19 | 9 |
| Cigars, Hookah | 4 | 3 | | 2 | 1 | 3 | 2 | 1 | | | 9 | |
| SLT, E-cigarettes | | | | | 5 | 3 | | 4 | 9 | 1 | 4 | 27 |
| Pipe, E-cigarettes | | | | | | 2 | | 21 | 3 | 10 | 5 | |
| Pipe, Hookah | 3 | | | | 4 | 8 | 9 | 7 | 1 | 2 | | |
| E-cigarettes, Hookah | | | | | 3 | | 6 | 20 | 4 | 11 | | |
| Other combinations | 16 | 3 | 12 | 7 | 7 | 9 | 12 | | 13 | 7 | | 4 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Poly users (*n* = 811) | | | | | | | | | | | | |
| Cigarettes, Cigars, SLT | 44 | 32 | 39 | 28 | 37 | 10 | 27 | 40 | 31 | 14 | 32 | 42 |
| Cigarettes, Cigars, Pipe | 30 | 36 | 63 | 44 | 26 | 23 | 28 | 51 | 30 | 37 | 37 | 38 |
| Cigarettes, Cigars, Snus | 21 | 6 | 23 | 9 | 18 | 2 | 14 | 22 | 16 | 6 | 10 | |
| Cigarettes, Cigars, Hookah | 23 | 17 | 40 | 19 | 28 | 18 | 30 | 22 | 24 | 24 | 17 | 24 |
| Cigarettes, Cigars, Bidis | 13 | 15 | 47 | 56 | 13 | 10 | 31 | 15 | 15 | 12 | 23 | 32 |
| Cigarettes, Cigars, E-cigarettes | 17 | 12 | 29 | 23 | 37 | 15 | 26 | 10 | 53 | 55 | 58 | 92 |
| Cigarettes, Cigars, Dissolvables | 6 | | 24 | 19 | 7 | 1 | 5 | 4 | 7 | 9 | 5 | 24 |
| Cigarettes, SLT, E-cigarettes | 14 | 7 | 22 | 26 | 26 | 9 | 13 | 7 | 41 | 17 | 29 | 33 |
| Cigarettes, SLT, Snus | 30 | 13 | 23 | 8 | 20 | 2 | 10 | 10 | 15 | 6 | 12 | |
| Cigarettes, Pipe, Hookah | 22 | 18 | 37 | 21 | 21 | 30 | 27 | 22 | 19 | 28 | 11 | 24 |
| Cigars, SLT, E-cigarettes | 11 | | 22 | 21 | 20 | 7 | 10 | 7 | 34 | 14 | 28 | 33 |
| Cigars, SLT, Pipe | 17 | 15 | 29 | 34 | 16 | 3 | 21 | 12 | 18 | 10 | 18 | 8 |
| Cigars, SLT, Hookah | 19 | 9 | 21 | 38 | 17 | 6 | 16 | 5 | 18 | 18 | 12 | |
| Cigars, E-cigarettes, Pipe | 5 | | 28 | 19 | 13 | 14 | 17 | 7 | 27 | 34 | 38 | 30 |
| Cigars, E-cigarettes, Hookah | 8 | 5 | 25 | 19 | 22 | 16 | 22 | 5 | 22 | 33 | 15 | 24 |
| Cigars, Pipe, Hookah | 16 | 9 | 40 | 37 | 19 | 32 | 23 | 22 | 15 | 26 | 11 | 24 |
| Cigars, Bidis, Clove | 11 | 15 | 43 | 44 | 11 | 9 | 33 | 12 | 14 | 10 | 23 | 32 |

*n* reflect the unweighted sample size; numbers are weighted percentages rounded to the nearest whole number; empty cells represent zero or less than 0.5% use prevalence. Poly use constitutes use of three or more tobacco products; hence, column percentages for this group add up to more than 100%.
SLT = smokeless tobacco.

was the most common in 2015. Across years, combining cigarettes and/or cigars with Bidis and/or Clove cigarettes and combining cigarettes, cigars, or e-cigarettes with pipe and hookah smoking were particularly high among Hispanics and other race poly users.

## Discussion

In this study, we examined racial disparities in mono, dual, and polytobacco use among high school youth in North Carolina over three time periods (2011, 2013, and 2015), as well as types of tobacco products most commonly used by youth from different racial groups. Supporting earlier work,[3,24,25] our analyses indicate that relative to Black youth, White youth exhibit a higher relative risk for mono use of tobacco, as well as significantly higher risk for multiple tobacco product use. Hispanics show a higher relative risk than Blacks for multiple tobacco product use. We also found substantial racial variations in the types of tobacco products used by youth mono, dual, and poly users between 2011 and 2015.

It is unclear why Black students are less likely to use single or multiple tobacco products than Whites or Hispanics. Some past

studies have highlighted psychosocial factors as contributors to variations between White and African American youth in smoking initiation and progression to regular tobacco use.[25,34–36] Specifically, weaker pro-smoking attitudes and social environments that are less conducive of smoking (eg, having less friends who smoke, parental disapproval of smoking, and stronger religious ties) explain much of the lower rates of cigarette smoking among Black youth relative to Whites.[25,34–36] As such, it is possible that similar psychosocial influences prevent Black youth from using OTPs as well, leading to lower prospect for multiple tobacco product use. Understanding factors that protect Black youth from using tobacco as well as factors that drive tobacco use among White and Hispanic youth is an important research priority. While psychosocial influences are important to consider, other factors related to marketing exposure and product characteristics may be influential as well and could potentially be changed by policy. Tobacco product characteristics (eg, enticing characterizing flavors), tobacco marketing receptivity, and reduced harm perceptions of tobacco use are significant correlates of multiple tobacco product use relative to exclusive cigarette use.[9] However, whether those play a role in explaining racial disparities in multiple tobacco product use remains unclear and should be explored in further research. In addition, there is a need to understand, despite the lower tobacco use rates among Black youth in adolescence, when and why Blacks start to use some tobacco products at higher rates than Whites in adulthood.[37,38]

Despite decreases in cigarette smoking among high schoolers,[3] tobacco use remains high. National data show that cigarette use among high school students decreased from 15.8% in 2011 to 9.2% in 2014, whereas tobacco use prevalence remained unchanged at about 24%.[3] This is mainly due to increasing use of OTPs, primarily e-cigarette and hookah use that increased from 1.5% to 13.4% and from 4.1% to 9.4% in 2011 and 2014, respectively.[3] Consistent with these data, our results show that the decrease in cigarette use between 2011 and 2015 co-occurred with increases in cigar, SLT, pipe, hookah, and e-cigarette use in that same period, with the highest increases occurring between 2011 and 2013 (data not shown in tables). These findings suggest that youth not using cigarettes are turning to OTPs and raise concerns on whether existing tobacco prevention and cessation programs, especially if designed to curb cigarette smoking, are adequate in capacity and can effectively address youth use of OTPs and youth use of multiple tobacco products. At the local level, increases in OTP use among youth are particularly alarming given the 2011–2012 massive funding cuts and ending of the Teen Initiative—a North Carolina statewide teen tobacco use prevention and cessation program.[39]

Although racial disparities in the prevalence of mono, dual, or poly use did not change between 2011 and 2015, substantial racial variations were observed in the types of tobacco products used by mono, dual, and poly users over that period. For example, in 2011 and in 2013, cigarettes and cigars were the most commonly used products by all racial groups. SLT, however, was more commonly used among Whites, while cigars were significantly more prevalent among Blacks. In 2015, e-cigarettes became the most commonly used product among all racial groups, while use of cigarettes, cigars, SLT, pipe, and hookah remained particularly high. Notably, the majority of youth who used multiple tobacco products (ie, dual and poly users) used cigarettes with OTPs, suggesting that youth are using OTPs in addition to cigarettes rather than as substitute forms of tobacco in place of cigarettes. Further, with the exception of Blacks among which dual and poly use prevalence was fairly equivalent, among all other race groups poly use was persistently higher than dual use. Moreover, our data suggest that the majority of youth poly users use more than three tobacco products at a time. Such findings are particularly concerning given the health risks associated with multiple tobacco product use.

The wide variability in products used by youth has significant policy implications, as the decline in use of some products (eg, cigarettes) seems to mirror the rise in use of OTPs (eg, cigars, e-cigarettes, hookah, and pipe). Indeed, stronger regulations related to cigarette marketing, taxation, flavor ban, packaging, and other antismoking media campaigns are likely at the heart of observed decreases in cigarette use among youth.[40–43] On the other hand, weaker regulatory oversight over OTPs (eg, cigar and e-cigarettes) including lower taxes and cheaper prices,[44,45] characterizing flavors,[45,46] and weaker advertising restrictions[47] may also be at the heart of increases in use of OTPs among youth. Strengthening regulations of tobacco products other than cigarettes, in the United States and worldwide, and media campaigns to counter misperceptions about OTPs are potentially key strategies to reducing multiple tobacco use among youth.

## Limitations

This study has some limitations. Data used in this study were only collected from youth who attended either public or charter high schools in North Carolina and might not be generalizable to all high school-aged youth in North Carolina or nationally. In addition, the sample consisted only of youth enrolled in school and did not include youth dropouts or youth not enrolled in school, who may have higher rates of tobacco use. Data on tobacco use were self-reported; hence the results may be subject to related biases, such as recall or response biases. Mono, dual, and poly use estimates were calculated by including students who reported use data for all ten tobacco products. Students with missing data on any of the 10 tobacco products were excluded from the analytic sample. Missing data on tobacco use variables were very small (1%–3%); hence, we expect little or no impact on our estimates. Questions on cigar use assessed use of any type of cigar, including large or little cigars, and cigarillos. Thus, deriving use estimates for each type of cigar separately was not possible. Also, previous studies on cigar use among youth found that brand-specific cigar use assessment that clarifies to youth what constitutes a cigar (compared with a generic assessment) increases the reported rate of use.[48,49] Since our cigar use questions did not include brand name examples, our results may underestimate how prevalent cigar use is among North Carolina youth.

Students who selected multiple race groups were assigned to a single race category based on a predetermined assignment rule. This approach to race categorization may have introduced some measurement error by retaining incomplete information about respondents' reported races. In addition, due to small sample sizes, we were unable to distinguish between Asians, American Indian or Alaska Native, and Native Hawaiian or Other Pacific Islander, and those groups were combined into one race group. This classification may have prevented us from observing how each group differed relative to Black youth as previous research has shown, for example, that Asian American have the lowest rates of smoking.[25] Lastly, small sample sizes of dual and poly users across racial groups may have resulted in inadequate statistical power to detect population overtime changes in racial disparities in dual and poly use.

## Conclusions

Tobacco use has not decreased between 2011 and 2015 among high school youth in North Carolina, and a significant number of youth are using multiple tobacco products concurrently as either dual or poly users. Mono tobacco product use was significantly higher among White youth compared to Black youth. Multiple tobacco product use was significantly higher among White and Hispanic youth relative to Black youth. These racial differences did not change between 2011 and 2015; however, substantial racial variation was observed in the types of tobacco products used by mono, dual, and poly users. Cigarettes, cigars, SLT, and e-cigarettes were the most commonly used tobacco products among all racial groups, whereas pipe and hookah were particularly prevalent among Hispanics. Research to disentangle factors that drive or protect youth against tobacco use is needed along with strengthening tobacco control regulations of OTPs to reduce multiple tobacco product use among youth. Attention should be given to the types of products used by racial groups as such variations may warrant tailored prevention efforts.

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## Declaration of Interests

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