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Examining Sex and Racial/Ethnic Differences in Co-Use of Alcohol, Cannabis, and Cigarettes in a Community Sample of Adolescents

Juliann B. Purcell^{a,*}, Catheryn A. Orihuela^a, Marc N. Elliott^b, Susan Tortolero Emery^c, Mark A. Schuster^{d,1}, Sylvie Mrug^a

^aUniversity of Alabama at Birmingham, 1720 2nd Ave S., Birmingham, AL 35294, USA

^bRAND Corporation, 1776 Main Street, Santa Monica, CA 90401, USA

^cUniversity of Texas Health Science Center, 7000 Fannin Street, Houston, TX 77030, USA

^dBoston Children's Hospital and Harvard Medical School, 300 Longwood Avenue, Boston, MA 02115, USA

Abstract

Introduction: Although adolescents often co-use alcohol, cigarettes, and cannabis, little is known about sex and racial/ethnic differences in the co-use of these substances. Therefore, the present investigation examined sex and racial/ethnic differences in alcohol, cigarette, and cannabis co-use in a large and ethnically diverse.

Methods: Participants were drawn from a large, multi-site study of adolescents from three regions in the United States (N=4,129; M_{age}=16.10 years, SD=0.59; 51% female, 49% male; 37% Black, 37% Hispanic, 25% White). Participants were categorized into 8 mutually exclusive groups based on their self-reported use of alcohol, cannabis, and cigarettes in the last 30 days.

Results: Unadjusted multinomial logistic regression revealed that males were more likely than females to use cannabis-only and to co-use all three substances. Additionally, Black and Hispanic adolescents were more likely to use cannabis-only, while White adolescents were more likely than Black and Hispanic adolescents to co-use alcohol-and-cigarettes. After adjusting for other sociodemographic variables (age, household income, parental education, and parent marital status), males were more likely to use cannabis-only than females; White youth were more likely than Hispanic youth to use cigarettes-only and co-use cigarettes-and-alcohol. White youth were more likely than Black youth to co-use alcohol-and-cigarettes and co-use all three substances.

Discussion: These results indicate sex and racial/ethnic differences in substance co-use that were not explained by socioeconomic factors. Results of the present work suggest potential

*Corresponding Author: Juliann B. Purcell, University of Alabama at Birmingham, Department of Psychology, CH 201 1720 2nd Ave South, Birmingham, AL 35294, USA. juliannp@uab.edu.

¹Present Address: Mark A. Schuster, Kaiser Permanente Bernard J. Tyson School of Medicine, 98 S Los Robles Ave, Pasadena, CA 91101, USA

Declaration of interest

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strategies for targeted prevention efforts and underscore the importance of continued efforts to better understand patterns of alcohol and substance co-use.

Keywords

alcohol use; cigarette use; cannabis use; polysubstance use; adolescence

Introduction

Although rates of adolescent substance use have been declining in general over the last decade (Johnston et al., 2017b, 2019b), a large proportion of adolescents still use substances. Since the year 2000, prevalence of 30-day alcohol use for 12th graders has ranged between 30% – 50% in most recently available data (Johnston et al., 2019b). In the same time frame, 12th graders' prevalence of 30-day cigarette use has also decreased, ranging from between 6% – 30% (Johnston et al., 2019b). Finally, prevalence of 30-day cannabis use for 12th graders has remained relatively stable since the year 2000, with prevalence rates hovering around 22% (Johnston et al., 2019b). Alcohol, cigarettes, and cannabis have historically been the most commonly used substances during adolescence (Kann et al., 2016), although since 2017, vaping has surpassed cigarette use (Johnston et al., 2019b; Kann et al., 2018). Alcohol, cigarettes, and cannabis are often examined individually in adolescent prevalence studies, despite evidence that adolescents often use them concurrently (Tomczyk, Isensee, et al., 2016). Substance co-use is associated with less favorable outcomes than single-substance use, including poorer physical and psychological health (Bhalla et al., 2018; Johnson & Richter, 2002; Neumann et al., 2018), increased involvement in delinquency, and decreased educational achievement (Hoffman et al., 2001; Kelly, Chan, et al., 2015; Kokkevi et al., 2014). Thus, a better understanding of how adolescents co-use alcohol, cigarettes, and cannabis is necessary.

Previous work has consistently found sex differences in patterns of alcohol, cigarette, and cannabis use (Chen & Jacobson, 2012; Johnston et al., 2017a; Kann et al., 2018; Kokkevi et al., 2014). Most often, males have a higher prevalence of use than females, although there is not presently a theoretical framework explaining these sex differences (Chen & Jacobson, 2012; Johnston et al., 2017b, 2019b; Kann et al., 2018). Discrepancies in sociocultural expectations are one factor that may contribute to sex differences in substance use (Ohannessian et al., 2016), although additional work is necessary to better understand these differences. Despite consistent evidence of sex differences in single-substance use, few studies have explored possible sex differences in substance co-use. One such investigation surveyed a large sample of 16-year-old European adolescents. Results indicated a higher prevalence of tobacco-and-alcohol co-use, alcohol-and-cannabis co-use, and alcohol-tobacco-and-cannabis co-use for males compared to females (Kokkevi et al., 2014). Males and females did not differ, however, in reported prevalence of tobacco-and-cannabis co-use (Kokkevi et al., 2014). Another study examined sex differences in substance co-use in an American group of adolescents, ages 12 – 18. This study found that females were more likely than males to use alcohol-only, while males were more likely to belong to all other substance use groups (Banks et al., 2017). Thus, evidence suggests that males may be at higher risk of substance co-use than females.

Similarly, many large investigations have found racial/ethnic differences in patterns of alcohol, cigarette, and cannabis use (Chen & Jacobson, 2012; Johnston et al., 2017a, 2019a; Kann et al., 2018; Kokkevi et al., 2014). Most often, White adolescents have higher prevalence of alcohol and substance use compared to Black and Hispanic adolescents, though these patterns have been variable over time (Chen & Jacobson, 2012; Hoffman et al., 2001; Johnston et al., 2017b, 2019b; Kann et al., 2018). In the most recent reports from the Monitoring the Future (MTF) studies, racial/ethnic differences in 30-day prevalence of alcohol and cigarette use indicate increased prevalence among White adolescents compared to their Black or Hispanic peers (Johnston et al., 2019a). Prevalence of cannabis use has been associated with less consistent racial/ethnic differences (Johnston et al., 2019a). The most recent results from the MTF indicated that prevalence of 30-day cannabis use may have increased for Black adolescents over the last several years, surpassing White adolescents' use (Johnston et al., 2019a). Theory-driven models of racial/ethnic differences in alcohol and substance use are limited. Some models focus on racial/ethnic minority youth's increased exposure to risk factors (e.g., discrimination, physical victimization, limited social support; Ash-Houchen & Lo, 2020; Feldstein Ewing et al., 2011; Steele, 2016), but do not explain the generally lower prevalence of substance use among racial/ethnic minority youth. Additionally, these theories take a deficit perspective of racial/ethnic minority groups, which may be less useful than focusing on protective factors that exist for ethnic minority individuals and communities (e.g., ethnic belonging, increased religiosity, and cultural norms; Bowman Heads et al., 2018; Germán et al., 2009; Gil et al., 2000; Ransome & Gilman, 2016; Romero & Ruiz, 2007; Rote & Brown, 2013; Zapolski et al., 2014). However, a theoretical framework systematically explaining racial/ethnic differences in substance use has yet to be developed. Despite evidence of racial/ethnic differences, few studies have examined possible differences in substance co-use. One investigation found that racial/ethnic minority groups (Asian, Black, Hispanic, and Native American) were more likely to use cannabis-only, rather than co-use cannabis with other substances, with one exception. Black adolescents were more likely to co-use alcohol-and-cannabis than White youth (Banks et al., 2017).

There have been few investigations into adolescent substance co-use, leaving several important questions unanswered. The few investigations on this topic have provided important information on sex and racial/ethnic differences in co-use among adolescents who *already use* substances (Banks et al., 2017; Kokkevi et al., 2014). This information is valuable in the development of targeted treatment strategies but does not clarify whether there are sex and racial/ethnic differences in co-use between individuals who use substances and those who *do not use* substances. This question remains to be answered and represents an important contribution of the current study to the literature. A more thorough understanding of sex and racial/ethnic differences in substance co-use would aid in the development of more targeted prevention programs to help youth remain abstinent from substances or engage in less risky substance co-use. Further, although previous work consistently found sex and racial/ethnic differences in substance use, these two factors have been typically treated as independent dimensions (Banks et al., 2017; Chen & Jacobson, 2012; Johnston et al., 2017b, 2019a). The experiences of adolescents at intersecting identities (e.g., Black females compared to White females) remain largely unknown at this

time. Intersectionality acknowledges that various identities (e.g., race/ethnicity, sex, ability level, etc.) can impact a person in different ways, depending on the combination of these identities (Crenshaw, 1991). Although some researchers have advocated for applying an intersectional framework to the study of adolescent substance use (Mereish & Bradford, 2014), prior work examining adolescent co-use has not included the intersection (i.e., interactions) of sex and race/ethnicity.

Thus, the current investigation extends previous work in two important ways. First, the present study includes a non-using group as the reference, providing information on sex and racial/ethnic differences in users compared to non-users. As discussed above, prior work has focused on sex and racial/ethnic differences in co-use for adolescents who are already using substances. Second, the present investigation examined the interactive effects of sex and race/ethnicity in alcohol and substance co-use in an attempt to elucidate the intersectional nature of sex and race/ethnicity identities. We hypothesize that males will be more likely than females to be members of all substance use groups, compared to non-users. Additionally, we hypothesize that White adolescents will be more likely than Hispanic and Black adolescents to be members of all substance use groups, with one exception; given previous work, we hypothesize that Black adolescents will be more likely than White adolescents to be members of the cannabis-only category. Finally, we hypothesize that there will be larger sex differences between co-use for White males and females compared to Black and Hispanic males and females.

Materials and Methods

Participants

This study utilizes cross-sectional data from Wave 3 of Healthy Passages, a multi-site, longitudinal investigation of adolescent health behaviors (discussed in further detail below; Schuster et al., 2012). Data collection for Wave 3 took place between 2009 and 2011. The sample used in the present study consisted of 4,129 adolescents who completed Wave 3 (10th grade; $M_{age}=16.09$; $SD=0.59$). Further description of the sample is provided in Table 1.

The larger Healthy Passages study consisted of 5,147 children and their caregivers from three sites who were interviewed at three time points. At Wave 1, students were recruited from 5th-grade classrooms in public schools in Los Angeles, California; Birmingham, Alabama; and Houston, Texas (Windle et al., 2004). Schools were selected based on two-stage probability sampling. Design and nonresponse weights were computed and combined into a sampling weight representing the population of 5th-grade students in the sampled area; at Wave 3, the weights were further adjusted to account for differential attrition. Data collection for Waves 1-3 took place between 2004 and 2011. At each wave, the parent signed informed consents for themselves and their child and the child signed an assent. Individual interviews were conducted using a computer-assisted personal interview (CAPI). Sensitive questions (including those on substance use) were asked via an audio-computer-assisted self-interview (CASI). Children and parents were interviewed separately in private spaces and received gift cards for participating. Institutional review boards at all sites and the CDC approved the study procedures and materials. Only Wave 3 data (mean age 16) are used in

this project due to very low rates of substance use in the previous Waves (mean ages 11 and 13).

Measures

Background demographics—At Wave 1, parents reported their child’s sex and race/ethnicity. Child racial/ethnic identity was dummy-coded as Black, Hispanic, and White, with White as the reference category. Other racial/ethnic groups (6.2% of the sample) were omitted from the analyses due to their small size. Additional demographic information such as household income, parent education and marital status, and child age were obtained from parents at Wave 3. Annual household income was reported on a 16-point scale (1=<\$5,000 to 20=>\$250,000). Highest education completed by the primary caregiver was reported on a 7-point scale (1=8th grade or less to 7=more than a four-year college degree). Caregiver marital status was coded as 0 (*not married*) or 1 (*married*). Child age was computed based on parent reported child’s date of birth and date of interview.

Substance use—At Wave 3, youth were asked to report on the frequency of their cigarette, alcohol, and cannabis use in the last 30 days (0=0 days to 6=all 30 days). Responses were dichotomized (0=no use, 1=any substance use in last 30 days) and then combined into a single 8-category multinomial variable to indicate different co-use patterns in the last 30 days (no use, alcohol-only, cigarettes-only, cannabis-only, alcohol-and-cigarettes, alcohol-and-cannabis, cannabis-and-cigarettes, and all three substances).

Data Analysis

SPSS version 24 (IBM Corp., 2013) and Mplus version 7 (L. K. Muthén & Muthén, 2017) were used to carry out analyses. Preliminary analyses explored distributions and other descriptive statistics for all variables, including bivariate correlations between covariates, t-tests and chi-square tests examining whether the covariates differed between the sex or racial/ethnic groups, and a univariate ANOVA examining whether the alcohol and substance use groups differed on covariates. Chi-square tests determined whether the use of individual substances differed between males and females and among the three racial/ethnic groups. An analysis of co-occurrence was performed to determine whether co-occurrence of each pair of substances (i.e., alcohol with cigarettes, alcohol with cannabis, and cigarettes with cannabis) differed between males and females and among the three racial/ethnic groups. Understanding the rates of co-occurrence of each pair of substances is important in contextualizing results of the main analyses, as groups with greater use of each substance will also tend to have greater co-use. Phi correlation coefficients and approximated standard errors (McNemar, 1962) were used to calculate a z-test comparing the rate of co-occurrence between males and females and among the three racial/ethnic groups.

Main analyses were hierarchical multinomial logistic regressions testing the likelihood of being in each substance use category vs. being a non-user (the reference group) based on race/ethnicity, sex, and their interaction. Interaction terms were included in step 2 while all other variables were entered in step 1. Analyses accounted for the complex sampling design (stratification by site, clustering by school, and sampling weights). Regressions were first conducted without adjusting for additional sociodemographic covariates then repeated

with the following covariates: child age, household income, parent highest education, and parent marital status. Because the interaction term was not significant in either model, it was removed from the final models.

Results

Preliminary analyses

The analytic sample included 4,129 adolescents, with a nearly even split by sex and 37% Black, 37% Hispanic, and 25% White youth (see Table 1). Chi-square tests of independence did not find significant evidence that individuals lost to attrition at Wave 3 differed by sex or race/ethnicity from those who remained in the sample ($ps > 0.07$), though nonresponse weights would account for any differences. Nearly 70% of participants reported no past-month use of any of the three substances (Table 1). The alcohol-only group was the largest of the substance use categories at 12% of the sample. The cigarette-only and the cigarette-and-cannabis groups were the smallest, with only 2% of the sample included in each group. Bivariate correlations among the covariates are presented in Supplementary Table 1. All covariates (i.e., parental marital status, child's age, parental education, and household income) were significantly correlated (range $r=-0.08$ to 0.61). Although parental education and household income were moderately correlated ($r=0.61$; $p<0.001$), multicollinearity is typically defined by stronger relationships between variables (e.g., between 0.8 and 0.9). Therefore, multicollinearity was not present in the main analyses. Sex differences in covariates are presented in Supplementary Table 2. Briefly, males were slightly older than females and parents of male adolescents reported slightly higher household income. Racial/ethnic differences in covariates are presented in Supplementary Table 3. Briefly, parents of White adolescents reported the highest education and household income. Parents of Hispanic adolescents reported the lowest education, while parents of Black adolescents reported the lowest household income. Finally, the 8 alcohol and substance use groups differed in child's age, parental education, and household income. Detailed results are presented in Supplementary Table 4. Briefly, the non-use group was significantly younger than the cigarettes-only, the alcohol-and-cigarettes, and the alcohol-cigarettes-and-cannabis groups. Parents of adolescents in the non-use group reported higher education than parents of adolescents in the cigarettes-only and cannabis-only groups. Finally, the non-use group reported a higher household income than the cannabis-only group.

Chi-square tests of independence assessed sex and racial/ethnic differences in the use of each substance. These tests revealed racial/ethnic differences in past 30-day cigarette use among the three racial/ethnic groups ($\chi^2(2)=19.72$, $p<0.001$). Post-hoc analyses (Garcia-Perez & Nunez-Anton, 2003) with Bonferroni adjustment for multiple comparison ($p<0.008$) indicated greater prevalence of cigarette use in White adolescents (16.8%, *adjusted residual*=3.6) than in Hispanic adolescents (10.6%, *adjusted residual*=-4.0), with neither group significantly different from Black adolescents (14.1%, *adjusted residual*=0.8). There were no significant racial/ethnic differences for alcohol or cannabis use and no significant sex differences for any substance use.

Analyses of co-occurrence revealed no differences in co-occurrence of any pairs of substances between males and females (see Table 2). There were no differences in

co-occurrence of alcohol with cannabis among the three racial/ethnic groups. However, Hispanic adolescents had lower co-occurrence of cigarettes with both alcohol and cannabis compared to both White and Black youth ($|z|=2.47$ to 2.98 , $p=0.014$ to 0.003).

Main analyses

Multinomial regressions were run both without (Table 3) and with sociodemographic covariates (i.e., age, parental education, parental marital status, and household income; Table 4). In the unadjusted analyses, males were more likely to use cannabis-only than females (OR=1.65; 95% CI [1.11, 2.45]) and to co-use all three substances (OR=1.38; 95% CI [1.01, 1.88]). Additionally, Black and Hispanic adolescents were more likely to use cannabis-only than their White peers (OR=2.08; 95% CI [1.15, 3.76] and OR=2.17; 95% CI [1.19, 3.95], respectively). White youth were more likely to co-use alcohol-and-cigarettes compared to Black and Hispanic youth (Black youth: OR=0.31; 95% CI [0.17, 0.55]; Hispanic youth: OR=0.41; 95% CI [0.24, 0.72], respectively).

After accounting for sociodemographic covariates, males were still more likely to use cannabis-only than females (AOR=1.62; 95% CI [1.08, 2.44]; Table 4). White youth were still more likely to co-use alcohol-and-cigarettes compared to Black (AOR=0.22; 95% CI[0.11, 0.43]) and Hispanic (AOR=0.29; 95% CI[0.14, 0.62]) youth. Finally, White adolescents were more likely to use cigarettes-only than Hispanic adolescents (AOR=0.32; 95% CI [0.13, 0.82]) and were more likely to co-use all three substances than Black adolescents (AOR=0.48; 95% CI [0.30, 0.78]).

Among the sociodemographic covariates, older age was linked with greater likelihood of using cigarettes-only and co-using all three substances. Additionally, males and females differed slightly in age (Males: $M_{age}=16.13$ years; $SD=0.67$; Females: $M_{age}=16.06$ years, $SD=0.56$; $t(3923)=-3.53$, $p<0.001$). A univariate ANOVA found no difference in age among the three racial/ethnic groups ($F(2)=0.146$, $p>0.05$). Having unmarried parents was associated with greater likelihood of using alcohol-only, co-using cigarettes-and-cannabis, and co-using all three substances.

Discussion

Extending prior work in the field, the present investigation examined sex and racial/ethnic differences in substance use and co-use in a sample of both users and non-users. Sixty-eight percent of individuals in the present study did not report using any of the three substances in the last 30 days. Of those who did report using substances, the alcohol-only category was the largest (12%), followed by the alcohol, cigarette, and cannabis category (6%), which is consistent with previous work (Banks et al., 2017; Tomczyk, Pedersen, et al., 2016). The cigarettes-only and the cigarettes-and-cannabis groups represented the smallest groups at 2% of the sample each, which is also generally consistent with previous work (Banks et al., 2017). The analysis of co-occurrence did not find evidence of sex differences in the co-occurrence of alcohol, cigarettes, and cannabis. However, there were racial/ethnic differences in co-occurrence of alcohol, cigarettes, and cannabis. White adolescents reported greater prevalence of cigarettes-only use in the last 30 days than Hispanic adolescence, but the racial/ethnic groups did not differ in the prevalence of alcohol-only or cannabis-only use.

Similarly, Hispanic youth had lower co-occurrence of cigarettes with alcohol and cannabis than White and Black youth.

Results of the main analyses predicting co-use of the three substances indicated that at age 16, males were more likely to use cannabis-only and to co-use all three substances than females. However, when adjusting for SES factors, males and females no longer differed in the co-use of all three substances. Post-hoc power ranged from .03 to .88, suggesting that some comparisons were underpowered (e.g., main effects of sex for the alcohol-only vs. non-use group), while others were appropriately powered (e.g., the main effects of sex for the cannabis-only vs. non-use group). Power for the sex differences in all three vs. non-use comparison in the unadjusted model was .68 but dropped to .54 after adjusting for covariates. Thus, it is possible that this comparison was underpowered to detect effects in the adjusted model. Additionally, the slightly older age of males in the present sample may have also contributed to observed sex differences in co-use of all three substances (unadjusted model), given prior research indicating that increased age is linked with higher risk of substance co-use (Tomczyk, Pedersen, et al., 2016). Overall, these results indicate that males and females were equally likely to be members of each of the co-use groups, with the exception of the cannabis-only group, where males were more likely to be members than females.

In terms of race/ethnicity, unadjusted results indicated that Black and Hispanic youth were more likely to use cannabis-only, while White youth were more likely than either to co-use alcohol-and-cigarettes. After adjusting for SES factors, White youth were still more likely than Black and Hispanic youth to co-use alcohol-and-cigarettes, but the racial/ethnic groups no longer differed in the likelihood of using cannabis-only. Additionally, White youth were more likely than Hispanic youth to use cigarettes-only, and more likely than Black youth to co-use all three substances. In line with previous work (Banks et al., 2017; Kann et al., 2016), the present study found that the overall prevalence of cannabis-only use is higher among Black and Hispanic youth, compared to their White peers. However, our results also suggest that, at least for the cannabis-only group, racial/ethnic differences in use may also be driven by sociodemographic factors, such as parental education and marital status, and household income, rather than by race/ethnicity alone.

The interactive effects of sex and race/ethnicity were not significant in the present study. This was somewhat unexpected, given literature documenting that the impact of some protective factors (e.g., religious involvement, acculturation, family social support, acceptability of use within social networks, etc.) may differ between Black men and women and Hispanic men and women (Mulia et al., 2018; Ransome & Gilman, 2016; Rote & Brown, 2013). Many of these investigations find that alcohol and substance use for racial/ethnic minority women is lowered to a greater extent than men exposed to similar protective factors (Mulia et al., 2018; Ransome & Gilman, 2016; Rote & Brown, 2013). Post-hoc power analyses of the interactions, however, ranged from .03 to .40. Thus, analyses examining the interactive effects of sex and race/ethnicity were underpowered to detect small effects. The field will benefit from future work with larger sample sizes to more fully examine the intersectionality of sex and race/ethnicity in adolescent alcohol and substance co-use.

Results of the present study underscore the importance of contextualizing sex and race/ethnicity within larger society. For example, in this group of adolescents, parents of racial/ethnic minority youth were more likely to have lower income and education than parents of White youth. Additionally, the proportion of adolescents with unmarried parents was 2 times higher for Black youth than for White youth. Many studies include race/ethnicity as an independent variable or a nuisance variable to be “controlled”. While this approach may provide documentation of health disparities, it does not provide information about how factors associated with race/ethnicity relate to observed disparities. Some have suggested that psychology can play a significant role in addressing disparities associated with sex or race/ethnicity, but only if system-level differences in life experiences are considered (Volpe et al., 2019). The present results highlight the importance of considering how factors associated with sex and race/ethnicity (e.g., education, income, neighborhood factors, experiences of discrimination) might influence an individual’s behavior.

Prior work has found that racial/ethnic minority adolescents report lower rates of alcohol and substance use, in general (Chen & Jacobson, 2012; Johnston et al., 2017a, 2019a; Kann et al., 2018). It remains unclear why racial/ethnic minority identity is protective; however, several possible factors have been identified. *Familismo* is a fundamental aspect of Latin cultures and refers to a deep sense of connection and responsibility to one’s family (Dillon et al., 2013; Germán et al., 2009; Romero & Ruiz, 2007; Smith-Morris et al., 2013; Strunin et al., 2015). Prior research indicates that higher levels of *familismo* are protective against risky behaviors, including alcohol and substance use (Dillon et al., 2013; Gil et al., 2000; Lopez-Tamayo et al., 2016; Strunin et al., 2015). Of note, research indicates that different dimensions of *familismo* may not provide equivalent protection (Strunin et al., 2015) and that acculturation likely alters the protective nature of *familismo* (Lopez-Tamayo et al., 2016).

Other possible protective factors have been investigated specifically for Black youth. For example, increased identification with and pride in one’s racial identity was associated with less alcohol and substance use (Bowman Heads et al., 2018). Additionally, Black individuals tend to report higher religiosity, which may serve as a protective factor against risky behaviors, including alcohol and substance use (Ransome & Gilman, 2016). Others have suggested that lower alcohol and substance use for racial/ethnic minority youth may be the result of attempts to limit racial/ethnic stereotyping or racially-motivated punitive consequences of adolescent alcohol and substance use (Bowman Heads et al., 2018; Mulia et al., 2009; Zapolski et al., 2014). Factors associated with the protective nature of racial/ethnic minority identity are complex and vary both between individuals and potentially across the lifespan (Mulia et al., 2009; B. O. Muthén & Muthén, 2000).

The present results suggest several potential targets for intervention and prevention, as well as directions for future research. Prevention efforts preferentially targeting males’ cannabis use and White adolescents’ use of cigarettes, co-use of alcohol-and-cigarettes, and co-use of all three substances may be beneficial. Co-use of alcohol and other substances is consistently associated with more severe psychiatric symptomology (Kelly, Chan, et al., 2015) and greater risk of negative outcomes (Hedden et al., 2010; Kelly, Evans-Whipp, et al., 2015) compared to single-substance use. However, research examining outcomes of substance

co-use has only recently begun to emerge. More work is necessary to better understand the impact of substance co-use and investigate efficacy of treatment strategies. Additionally, future work should aim to better understand sex and racial/ethnic differences in factors associated with alcohol and substance use (e.g., use motivations, age of initiation, and the role of protective factors). Initiation of co-use is poorly understood at present, but a better understanding may be helpful in prevention efforts. Further, future work should explore the role of protective factors for racial/ethnic minority youth in the context of alcohol and substance co-use. The present study highlights the importance of considering relationships between race/ethnicity and SES factors. Analyses presented here represent a first step toward understanding relationships among race/ethnicity, SES, and alcohol and substance co-use, although more work is necessary. Future investigations should use purposeful sampling and analytic techniques to further characterize relationships among these factors.

The present work should be interpreted in the context of its limitations. The sample of adolescents was representative of the three sampled metropolitan areas; however, it was not nationally representative so findings may not generalize to adolescents in other regions. Additionally, although some of the co-use groups represented relatively small portions of the overall sample (e.g., 2% in the case of cigarettes-only), post-hoc power estimates for the main effects for the cigarettes-only vs, non-use group comparisons were .73, .37, and .86. Thus, some of the relatively small sample sizes did not necessarily mean that all main effect analyses were underpowered. However, some analyses in the adjusted model were certainly underpowered, with the interaction effects most considerably impacted, as discussed above. Larger studies with greater power are necessary to better understand how adolescent alcohol and substance use may differ between males and females and between racial/ethnic groups. Further, substance use was self-reported by the adolescents. Study procedures aimed to maximize validity of these reports (e.g., assuring youth of confidentiality and using a computer-assisted self-interview for these questions), however, these data could be susceptible to under-reporting. Additionally, the present investigation focused only on sex and racial/ethnic differences in alcohol and substance use and did not incorporate other factors that may be relevant to adolescent substance use (e.g., peer and parental use, attitudes about the harmfulness of alcohol and substances). The analyses presented here cannot fully separate race/ethnicity and SES. As discussed above, these variables are closely linked and future work should attempt to tease them apart through purposeful sampling of distinct subgroups in the population. Further, the present study focused on sex, rather than gender identity. Teasing apart the impacts of sex and gender identity will be an important next step for future work.

The data presented here are about a decade old. The landscape surrounding adolescent alcohol and substance use has changed significantly in recent years, particularly with respect to increased e-cigarette use and cannabis legalization. Prevalence of adolescent e-cigarette use and co-use has increased in recent years (Gilbert et al., 2020). Of note, racial/ethnic minority youth are less likely to co-use e-cigarettes with other substances (Gilbert et al., 2020), which is similar to the present finding of less prevalent co-use of alcohol and cigarettes among Black and Hispanic adolescents. The impact of recreational cannabis legalization on adolescent use has been unclear. Some investigations found increased cannabis use among adolescents following recreational legalization (Cerdá et al., 2017;

Miech et al., 2015). While others caution against using nationally-representative samples to investigate state-level trends, and found no evidence of increased adolescent use following recreational legalization with state-level data (Midgette & Reuter, 2020). Thus, future work should seek to clarify how patterns of adolescent substance co-use may have changed since the collection of these data. Despite these changes, the racial/ethnic disparities in income and education persist, even years after the data were collected (Musu-Gillette et al., 2016; Ryabov, 2020). Given that the present results indicate that sociodemographic factors may be responsible, at least in part, for racial/ethnic differences in alcohol and substance use, we believe the results of the current study remain relevant.

The present investigation examined the interactive effects of sex and race/ethnicity on alcohol and substance co-use, compared to non-use. Results provide several novel insights. Firstly, the present investigation sheds light on sex and racial/ethnic differences in alcohol and substance use, compared to a group of non-users. Additionally, the interactive effects of sex and race/ethnicity were examined and were found to be not significant in the present study. If this result is replicated in future work, it suggests that interventions need not be specialized for the intersection of sex and race/ethnicity, for example for Black females vs White females. Rather, interventions that are sensitive to sex and racial/ethnic differences may be sufficiently tailored. Further, the current study provides a more thorough understanding of the impact of demographic factors on alcohol and substance co-use. Sex and race/ethnicity are often included as nuisance variables or considered explanatory on their own. The present investigation underscores the importance of examining other explanatory variables related to sex and race/ethnicity. Considering results both with and without sociodemographic covariates allowed for a more comprehensive understanding of sex and racial/ethnic differences in adolescent co-use of common substances. Prevention and intervention efforts will be enhanced by greater knowledge of these and other factors related to adolescent alcohol and substance co-use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Descriptive statistics by sex and race/ethnicity proportion (%) for alcohol, cigarettes, and cannabis co-use in last 30 days.

	Overall N (%)	Black N (%)	Hispanic N (%)	White N (%)
Overall				
Female	2098 (51%)	811 (53%)	777 (50%)	510 (48%)
Male	2031 (49%)	713 (47%)	763 (50%)	555 (52%)
Total	4129 (100%)	1524 (100%)	1540 (100%)	1065 (100%)
No Use				
Female	1418 (68%)	540 (67%)	530 (68%)	348 (68%)
Male	1398 (69%)	500 (70%)	542 (71%)	356 (64%)
Total	2816 (68%)	1040 (68%)	1072 (70%)	704 (66%)
Any Use				
Female	680 (32%)	271 (33%)	247 (32%)	162 (32%)
Male	633 (31%)	213 (30%)	221 (29%)	199 (36%)
Total	1313 (32%)	484 (32%)	468 (30%)	361 (34%)
Alcohol only				
Female	273 (13%)	98 (12%)	106 (14%)	69 (14%)
Male	223 (11%)	70 (10%)	88 (12%)	65 (12%)
Total	496 (12%)	168 (11%)	194 (13%)	134 (13%)
Cigarettes only				
Female	45 (2%)	17 (2%)	17 (2%)	11 (2%)
Male	39 (2%)	13 (2%)	14 (2%)	12 (2%)
Total	84 (2%)	30 (2%)	31 (2%)	23 (2%)
Cannabis only				
Female	68 (3%)	33 (4%)	27 (3%)	8 (2%)
Male	70 (3%)	26 (4%)	29 (4%)	15 (3%)
Total	138 (3%)	59 (4%)	56 (4%)	23 (2%)
Alcohol and cigarettes				
Female	49 (2%)	18 (2%)	16 (2%)	15 (3%)
Male	54 (3%)	14 (2%)	16 (2%)	24 (4%)
Total	103 (3%)	32 (2%)	32 (2%)	39 (4%)
Alcohol and cannabis				
Female	95 (5%)	43 (5%)	35 (5%)	17 (3%)
Male	88 (4%)	28 (4%)	36 (5%)	24 (4%)
Total	183 (4%)	71 (5%)	71 (5%)	41 (4%)
Cigarettes and cannabis				
Female	40 (2%)	14 (2%)	11 (1%)	11 (2%)
Male	36 (2%)	19 (3%)	13 (2%)	8 (1%)
Total	76 (2%)	33 (2%)	24 (2%)	19 (2%)
Alcohol, cigarettes, cannabis				
Female	114 (5%)	48 (6%)	35 (5%)	31 (6%)

	Overall N (%)	Black N (%)	Hispanic N (%)	White N (%)
Male	119 (6%)	43 (6%)	25 (3%)	51 (9%)
Total	233 (6%)	91 (6%)	60 (4%)	82 (8%)

Note: All N represent raw values, while percentages represent weighted values.

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Table 2.

Phi coefficients and z-tests for analysis of co-occurrence.

	Alcohol with Cigarettes		Alcohol with Cannabis		Cigarettes with Cannabis	
	Phi (SE)	<i>p</i>	Phi (SE)	<i>p</i>	Phi (SE)	<i>p</i>
Sex						
Male	0.429 (0.03)	< 0.001	0.457 (0.03)	< 0.001	0.568 (0.02)	< 0.001
Female	0.430 (0.02)	< 0.001	0.485 (0.02)	< 0.001	0.549 (0.02)	< 0.001
Race/ethnicity						
Black	0.452 (0.03)	< 0.001	0.484 (0.03)	< 0.001	0.581 (0.03)	< 0.001
Hispanic	0.350 (0.03)	< 0.001	0.434 (0.03)	< 0.001	0.489 (0.03)	< 0.001
White	0.482 (0.03)	< 0.001	0.496 (0.03)	< 0.001	0.615 (0.03)	< 0.001
	Alcohol with Cigarettes		Alcohol with Cannabis		Cigarettes with Cannabis	
	<i>Z</i>	<i>p</i>	<i>Z</i>	<i>p</i>	<i>Z</i>	<i>p</i>
Male vs Female	-0.028	0.978	-0.798	0.425	0.551	0.582
Black vs White	-0.668	0.504	-0.269	0.788	-0.773	0.440
Hispanic vs White	-2.981	0.003	-1.405	0.106	-2.895	0.004
Black vs Hispanic	2.466	0.014	1.214	0.225	2.279	0.023

Note: Phi coefficients and z-tests for analyses of co-occurrence of pairs of substances. Significance of the phi coefficients indicates whether the value differs significantly from zero. Significance of Z-tests indicate whether the phi coefficients of the two groups differ. Bolded z-test values indicate instances where the two groups differ significantly.

Table 3.

Odds ratios and 95% confidence intervals from a multinomial logistic regression predicting membership in each substance use category from race/ethnicity and sex.

	Substance Use Category						
	Alcohol only	Cigarettes Only	Cannabis Only	Alcohol & Cigarettes	Alcohol & Cannabis	Cigarettes & Cannabis	Alcohol & Cigarettes & Cannabis
Sex ^a							
Male	0.99 (0.79, 1.24)	1.54 (0.93, 2.56)	1.65 (1.11, 2.45)	1.38 (0.86, 2.22)	1.05 (0.74, 1.48)	1.64 (0.95, 2.85)	1.38 (1.01, 1.88)
Race/ethnicity ^b							
Black	0.78 (0.58, 1.04)	1.26 (0.67, 2.38)	2.17 (1.19, 3.95)	0.31 (0.17, 0.55)	1.25 (0.80, 1.94)	1.06 (0.55, 2.04)	0.75 (0.51, 1.10)
Hispanic	0.94 (0.71, 1.25)	0.91 (0.47, 1.77)	2.08 (1.15, 3.76)	0.41 (0.24, 0.72)	1.01 (0.64, 1.59)	1.10 (0.56, 2.15)	0.71 (0.49, 1.05)
Interactions ^c							
Sex x Black	-0.06 (-0.64, 0.51)	0.13 (-1.31, 1.56)	0.09 (-1.10, 1.28)	0.02 (-1.20, 1.24)	0.03 (-0.88, 0.93)	-0.21 (-1.55, 1.14)	0.10 (-0.64, 0.83)
Sex x Hispanic	0.23 (-0.33, 0.80)	-1.01 (-2.51, 0.50)	0.77 (-0.47, 2.00)	0.41 (-0.73, 1.55)	0.16 (-0.76, 1.09)	-0.83 (-2.21, 0.55)	-0.20 (-0.96, 0.57)

Note: The no-use group was used as the reference category for all analyses. Bolded values indicate differences from the reference category.

^aFemale sex was the reference category.

^bWhite race was the reference category.

^cWhite Females were the reference category

Table 4.

Adjusted Odds ratios with 95% confidence intervals from a multinomial logistic regression predicting membership in each substance use category from race/ethnicity and sex.

	Substance Use Category						
	Alcohol only	Cigarettes Only	Cannabis Only	Alcohol & Cigarettes	Alcohol & Cannabis	Cigarettes & Cannabis	Alcohol & Cigarettes & Cannabis
Sex ^a							
Male	1.01 (0.80, 1.28)	1.66 (0.98, 2.79)	1.62 (1.08, 2.44)	1.32 (0.80, 2.18)	1.08 (0.75, 1.56)	1.56 (0.89, 2.75)	1.32 (0.96, 1.82)
Race/ethnicity ^b							
Black	0.73 (0.50, 1.06)	0.60 (0.27, 1.35)	1.37 (0.67, 2.80)	0.22 (0.11, 0.43)	1.25 (0.78, 1.98)	0.66 (0.30, 1.47)	0.48 (0.30, 0.78)
Hispanic	0.93 (0.64, 1.36)	0.32 (0.13, 0.82)	1.14 (0.52, 2.53)	0.29 (0.14, 0.62)	0.99 (0.56, 1.74)	0.67 (0.27, 1.64)	0.61 (0.35, 1.05)
Interactions ^c							
Sex x Black	-0.06 (-0.66, 0.53)	0.26 (-1.24, 1.76)	0.06 (-1.13, 1.24)	0.14 (-1.15, 1.43)	0.05 (-0.90, .99)	-0.26 (-1.60, 1.08)	0.09 (-0.68, 0.85)
Sex x Hispanic	0.26 (-0.33, 0.84)	-0.92 (-2.48, 0.64)	0.76 (-0.50, 2.02)	0.51 (-0.71, 1.74)	0.20 (-0.75, 1.14)	-1.03 (-2.43, 0.37)	-0.14 (0.93, 0.64)
Covariates							
Child's Age	1.14 (0.94, 1.37)	2.16 (1.52, 3.08)	1.24 (0.82, 1.85)	1.29 (0.82, 2.03)	0.94 (0.64, 1.36)	1.07 (0.78, 1.48)	1.67 (1.30, 2.15)
Parental Education	0.99 (0.91, 1.08)	0.85 (0.68, 1.06)	0.96 (0.83, 1.12)	0.99 (0.80, 1.21)	0.94 (0.82, 1.08)	0.98 (0.79, 1.22)	0.98 (0.85, 1.12)
Household Income	1.05 (0.76, 1.47)	0.55 (0.29, 1.06)	0.62 (0.36, 1.08)	0.88 (0.48, 1.63)	1.44 (0.89, 2.31)	0.80 (0.31, 2.02)	1.22 (0.75, 2.00)
Parental Marital Status	0.76 (0.58, 0.99)	0.94 (0.53, 1.65)	0.78 (0.50, 1.22)	0.67 (0.39, 1.17)	0.79 (0.53, 1.18)	0.53 (0.29, 0.99)	0.41 (0.28, 0.59)

Note: The no-use group was used as the reference category for all analyses. Bolded values indicate significant differences from the reference category.

^aFemale sex was the reference category.

^bWhite race was the reference category.

^cWhite Females were the reference category.