Latent Classes of Polysubstance Use Among Adolescents in the United States: Intersections of Sexual Identity with Sex, Age, and Race/Ethnicity

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Abstract

Purpose: We aimed to estimate latent classes of concurrent polysubstance use and test for sexual orientation differences in latent class memberships with representative data from adolescents living in 19 U.S. states. We also tested whether sex, race/ethnicity, and age moderated the sexual identity differences in polysubstance use class memberships.

Methods: We analyzed data from 119,437 adolescents from 19 states who participated in the 2015 Youth Risk Behavior Survey. Latent class analysis characterized polysubstance use patterns based on self-reported frequency of lifetime and past-month use of alcohol (including heavy episodic drinking), tobacco (cigarettes, cigars, and smokeless tobacco), and marijuana. Multinomial logistic regression models tested differences in latent class memberships by sexual identity. Interaction terms tested whether sex, race/ethnicity, and age moderated the sexual identity differences in polysubstance use class memberships.

Results: A six-class model of polysubstance use fit the data best and included nonusers (61.5%), experimental users (12.2%), marijuana-alcohol users (14.8%), tobacco-alcohol users (3.8%), medium-frequency three-substance users (3.6%), and high-frequency three-substance users (4.1%). Gay/lesbian- and bisexual-identified adolescents had significantly higher odds than heterosexual-identified adolescents of being in all of the user classes compared with the nonuser class. These sexual identity differences in latent polysubstance use class memberships were generally larger for females than for males, varied occasionally by race/ethnicity, and were sometimes larger for younger ages.

Conclusion: Compared with their heterosexual peers, gay/lesbian and bisexual adolescents—especially females—are at heightened risk of engaging in multiple types of polysubstance use. Designing, implementing, and evaluating interventions will likely reduce these sexual orientation disparities.

Keywords: adolescents, polysubstance use, sex, sexual minority youth, sexual orientation, YRBS

Introduction

ADOLESCENTS' USE OF multiple substances during a defined period—also known as concurrent polysubstance use¹—is a substantial public health problem. Polysubstance use during adolescence has been associated with many negative health outcomes, including substance use disorders,² overdose,³ poor brain function,⁴ psychological distress,⁵

and HIV risk.^{6,7} Researchers often use advanced statistical techniques to characterize polysubstance use, including latent class analysis (LCA).⁸ LCA is well suited for identifying homogenous, mutually exclusive classes, or patterns, of adolescent substance use.⁹

A recent systematic review⁸ found that 23 studies used LCA for characterizing substance use among 10- to 19-year olds and identified common latent classes of polysubstance

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use across studies. Eighty-three percent of studies identified a “non-using” (or “abstaining”) class, which comprised the largest proportion of adolescents. Seventy percent of studies found a “predominantly alcohol use” class. In addition, all 23 studies found at least 1 polysubstance use class, with the “alcohol, tobacco, and marijuana use” class being the most common polysubstance use class. Although the results across studies varied (e.g., studies found three to seven latent classes), they were largely affected by study population, sampling techniques, included substances, and defined recall periods.⁸ Subsequently, the review authors recommended that future LCA studies examining adolescent polysubstance use⁸ utilize separate indicators for each substance, use categorical instead of binary variables, and analyze three or more substances.

Although many studies have examined demographic differences in polysubstance use classes,⁸ few studies have examined differences in polysubstance use among adolescents by sexual orientation. Despite decades of research documenting that sexual minority (i.e., gay, lesbian, and bisexual) adolescents are more likely to use tobacco,^{10–14} alcohol,^{10,13–17} and marijuana,^{10,14,18,19} most studies examine each substance individually and not in combination. Few studies to our knowledge have examined the relationships between sexual orientation and polysubstance use.^{20–22} One study used data solely from young men who have sex with men in the Chicago, Illinois, area to characterize polysubstance use classes and found three classes: low marijuana users, alcohol and marijuana users, and polysubstance users.²⁰ Another study of adolescent females from Pittsburgh, Pennsylvania, found that lesbian and bisexual females were more likely than heterosexual females to be polysubstance users, exclusive cigarette users, and exclusive marijuana users.²¹ Using data from the Growing Up Today Study (a U.S.-based longitudinal cohort), researchers found that sexual minority youth were more likely than completely heterosexual youth to use three or more substances in the past year.²² These sexual orientation differences were larger among females than males,²² which is common across research that examines individual substances as outcomes.^{10–13,16–19}

In addition, sexual orientation disparities in the use of individual substances tend to be larger at younger ages and vary by race/ethnicity.^{10–12,16–18,23} A more recent study of polysubstance use in the Youth Risk Behavior Survey (YRBS) found that gay/lesbian youth were more likely than heterosexual youth to co-use nicotine and marijuana, and bisexual youth were more likely to be in all substance-using classes relative to an abstaining class.²⁴ In addition, the sexual orientation differences in the polysubstance/tobacco using class, relative to abstainers, were larger for sexual minority youth of color.²⁴

Our objective in this study was to build on the extant literature by: (1) following the most recent recommendations for examining polysubstance use with LCA⁸; (2) utilizing population-representative data to compare polysubstance use class memberships based on initiation, life course, and frequency of use; and (3) examining sexual orientation differences in polysubstance use by sex, race/ethnicity, and age. Therefore, we used contemporary population-representative data from high school students living in jurisdictions across the United States to characterize latent classes of concurrent polysubstance use and estimate sexual orientation differences in polysubstance use class membership. We also tested

whether sex, race/ethnicity, and age modified the effects of sexual orientation on latent polysubstance use class memberships. We hypothesized that there would be multiple latent classes of polysubstance use and that sexual minority adolescents would have higher odds than heterosexual adolescents of being in polysubstance use classes. We also hypothesized that these sexual orientation differences would be larger among females than males and larger for younger ages.

Methods

Study design and population

The YRBS was developed in 1990 to monitor health-risk behaviors among adolescents. A three-stage cluster survey design was used to obtain a representative sample of students in grades 9–12 in all 50 states and the District of Columbia. Surveys were self-administered biannually during the spring 2015. Additional information on the methodology of YRBS is reported elsewhere.²⁵ Data for this article were from 19 jurisdictions (Arizona, Arkansas, California, Connecticut, Delaware, Florida, Illinois, Kentucky, Maine, Maryland, Michigan, Nevada, New York, North Carolina, North Dakota, Oklahoma, Rhode Island, West Virginia, and Wyoming) that measured sexual orientation identity. These jurisdictions had an average response rate of 68% (range: 60%–82%), and 124,519 participants completed surveys. This study was deemed to be exempt by the University of Pittsburgh’s Institutional Review Board because it involved the study of existing data.

Measures

Exact question wording for all YRBS questions and responses is publicly available online.²⁶ The substance use items in this study have moderate-to-strong test–retest reliability.²⁷ We coded all substance use variables based on meaningful cutoffs, the low prevalence of extremely frequent use, prior research,^{6,28} and recommended practices.⁸ Alcohol use was assessed with three items: lifetime alcohol use; frequency of past-month alcohol use; and frequency of past-month heavy episodic drinking (HED), which was defined as having five or more drinks within a couple of hours. These variables were collapsed into a single variable with five categories: never drank alcohol in lifetime; drank in lifetime, but not in the past month; drank in the past month, but no HED in the past month; 1–5 days of HED in the past month; and 6 or more days of HED in the past month.

Cigarette use was assessed with two items: lifetime cigarette smoking and past-month cigarette smoking frequency. These variables were collapsed into a single variable with four categories: never smoked in lifetime; smoked in lifetime but not in the past month; smoked 1–5 days in the past month; and smoked on 6 or more days in the past month.

Past-month use of cigars (including cigarillos and little cigars) and smokeless tobacco (including chew, snuff, or dip) was assessed using two separate items. Both items were categorized into three-level categorical variables: never used in the past month; used 1–5 days in the past month; and used on 6 or more days in the past month.

Marijuana use was assessed with two items: lifetime use and past-month use. These items were collapsed into a single variable with six categories: never used in lifetime; used in lifetime, but not in the past month; used 1 or 2 times in the past month; used 3–9 times in the past month; used 10–19 times in the past month; and used 20 or more times in the past month.

Sexual orientation identity was measured with the item: “Which of the following best describes you? Heterosexual (straight); Gay or Lesbian; Bisexual; or Not Sure.” Heterosexual was the referent group for all analyses. Sex (male/female), age (continuous, range 12–18), race/ethnicity (White, Black, Hispanic, Asian or Pacific Islander [API], and other), and geographic region (Midwest, Northeast, South, and West) were also examined.

Statistical analyses

All analyses accounted for the complex survey design of the YRBS.²⁹ We removed 4.1% of the sample because they were missing data on sexual identity, and two participants were removed because they were missing data on all substance use items. The final analytic sample contained 119,437 participants. Statistical significance criterion was set at the $p < 0.05$ level. Analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC). Frequencies and weighted percentages for categorical variables, and mean and 95% confidence intervals for age by sexual identity were generated.

A classify-analyze approach⁹ was used to test our primary research questions. First, using the PROC LCA macro,³⁰ we identified underlying subgroups based on youths’ concurrent polysubstance use using an unconditional LCA model (i.e., no covariates). Missing values on substance use items were handled with a full-information maximum likelihood estimation during LCA, wherein missing substance use values were assumed to be missing at random. Model enumeration followed a step-wise approach testing two to seven class models. The Akaike information criterion (AIC), Bayesian information criterion (BIC), sample size-adjusted Bayesian information criterion (SSA-BIC), entropy, and interpretative validity of the class structures were used to select the best fitting model.^{9,31} Models with the lowest AIC, lowest BIC, lowest SSA-BIC, highest entropy, and highest interpretative validity were preferred.^{9,31} We assigned participants to the class for which they had the highest posterior probability of membership.

After selecting the number of classes that best represented the data, weighted percentages were used to describe the demographic composition of the latent polysubstance use classes. Multinomial logistic regression was used to estimate the effect of sexual identity on polysubstance use class membership, adjusting for sex, race/ethnicity, age, and region. The next model used interaction terms to test whether sex, race/ethnicity, and age modified the effects of sexual identity on latent polysubstance use class membership.

Results

Overall, 87.3% of participants identified as heterosexual, 6.3% as bisexual, 2.4% as gay/lesbian, and 4.1% were unsure of their sexual identity. Table 1 shows the demographic char-

acteristics of our sample by sexual identity. Demographics varied significantly by sexual identity ($p < 0.0001$).

Concurrent polysubstance use classes

The best fitting number of classes was not clearly identified across all fit indices (Supplementary Table S1), as these indices are often asymptotic in nature.⁹ Therefore, we also based our findings on highest interpretative validity of the class structures. The six-class model fit the data best (Fig. 1).

Nonusers (class 1) represented 61.5% of participants. Nonusers mostly abstained from alcohol, tobacco, and marijuana in their lifetime. *Experimental users* (class 2) represented 12.2% of participants. Large proportions of this class reported trying alcohol, marijuana, and cigarettes in their lifetime but reported no current use. Overall, 14.8% of youth were categorized as *marijuana-alcohol users* (class 3). Most marijuana-alcohol users reported using marijuana or alcohol in the past month, and nearly 40% of them engaged in HED in the past month. Marijuana-alcohol users reported minimal past-month tobacco use. *Tobacco-alcohol users* (class 4) represented 3.8% of youth. Among tobacco-alcohol users, ~40% reported using cigarettes, cigars, and snuff in the past month, and two-thirds of them used alcohol in the past month, including ~40% who engaged in HED. Tobacco-alcohol users reported minimal past-month marijuana use. In total, 3.6% of youth were categorized as *medium-frequency three-substance users* (class 5). A plurality of youth in this class engaged in past-month HED, tobacco use, and marijuana use with medium frequency. Overall, 51.3% of this class engaged in past-month HED, 41.9% smoked cigarettes, and 64.6% smoked cigars on 1–5 days in the past month. In addition, 70.2% of participants used marijuana 1–19 times in the past month. Finally, *high-frequency three-substance users* (class 6) categorized 4.1% of participants. Approximately 60% of these users smoked cigarettes on 6 or more days, used marijuana 20 or more times, and engaged in HED on 1 or more days in the past month, including 31.1% who engaged in HED 6 or more times in the past month. The percentage of participants using cigars and snuff on six or more days in the past month was also highest in this class.

Demographics of polysubstance use classes

Table 2 describes the demographic characteristics of the latent polysubstance use classes. Overall, sexual identity, sex, race/ethnicity, age, and geographic region were associated with polysubstance use classes. Compared with the non-user class, all other classes had greater proportions of bisexual adolescents and gay/lesbian adolescents and lower proportions of heterosexual adolescents.

Multivariable main effects

As shown in Table 3, bisexual youth were more likely than heterosexual youth to be experimental users, marijuana-alcohol users, tobacco-alcohol users, medium-frequency three-substance users, and high-frequency three-substance users compared with nonusers. Gay/lesbian youth had higher odds than heterosexual youth of being experimental users, marijuana-alcohol users, tobacco-alcohol

TABLE 1. DEMOGRAPHICS AND SUBSTANCE USE BY SEXUAL IDENTITY:
YOUTH RISK BEHAVIOR SURVEY, UNITED STATES, 2015

	<i>Sexual identity</i>				<i>p</i>
	<i>Heterosexual</i> (<i>n</i> = 102,369), <i>n</i> (%)	<i>Bisexual</i> (<i>n</i> = 8489), <i>n</i> (%)	<i>Gay/Lesbian</i> (<i>n</i> = 3472), <i>n</i> (%)	<i>Unsure</i> (<i>n</i> = 5107), <i>n</i> (%)	
Sex					
Female	49,854 (47.0)	6358 (76.1)	1638 (43.9)	3016 (63.8)	<0.0001
Male	52,058 (53.0)	1991 (23.9)	1731 (56.1)	1978 (36.2)	
Race/Ethnicity					
White	52,346 (48.2)	3605 (43.1)	1306 (41.0)	2132 (44.4)	<0.0001
Black	17,767 (13.1)	1804 (16.3)	783 (18.0)	794 (10.2)	
Hispanic	17,341 (27.5)	1657 (29.8)	705 (30.2)	1038 (28.1)	
API	5497 (6.6)	304 (4.6)	164 (5.2)	414 (9.9)	
Other	6545 (4.6)	828 (6.1)	296 (5.6)	457 (7.4)	
Age, mean (95% CI)	16.0 (15.9–16.1)	16.0 (15.9–16.1)	16.0 (15.9–16.2)	15.6 (15.5–15.8)	<0.0001
Region					
Midwest	8671 (8.5)	257 (7.4)	655 (7.7)	371 (7.3)	<0.0001
Northeast	69,230 (67.6)	2442 (70.3)	6035 (71.1)	3605 (70.6)	
South	17,426 (17.0)	577 (16.6)	1280 (15.1)	783 (15.3)	
West	7042 (6.9)	196 (5.7)	519 (6.1)	348 (6.8)	
Alcohol use					
Never used in lifetime	51,088 (46.5)	2806 (30.1)	1283 (38.8)	2491 (51.4)	<0.0001
Used in lifetime, but not in the past month	19,390 (20.8)	1944 (24.0)	523 (16.9)	771 (16.5)	
Used in the past month, but no heavy episodic drinking	18,176 (18.4)	2196 (25.9)	1076 (30.0)	1030 (17.3)	
1–5 days of heavy episodic drinking in the past month	11,457 (12.2)	1277 (16.7)	466 (11.6)	535 (11.1)	
≥6 days of heavy episodic drinking in the past month	1901 (2.0)	253 (3.3)	115 (2.7)	263 (3.6)	
Cigarette use					
Never used in lifetime	79,546 (78.0)	4873 (56.3)	1798 (57.7)	3355 (73.1)	<0.0001
Used in lifetime, but not in the past month	11,312 (13.5)	1568 (22.7)	738 (25.3)	668 (14.3)	
1–5 days in the past month	4111 (4.5)	808 (9.5)	310 (8.6)	261 (5.2)	
≥6 days in the past month	4139 (4.0)	893 (11.4)	366 (8.3)	531 (7.5)	
Smokeless tobacco use					
None in the past month	87,831 (94.7)	7076 (92.8)	2531 (86.9)	4036 (91.9)	<0.0001
1–5 days in the past month	2743 (2.6)	368 (4.8)	369 (7.6)	206 (3.2)	
≥6 days in the past month	2599 (2.7)	291 (2.4)	234 (5.5)	367 (4.9)	
Cigar use					
None in the past month	81,944 (91.9)	6315 (86.4)	2276 (77.7)	3727 (89.6)	<0.0001
1–5 days in the past month	5220 (5.8)	735 (10.4)	473 (16.0)	328 (3.8)	
≥6 days in the past month	2241 (2.3)	435 (3.2)	264 (6.3)	410 (6.6)	
Marijuana use					
Never used in lifetime	67,884 (64.7)	3854 (44.2)	1420 (50.9)	3046 (65.1)	<0.0001
Used in lifetime, but not in the past month	14,666 (15.9)	1652 (19.6)	671 (21.0)	665 (15.2)	
1 or 2 times in the past month	6289 (7.0)	868 (11.5)	294 (8.8)	297 (7.8)	
3–9 times in the past month	4395 (4.9)	697 (8.4)	237 (9.3)	208 (3.3)	
10–19 times in the past month	2262 (2.4)	352 (5.2)	119 (3.0)	147 (2.0)	
≥20 times in the past month	4545 (5.0)	688 (11.0)	264 (7.1)	424 (6.5)	

All percentages are weighted based on recommendations from the Centers for Disease Control and Prevention.
API, Asian or Pacific Islander; CI, confidence interval.

users, medium-frequency three-substance users, and high-frequency three-substance users compared with nonusers. Participants unsure of their sexual identity had higher odds than heterosexual youth of being tobacco-alcohol users and high-frequency three-substance users compared with nonusers.

Multivariable interaction effects

Overall, there were significant interactions of sexual identity with sex, race/ethnicity, and age on latent class membership ($p < 0.0001$). As shown in Table 4, the differences between bisexual and heterosexual adolescents were

FIG. 1. Latent class analysis profile plots for alcohol, tobacco, and marijuana use: Youth Risk Behavior Survey, United States, 2015.

generally larger for females than for males across all latent polysubstance use classes; however, these interactions were only statistically significant for those who were experimental users, tobacco-alcohol users, and high-frequency three-substance users compared with nonusers. Similarly, the differences between gay/lesbian and heterosexual adolescents were generally larger for females than for males, yet the interaction term achieved statistical significance only for those who were high-frequency three-substance users compared with nonusers. There were no significant differences in latent class membership by sex for adolescents who were unsure of their identity versus heterosexual adolescents.

The differences between bisexual and heterosexual adolescents were: larger for Black adolescents than White adolescents for those who were marijuana-alcohol users compared with nonusers; and smaller for Hispanic adolescents than White adolescents for those who were experimental users and high-frequency three-substance users. The differences between gay/lesbian and heterosexual adolescents were: larger for Black adolescents than White adolescents for those who were tobacco-alcohol users and medium-frequency three-substance users; smaller for Hispanic adolescents than White adolescents for those who were experimental users; and smaller for API adolescents than White adolescents for those who were tobacco-alcohol

TABLE 2. FREQUENCIES AND PERCENTAGES OF DEMOGRAPHICS BY LATENT CLASS: YOUTH RISK BEHAVIOR SURVEY, UNITED STATES, 2015

	<i>Latent classes</i>					<i>p</i>
	<i>Class 1. Nonusers</i> (<i>n</i> = 76,326; 61.5%), <i>n</i> (%)	<i>Class 2.</i> <i>Experimental users</i> (<i>n</i> = 12,668; 12.2%), <i>n</i> (%)	<i>Class 3. Marijuana-</i> <i>alcohol users</i> (<i>n</i> = 15,486; 14.8%), <i>n</i> (%)	<i>Class 4. Tobacco-</i> <i>alcohol users</i> (<i>n</i> = 5181; 3.8%), <i>n</i> (%)	<i>Class 5. Medium-</i> <i>frequency three-substance</i> <i>users</i> (<i>n</i> = 4370; 3.6%), <i>n</i> (%)	<i>Class 6. High-frequency</i> <i>three-substance users</i> (<i>n</i> = 5406; 4.1%), <i>n</i> (%)
Sexual identity						
Heterosexual	68,024 (89.8)	10,609 (86.1)	12,585 (83.4)	3990 (81.5)	3310 (80.8)	3851 (77.1)
Bisexual	3803 (4.2)	1219 (8.0)	1784 (10.6)	471 (8.7)	537 (10.4)	675 (11.8)
Gay/Lesbian	1467 (1.8)	381 (2.6)	539 (2.6)	434 (5.2)	314 (5.7)	337 (4.1)
Unsure	3032 (4.2)	459 (3.3)	578 (3.4)	286 (4.6)	209 (3.1)	543 (7.0)
Sex						
Female	39,216 (49.6)	7154 (54.2)	9121 (56.4)	1585 (28.2)	1880 (39.2)	1909 (34.7)
Male	36,797 (50.4)	5452 (45.8)	6282 (43.6)	3472 (71.8)	2389 (60.8)	3365 (65.3)
Race/Ethnicity						
White	38,256 (47.2)	5704 (40.4)	7388 (46)	2964 (65.6)	2247 (55.8)	2829 (57.9)
Black	13,832 (13.6)	2463 (14.2)	2878 (14.1)	635 (9.7)	687 (11.1)	653 (9.4)
Hispanic	12,371 (26.4)	2683 (34.2)	3183 (31.3)	757 (17.8)	756 (25)	990 (24.9)
API	5049 (8.3)	443 (5.7)	419 (3.3)	163 (1.6)	121 (3.1)	184 (2.9)
Other	4730 (4.5)	1020 (5.5)	1188 (5.4)	368 (5.3)	364 (5.1)	456 (4.9)
Age, mean (95% CI)	15.8 (15.7–15.9)	16.3 (16.2–16.4)	16.3 (16.2–16.4)	16.3 (16.1–16.4)	16.3 (16.2–16.5)	16.4 (16.2–16.5)
Region						
Midwest	6370 (8.4)	1139 (9.0)	1307 (8.4)	453 (8.7)	339 (7.8)	346 (6.4)
Northeast	53,090 (69.6)	7956 (62.8)	10,249 (66.2)	3255 (62.8)	3057 (70.0)	3705 (68.5)
South	12,089 (15.8)	2521 (19.9)	2677 (17.3)	1080 (20.9)	650 (14.9)	1049 (19.4)
West	4777 (6.3)	1052 (8.3)	1253 (8.1)	393 (7.6)	324 (7.4)	306 (5.7)

All percentages are weighted based on recommendations from the Centers for Disease Control and Prevention.

TABLE 3. MULTINOMIAL LOGISTIC REGRESSION MODEL RESULTS FOR MAIN EFFECTS OF DEMOGRAPHICS ON LATENT CLASSES: YOUTH RISK BEHAVIOR SURVEY, UNITED STATES, 2015

	<i>Experimental users versus nonusers, OR (95% CI)</i>	<i>Marijuana-alcohol users versus nonusers, OR (95% CI)</i>	<i>Tobacco-alcohol users versus nonusers, OR (95% CI)</i>	<i>Medium-frequency three-substance users versus nonusers, OR (95% CI)</i>	<i>High-frequency three-substance users versus nonusers, OR (95% CI)</i>
Sexual identity					
Heterosexual	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Bisexual	1.96 (1.61–2.37)	2.61 (2.08–3.28)	2.95 (1.87–4.63)	3.38 (2.39–4.77)	4.53 (3.36–6.11)
Gay/Lesbian	1.54 (1.08–2.19)	1.56 (1.21–2.02)	3.10 (2.30–4.18)	3.59 (2.53–5.09)	2.77 (2.04–3.76)
Unsure	0.90 (0.67–1.20)	0.95 (0.78–1.17)	1.67 (1.02–2.73)	0.89 (0.57–1.41)	2.5 (1.86–3.37)
Sex					
Female	1.17 (1.05–1.30)	1.24 (1.10–1.41)	0.38 (0.31–0.45)	0.60 (0.50–0.73)	0.46 (0.39–0.55)
Male	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Race/Ethnicity					
White	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Black	1.19 (1.00–1.43)	1.05 (0.91–1.22)	0.49 (0.37–0.63)	0.68 (0.50–0.93)	0.51 (0.41–0.65)
Hispanic	1.46 (1.25–1.70)	1.07 (0.86–1.34)	0.51 (0.40–0.67)	0.69 (0.51–0.94)	0.84 (0.57–1.25)
API	0.76 (0.46–1.24)	0.33 (0.21–0.51)	0.14 (0.08–0.26)	0.24 (0.14–0.43)	0.31 (0.18–0.56)
Other	1.46 (1.17–1.83)	1.21 (1.03–1.42)	0.86 (0.60–1.24)	0.96 (0.61–1.51)	0.94 (0.66–1.33)
Age	1.38 (1.31–1.45)	1.40 (1.34–1.46)	1.42 (1.27–1.58)	1.47 (1.35–1.60)	1.51 (1.37–1.67)
Region					
Midwest	1.00 (0.86–1.16)	0.85 (0.73–1.00)	1.05 (0.81–1.35)	0.84 (0.67–1.04)	0.84 (0.66–1.07)
Northeast	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)
South	1.11 (0.98–1.26)	0.91 (0.79–1.05)	1.35 (1.11–1.64)	0.83 (0.69–1.01)	1.10 (0.90–1.34)
West	1.12 (0.93–1.35)	1.22 (0.97–1.53)	0.92 (0.64–1.33)	1.23 (0.89–1.69)	0.68 (0.40–1.17)

Boldface indicates $p < 0.05$.

OR, odds ratio.

users. The differences between unsure and heterosexual adolescents were: larger for Hispanic adolescents than White adolescents for those who were high-frequency three-substance users; larger for API adolescents than White adolescents for those who were tobacco-alcohol users; and smaller for API adolescents than White adolescents for those who were medium-frequency three-substance users.

The differences between gay/lesbian and heterosexual adolescents for those who were high-frequency three-substance users versus nonusers were smaller at older ages. Similarly, the differences between unsure and heterosexual adolescents for being marijuana-alcohol users, tobacco-alcohol users, and high-frequency three-substance users versus nonusers were also smaller for older ages, making these disparities larger for younger participants.

Discussion

Noting the dearth of knowledge about concurrent polysubstance use among sexual minority youth, the current study estimated latent classes characterized by alcohol use, cigarette use, smokeless tobacco use, cigar use, and marijuana use using a recent national sample of school-aged adolescents. Not unlike previous studies documenting polysubstance use classes among adolescents,⁸ our six-class model included a substantially populated nonusers class followed by several polysubstance using classes, three of which were characterized largely by alcohol use. Importantly, our results indicated that gay/lesbian and bisexual youth were at elevated risk for membership in all polysubstance-using classes relative to nonusers compared with heterosexual

youth. These sexual orientation disparities were particularly large among medium- and high-frequency polysubstance use classes.

Overall, our findings support a growing body of literature demonstrating how sexual minority youth are more likely to report substance use across several individual substances.^{10–19} Our findings extend this work by showing that lesbian/gay and bisexual youth are also more likely to participate in polysubstance use than their heterosexual peers. Given our approach, we also found that patterns of polysubstance use varied systematically across subgroups of sexual minority youth on the basis of sexual identity, as well as sex, race/ethnicity, and age.

Similar to other research in the area of sexual orientation disparities in substance use and polysubstance use,²² we noted that sexual minority females and bisexual females, in particular, had the greatest propensity for membership in polysubstance use classes relative to the nonusers class. These findings of elevated rates of substance use among bisexual females are consistent with previous studies documenting sexual orientation disparities in substance use.^{13,17} Elevated rates among bisexual females also suggest that there may be unique factors related to bisexuality, such as biphobia,³² that may alter risk for substance use during adolescence. Researchers have also hypothesized that elevated substance use among sexual minority females, in general, may be related to the rejection of traditional gender roles.^{33,34} If true, future research is needed to better understand whether the rejection of traditional female gender roles is directly related to experimentation with substance use (i.e., a traditionally male behavior) or the result of subsequent vulnerability for stigma

TABLE 4. MULTINOMIAL LOGISTIC REGRESSION MODEL RESULTS FOR INTERACTION EFFECTS ON LATENT CLASSES: YOUTH RISK BEHAVIOR SURVEY, UNITED STATES, 2015

	<i>Experimental users versus nonusers, OR (95% CI)</i>	<i>Marijuana-alcohol users versus nonusers, OR (95% CI)</i>	<i>Tobacco-alcohol users versus nonusers, OR (95% CI)</i>	<i>Medium-frequency three-substance users versus nonusers, OR (95% CI)</i>	<i>High-frequency three-substance users versus nonusers, OR (95% CI)</i>
Sexual identity					
Heterosexual	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Bisexual	1.68 (0.99–2.84)	1.78 (1.10–2.87)	1.37 (0.78–2.41)	2.17 (0.96–4.88)	1.98 (1.22–3.23)
Gay/Lesbian	2.21 (1.23–3.95)	1.19 (0.76–1.87)	2.56 (1.55–4.23)	1.91 (1.15–3.17)	1.95 (1.11–3.45)
Unsure	0.66 (0.35–1.24)	0.85 (0.57–1.27)	1.30 (0.77–2.19)	0.98 (0.53–1.78)	1.27 (0.73–2.18)
Sex					
Female	1.12 (0.99–1.27)	1.22 (1.06–1.40)	0.34 (0.28–0.41)	0.57 (0.46–0.7)	0.38 (0.31–0.46)
Male	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Race/Ethnicity					
White	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)
Black	1.21 (1.02–1.44)	0.96 (0.82–1.12)	0.42 (0.30–0.59)	0.60 (0.41–0.88)	0.53 (0.41–0.69)
Hispanic	1.58 (1.35–1.85)	1.05 (0.81–1.35)	0.51 (0.38–0.68)	0.67 (0.48–0.93)	0.81 (0.54–1.22)
API	0.76 (0.49–1.17)	0.34 (0.21–0.54)	0.14 (0.07–0.26)	0.25 (0.14–0.46)	0.31 (0.16–0.60)
Other	1.54 (1.20–1.97)	1.27 (1.04–1.56)	0.95 (0.62–1.44)	0.96 (0.60–1.54)	0.90 (0.65–1.26)
Age	1.4 (1.32–1.47)	1.42 (1.36–1.49)	1.48 (1.32–1.65)	1.49 (1.36–1.64)	1.68 (1.51–1.86)
Region					
Midwest	1.00 (0.86–1.16)	0.85 (0.73–1.00)	1.05 (0.82–1.35)	0.84 (0.67–1.04)	0.84 (0.66–1.06)
Northeast	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)	1.00 (referent)
South	1.11 (0.97–1.26)	0.92 (0.79–1.06)	1.35 (1.11–1.63)	0.83 (0.69–1.01)	1.10 (0.90–1.33)
West	1.11 (0.92–1.34)	1.22 (0.97–1.54)	0.92 (0.64–1.32)	1.23 (0.90–1.70)	0.67 (0.40–1.15)
Sexual identity × Sex					
Bisexual × Female	1.73 (1.05–2.85)	1.49 (0.92–2.40)	3.77 (1.73–8.22)	1.76 (0.74–4.17)	5.21 (2.87–9.45)
Gay/Lesbian × Female	1.29 (0.69–2.40)	1.39 (0.85–2.29)	1.49 (0.82–2.72)	2.11 (0.93–4.78)	1.85 (1.01–3.40)
Unsure × Female	1.55 (0.85–2.84)	1.03 (0.67–1.59)	0.84 (0.43–1.65)	0.83 (0.35–1.93)	1.44 (0.85–2.42)
Sexual identity × Race/Ethnicity					
Bisexual × Black	0.92 (0.62–1.37)	1.59 (1.12–2.27)	1.35 (0.56–3.23)	0.87 (0.37–2.01)	0.50 (0.25–1.00)
Bisexual × Hispanic	0.44 (0.27–0.69)	1.06 (0.54–2.09)	0.66 (0.34–1.29)	1.31 (0.58–2.93)	0.48 (0.25–0.94)
Bisexual × API	1.13 (0.32–4.06)	0.50 (0.12–2.04)	0.52 (0.13–2.06)	0.93 (0.24–3.56)	0.44 (0.11–1.82)
Bisexual × Other	0.79 (0.36–1.70)	0.88 (0.49–1.61)	0.45 (0.17–1.23)	1.05 (0.51–2.17)	0.97 (0.49–1.93)
Gay/Lesbian × Black	0.57 (0.29–1.14)	1.76 (0.94–3.28)	3.08 (1.43–6.64)	3.84 (1.20–12.31)	1.72 (0.77–3.83)
Gay/Lesbian × Hispanic	0.37 (0.19–0.70)	1.06 (0.57–1.99)	0.68 (0.31–1.47)	0.81 (0.34–1.97)	1.36 (0.56–3.31)
Gay/Lesbian × API	0.22 (0.04–1.28)	0.93 (0.21–4.23)	0.28 (0.11–0.75)	1.10 (0.24–5.15)	1.90 (0.46–7.83)
Gay/Lesbian × Other	0.54 (0.19–1.55)	0.83 (0.29–2.40)	0.71 (0.32–1.57)	1.23 (0.34–4.49)	0.64 (0.13–3.12)
Unsure × Black	1.35 (0.55–3.32)	1.85 (0.96–3.57)	2.00 (0.75–5.32)	2.15 (0.61–7.51)	1.56 (0.61–4.00)
Unsure × Hispanic	0.86 (0.38–1.93)	1.06 (0.55–2.01)	2.05 (0.90–4.67)	0.57 (0.22–1.47)	2.75 (1.55–4.88)
Unsure × API	1.06 (0.32–3.52)	0.94 (0.28–3.18)	3.08 (1.02–9.32)	0.05 (0.01–0.45)	1.03 (0.32–3.28)
Unsure × Other	0.67 (0.28–1.59)	0.50 (0.21–1.21)	0.81 (0.20–3.30)	0.74 (0.24–2.32)	1.77 (0.75–4.17)
Sexual identity × Age					
Bisexual × Age	0.96 (0.84–1.09)	0.92 (0.76–1.11)	0.85 (0.55–1.32)	0.81 (0.64–1.02)	0.82 (0.63–1.07)
Gay/Lesbian × Age	0.93 (0.75–1.15)	0.89 (0.70–1.11)	0.78 (0.58–1.05)	1.04 (0.83–1.31)	0.52 (0.36–0.75)
Unsure × Age	0.86 (0.70–1.05)	0.83 (0.71–0.96)	0.73 (0.57–0.92)	1.06 (0.76–1.46)	0.51 (0.36–0.71)

Boldface indicates $p < 0.05$.

and discrimination. Ultimately, these findings suggest that both sexual orientation and sex differences play distinct roles in increased risk for polysubstance use. Such findings point to the importance of investigating differences in sexual orientation and sex in substance use research. Failure to do so could bias inferences and subsequent intervention strategies.

Elevated rates of polysubstance use among sexual minority youth influence negative health outcomes during adolescence and across the life course.^{2–7} Contrary to research on individual substances,^{10–19} we found that the sexual orientation disparities in polysubstance use varied by age only for a

few polysubstance use classes, suggesting that polysubstance use disparities by sexual orientation are relatively consistent across the adolescent years. Early and frequent substance use during adolescence is associated with substance use disorders in adulthood.³⁵ Our findings indicate that sexual minority youth at risk for polysubstance use during adolescence need early intervention efforts. Given the prevalence of sexual orientation disparities in substance use disorders in adulthood,^{36–38} early intervention strategies could assist in altering sexual minority population health disparities later in the life course. Nevertheless, there is a paucity of

substance use intervention research for sexual minority youth,³⁹ and our article echoes prior literature calling for such interventions.^{10,15}

Similar to prior research,^{12,16,18} we found that sexual orientation differences in polysubstance use varied by race/ethnicity. Our findings suggest that typical patterns of youth substance use across race/ethnicity do not hold when we consider sexual orientation differences. Specifically, general population studies often find that substance use is higher for White youth, followed by Hispanic and then Black youth.⁴⁰ Several sexual orientation differences were stronger among youth of color, and this deserves further attention. Future research should explore how social processes related to being members of sexual minority and racial/ethnic subgroups contribute to the development of polysubstance use.

Limitations

Despite its contributions, this study is not without limitations. Although the YRBS is a national population-based sample, data were collected in schools and, therefore, do not represent youth who are not present or enrolled. For example, lesbian/gay, bisexual, and unsure youth are more likely to experience homelessness,⁴¹ school pushout,⁴² and absenteeism due to fears related to harassment and safety.⁴³ In addition, not all states were represented in our analyses because states with higher structural stigma were less likely to assess sexual identity; therefore, our results may not be generalized to those states. Despite the identification of several polysubstance use groups, we were unable to characterize a single episode of polysubstance use, to model exact frequency of use, or to model extremely high frequencies of use for some substances. Our results may not generalize to other operationalizations of sexual orientation (e.g., sexual attractions). Finally, data from this study were cross-sectional and derived from self-report.

Conclusion

The present study documents substantial sexual orientation disparities in polysubstance use using a recent national, population-based sample of youth. Future research is needed to test underlying mechanisms that contribute to these disparities, particularly for bisexual females. Studies should also consider more detailed instruments to measure the contemporaneousness of polysubstance use among youth. Ultimately, the development of empirically informed strategies aimed at preventing or reducing substance use among sexual minority youth is needed to help reduce sexual orientation-related substance use disparities and the related health consequences. Such programs have the potential to assist sexual minority populations achieve health equity.

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Disclaimer

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Author Disclosure Statement

No competing financial interests exist.

Supplementary Material

Supplementary Table S1

References

1. Connor JP, Feeney GFX, Kelly AB, Saunders JB: Polysubstance use. In: *The SAGE Handbook of Drug & Alcohol Studies: Biological Approaches*. Edited by Wolff K, White J, Karch S. London: Sage, 2016, pp 283–306.
2. Moss HB, Chen CM, Yi HY: Early adolescent patterns of alcohol, cigarettes, and marijuana polysubstance use and young adult substance use outcomes in a nationally representative sample. *Drug Alcohol Depend* 2014;136:51–62.
3. Werb D, Kerr T, Lai C, et al.: Nonfatal overdose among a cohort of street-involved youth. *J Adolesc Health* 2008;42:303–306.
4. Licata SC, Renshaw PF: Neurochemistry of drug action: Insights from proton magnetic resonance spectroscopic imaging and their relevance to addiction. *Ann N Y Acad Sci* 2010;1187:148–171.
5. White A, Chan GC, Quek LH, et al.: The topography of multiple drug use among adolescent Australians: Findings from the National Drug Strategy Household Survey. *Addict Behav* 2013;38:2068–2073.
6. Connell CM, Gilreath TD, Hansen NB: A multiprocess latent class analysis of the co-occurrence of substance use and sexual risk behavior among adolescents. *J Stud Alcohol Drugs* 2009;70:943–951.
7. Mustanski B, Garofalo R, Herrick A, Donenberg G: Psychosocial health problems increase risk for HIV among urban young men who have sex with men: Preliminary evidence of a syndemic in need of attention. *Ann Behav Med* 2007;34:37–45.
8. Tomczyk S, Isensee B, Hanewinkel R: Latent classes of polysubstance use among adolescents—A systematic review. *Drug Alcohol Depend* 2015;160:12–29.
9. Masyn KE: Latent class analysis and finite mixture modeling. In: *The Oxford Handbook of Quantitative Methods in Psychology: Vol. 2: Statistical Analysis*. Edited by Little TD. New York, NY: Oxford University Press, 2013, pp 551–611.
10. Coulter RWS, Bersamin M, Russell ST, Mair C: The effects of gender- and sexuality-based harassment on lesbian, gay, bisexual, and transgender substance use disparities. *J Adolesc Health* 2018;62:688–700.

11. Corliss HL, Wadler BM, Jun HJ, et al.: Sexual-orientation disparities in cigarette smoking in a longitudinal cohort study of adolescents. *Nicotine Tob Res* 2013;15:213–222.
12. Corliss HL, Rosario M, Birkett MA, et al.: Sexual orientation disparities in adolescent cigarette smoking: Intersections with race/ethnicity, gender, and age. *Am J Public Health* 2014;104:1137–1147.
13. Marshal MP, Friedman MS, Stall R, et al.: Sexual orientation and adolescent substance use: A meta-analysis and methodological review. *Addiction* 2008;103:546–556.
14. Garofalo R, Wolf RC, Kessel S, et al.: The association between health risk behaviors and sexual orientation among a school-based sample of adolescents. *Pediatrics* 1998;101:895–902.
15. Coulter RW, Birkett M, Corliss HL, et al.: Associations between LGBTQ-affirmative school climate and adolescent drinking behaviors. *Drug Alcohol Depend* 2016;161:340–347.
16. Talley AE, Hughes TL, Aranda F, et al.: Exploring alcohol-use behaviors among heterosexual and sexual minority adolescents: Intersections with sex, age, and race/ethnicity. *Am J Public Health* 2014;104:295–303.
17. Corliss HL, Rosario M, Wypij D, et al.: Sexual orientation disparities in longitudinal alcohol use patterns among adolescents: Findings from the Growing Up Today Study. *Arch Pediatr Adolesc Med* 2008;162:1071–1078.
18. Newcomb ME, Birkett M, Corliss HL, Mustanski B: Sexual orientation, gender, and racial differences in illicit drug use in a sample of US high school students. *Am J Public Health* 2014;104:304–310.
19. Russell ST, Driscoll AK, Truong N: Adolescent same-sex romantic attractions and relationships: Implications for substance use and abuse. *Am J Public Health* 2002;92:198–202.
20. Newcomb ME, Ryan DT, Greene GJ, et al.: Prevalence and patterns of smoking, alcohol use, and illicit drug use in young men who have sex with men. *Drug Alcohol Depend* 2014;141:65–71.
21. Dermody SS, Marshal MP, Cheong J, et al.: Adolescent sexual minority girls are at elevated risk for use of multiple substances. *Subst Use Misuse* 2016;51:574–585.
22. Kecojevic A, Jun HJ, Reisner SL, Corliss HL: Concurrent polysubstance use in a longitudinal study of US youth: Associations with sexual orientation. *Addiction* 2017;112:614–624.
23. Corliss HL, Rosario M, Wypij D, et al.: Sexual orientation and drug use in a longitudinal cohort study of U.S. adolescents. *Addict Behav* 2010;35:517–521.
24. Dermody SS: Risk of polysubstance use among sexual minority and heterosexual youth. *Drug Alcohol Depend* 2018;192:38–44.
25. Centers for Disease Control and Prevention (CDC), Brener ND, Kann L, et al.: Methodology of the Youth Risk Behavior Surveillance System-2013. *MMWR Recomm Rep* 2013;62:1–20.
26. Centers for Disease Control and Prevention: 2015 State and Local Youth Risk Behavior Survey. 2015. Available at ftp://ftp.cdc.gov/pub/data/yrbs/2015/2015_hs_questionnaire.pdf. Accessed November 28, 2016.
27. Brener ND, Collins JL, Kann L, et al.: Reliability of the Youth Risk Behavior Survey Questionnaire. *Am J Epidemiol* 1995;141:575–580.
28. Gilreath TD, Astor RA, Estrada JN, et al.: Substance use among adolescents in California: A latent class analysis. *Subst Use Misuse* 2014;49:116–123.
29. Centers for Disease Control and Prevention: *Software for Analysis of Youth Risk Behavior Survey (YRBS) Data*. Washington, DC: Department of Health and Human Services, 2018.
30. Lanza ST, Collins LM, Lemmon DR, Schafer JL: PROC LCA: A SAS procedure for latent class analysis. *Struct Equ Modeling* 2007;14:671–694.
31. Nylund KL, Asparouhov T, Muthén BO: Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Struct Equ Modeling* 2007;14:535–569.
32. Bostwick W: Assessing bisexual stigma and mental health status: A brief report. *J Bisex* 2012;12:214–222.
33. Rosario M, Schrimshaw EW, Hunter J: Butch/femme differences in substance use and abuse among young lesbian and bisexual women: Examination and potential explanations. *Subst Use Misuse* 2008;43:1002–1015.
34. Hughes TL, Wilsnack SC, Kantor LW: The influence of gender and sexual orientation on alcohol use and alcohol-related problems: Toward a global perspective. *Alcohol Res* 2016;38:121–132.
35. Schulenberg JE, Patrick ME, Kloska DD, et al.: Substance use disorder in early midlife: A national prospective study on health and well-being correlates and long-term predictors. *Subst Abuse* 2015;9:41–57.
36. Coulter RWS, Jun HJ, Calzo JP, et al.: Sexual-orientation differences in alcohol use trajectories and disorders in emerging adulthood: Results from a longitudinal cohort study in the United States. *Addiction* 2018. [Epub ahead of print]; DOI: 10.1111/add.14251.
37. Goldberg S, Strutz KL, Herring AA, Halpern CT: Risk of substance abuse and dependence among young adult sexual minority groups using a multidimensional measure of sexual orientation. *Public Health Rep* 2013;128:144–152.
38. McCabe SE, Hughes TL, Bostwick WB, et al.: Sexual orientation, substance use behaviors and substance dependence in the United States. *Addiction* 2009;104:1333–1345.
39. Institute of Medicine (US) Committee on Lesbian, Gay, Bisexual, and Transgender Health Issues and Research Gaps and Opportunities: *The Health of Lesbian, Gay, Bisexual, and Transgender People: Building a Foundation for Better Understanding*. Washington, DC: National Academies Press (US), 2011.
40. Kann L, Kinchen S, Shanklin SL, et al.: Youth risk behavior surveillance—United States, 2013. *MMWR Suppl* 2014;63:1–168.
41. Corliss HL, Goodenow CS, Nichols L, Austin SB: High burden of homelessness among sexual-minority adolescents: Findings from a representative Massachusetts high school sample. *Am J Public Health* 2011;101:1683–1689.
42. Snapp SD, Hoenig JM, Fields A, Russell ST: Messy, butch, and queer: LGBTQ youth and the school-to-prison pipeline. *J Adolesc Res* 2015;30:57–82.
43. Baams L, Talmage CA, Russell ST: Economic costs of bias-based bullying. *Sch Psychol Q* 2017;32:422–433.

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