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Patterns and Correlates of Poly-substance Use among U.S. Youth ages 15-17 years: Wave 1 of the Population Assessment of Tobacco and Health (PATH) Study

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Abstract

Background and Aims: Youth aged 15–17 years are at high risk of tobacco, alcohol, and drug use. Given the changing landscape with respect to availability, use of emerging products, and regulatory environments, we examined patterns and correlates of poly-substance use among U.S. youth aged 15–17 years.

Design: Cross-sectional self-reported data.

Setting: United States.

Participants: 6,127 U.S. youth aged 15–17 years from Wave 1 (2013–2014) of the nationally representative Population Assessment of Tobacco and Health (PATH) Study.

Measurements: Latent class analysis was used to identify subgroups of poly-substance use including 12 tobacco products, alcohol, marijuana, prescription drugs, and other drugs. Socio-demographic characteristics, residence in urban area, sensation seeking, sexual orientation, and internalizing and externalizing problems were examined as correlates.

Findings: Approximately 43.5% of 15–17-year olds used at least one substance in the past 12 months. A five-class model was identified: Class 1 ‘abstainers’ (67%), Class 2 ‘alcohol users’ (19%), Class 3 ‘alcohol, marijuana, and tobacco ($AMT_{predominant\ AM}$) users’ (8%), Class 4 ‘alcohol, marijuana, and tobacco ($AMT_{predominant\ T}$) users’ (4%), and Class 5 ‘alcohol, marijuana, tobacco, and other drug (AMTOD) users’ (1%). Abstainers were considered the reference class. Higher sensation seeking scores, higher age, and lower academic grades were each associated with greater likelihood of membership in all user classes. Gender, race/ethnicity, parents/guardians’ education, residence in non-urban areas, and sexual minority groups were associated with

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membership in some but not all user classes. Compared with no/low/moderate severity, high severity internalizing problems were associated with membership in classes 2, 3, and 5, whereas high severity externalizing problems were associated with membership in classes 3 and 5 only.

Conclusions: There appear to be three heterogeneous poly-substance use classes among U.S. youth aged 15–17 years. Correlates of substance use among U.S. youth include higher sensation seeking, poor academic performance, urban residence, minority sexual orientation, and mental health problems.

Keywords

poly-substance use; tobacco products; alcohol; marijuana; drugs; youth; correlates

INTRODUCTION

Onset of tobacco, alcohol, and drug use generally occurs during adolescence (1–3). Between 10–20% of U.S. youth report past month tobacco use (4, 5); cigarettes, e-cigarettes, certain cigar types (e.g. cigarillos) and hookah are most commonly used (4, 6). Among youth who use tobacco, multiple product use is common (7, 8), especially among high school students (5). Moreover, youth tobacco users, particularly those who use multiple tobacco products, are also more likely to use alcohol and drugs and to report substance use disorders (SUDs) (8–11). These youth are at risk for several immediate adverse outcomes including dropping out of high school and lower educational attainment (12), cognitive impairment (13), and problem behaviors (e.g. violence, criminal activity, and risky sexual behaviors (14)). Multiple substance use during adolescence is also known to predict substance use and dependence during adulthood (15).

Studies have used latent class analysis, a flexible, person-centric approach, to identify groups of youth defined by similar patterns of tobacco, alcohol, and drug use. A recent systematic review (16) revealed the following classes: no/low users of any substance (i.e. tobacco, alcohol, and drugs) (largest class ranging from 17–77%), alcohol users (second largest class ranging from 15–80%), and poly-substance users i.e. users of two or more substances in a certain time period (occasional and frequent users ranging from 9–29% and 7–18%, respectively). Several studies included in this review were conducted in national samples of U.S. youth; however, they focused on overall tobacco use or cigarette smoking only (16). Although two recent studies have included non-cigarette tobacco products (17, 18), these studies were limited in the range of tobacco products and drugs assessed, and only one utilized a nationally representative sample (17).

In addition to use patterns, studies have identified higher age, poor academic performance, and greater parental and peer substance use as correlates of poly-substance use (16). Findings for gender and race/ethnicity are mixed (16). Although youth substance use co-occurs with mental health problems (15, 19), few national studies have examined internalizing (i.e., anxiety, depression) and externalizing (i.e., behavioral, conduct) problems as correlates of poly-substance use (16). Additionally, high sensation seeking (20, 21), sexual minorities (22), and residence in rural areas (23) have been associated with poly-

substance use; yet, no nationally representative study has collectively examined these correlates.

To advance understanding of poly-substance use among high-school-age youth, the current study used latent class analysis to estimate 1) patterns and 2) correlates (including socio-demographic characteristics, sensation seeking, sexual orientation, residence in urban area, and mental health problems) of poly-substance use across 12 tobacco products, alcohol, marijuana, prescription drugs, and other drugs (cocaine and other stimulants, heroin, inhalants, solvents, and hallucinogens) in a nationally representative sample of U.S. youth ages 15–17 years.

METHODS

Study Design and Population

This study examined Wave 1 (September 2013-December 2014) data of the Population Assessment of Tobacco and Health (PATH) Study, an ongoing longitudinal study of U.S. youth and adults. Of the 6,653 15–17-year-olds recruited at Wave 1, the present analyses were restricted to 6,127 youth with data on covariates of interest. The Wave 1 Restricted-Use Files were accessed at the Inter-university Consortium for Political and Social Research through the National Addiction & HIV Data Archive Program.

Detailed methodological information about the study design and protocol is available elsewhere (24) and at https://doi.org/10.3886/Series606. Briefly, participants were recruited via an address-based, area-probability sampling approach that oversampled adult tobacco users, young adults, and African-American adults. An in-person household screener was used to select youth and adults from households. Generally, up to two youth were sampled per household. The weighting procedures adjusted for oversampling and nonresponse, allowing estimates to be representative of the non-institutionalized, civilian U.S. population (household screener response rate: 54%, weighted response rate among youth: 78.4%). Consent for youth interviews was obtained via written informed consent forms from either parents or emancipated youth and assent from non-emancipated youth. Data were collected using Audio-Computer Assisted Self-Interviews administered in English or Spanish. The study was conducted by Westat and approved by Westat's Institutional Review Board.

Measures

Tobacco, Alcohol, and Drug Use—Aided by brief descriptions and pictures of each product (except cigarettes), participants self-reported ever using the following tobacco products even one or two puffs/times: cigarettes, e-cigarettes, traditional cigars, cigarillos, filtered cigars, pipe, hookah, smokeless tobacco (i.e. loose snus, moist snuff, dip, spit, or chewing tobacco), snus pouches, kreteks, bidis, and dissolvable tobacco. Participants who reported ever using a tobacco product were asked when they last used the product. Those who reported using in the past 12 months were defined as past 12-month users of that specific tobacco product.

Similarly, participants self-reported ever use of alcohol, marijuana (including blunts), non-prescribed Ritalin® or Adderall® and painkillers, sedatives, or tranquilizers, and cocaine or

crack, and other stimulants (i.e. methamphetamine or speed), heroin, inhalants, solvents, and hallucinogens. These items were adapted from the National Epidemiologic Survey on Alcohol and Related Conditions (25) and the National Health and Nutrition Examination Survey (26). 'Other drug use' was defined as the use of cocaine or crack, other stimulants (i.e. methamphetamine or speed), heroin, inhalants, solvents, or hallucinogens.

Participants who reported ever using alcohol or drugs were asked how long it has been since last use; those who reported using in the past 12 months were defined as past 12-month users of that substance or class of substances.

Covariates—Socio-demographic characteristics included participants' age, gender, and race/ethnicity (White non-Hispanic, Black non-Hispanic, Other non-Hispanic, and Hispanic). Additionally, information was collected on participants' sexual orientation (straight/lesbian/gay/bisexual and something else) and parents/guardians' highest completed grade or year of school (less than high school, high school diploma or equivalent, some college/technical program, college/technical school/Associate's degree, and graduate/professional degree/some graduate school) and their child's school performance in the past 12 months.

Sensation seeking, a risk factor for substance use (27), was assessed via three modified items from the Brief Sensation Seeking Scale. The item "I would like to explore strange places.", was omitted. Response options for each item were summed to create a mean score (10). The scale is internally consistent among youth in the PATH Study (Cronbach's α=0.76).

The urban primary sampling unit (PSU) indicator variable was used to define residence as "not urban" if at least 70% of its measure of size for sampling is contributed by counties not belonging to a Core Based Statistical Area (CBSA), and "urban" otherwise (28).

Internalizing and externalizing problems were assessed via modified subscales of the Global Appraisal of Individual Needs - Short Screener (GAIN-SS) (29) and categorized into no/low/moderate (0–3 symptoms) or high (4/4+ symptoms) severity (10). The response option "1+ years ago" for both subscales was modified to "Over a year ago". The suicidality item in the internalizing problems subscale was omitted.

Analyses

Distributions of covariates, tobacco, alcohol, and drug use were examined. For ease of interpretation, all variables (except sensation seeking) were categorized for analyses.

For the latent class analysis, 17 dichotomous (yes, no) variables were created for past 12-month use of tobacco products, alcohol, and drugs. The optimal number of classes was selected by specifying separate models, beginning with the most parsimonious one-class model and estimating successive models with two to six classes (30). Pearson and likelihood ratio chi-square statistics were examined, with nonsignificant p-values indicating good absolute model fit. Model selection criteria included statistical fit indices such as Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), or sample-size-adjusted BIC. Smaller AIC and BIC values suggest a better model fit. The TECH11 Lo-Mendell-

Rubin (LMR) test was also used to assess relative model fit (31). A low p-value rejects the k-1 class model in favor of the k class model. Adequate classification quality was determined by relative entropy and average classification probabilities (ACP). Higher entropy values indicate greater classification accuracy and ACP values close to 1 indicate high certainty and reliability.

Subsequently, the 3-step method was used to examine covariates that predict latent class membership via the AUXILIARY (R3STEP) option (32). In this approach, the first step is a regular latent class analysis using only the latent class indicators; the second step creates the most likely class variable, a nominal variable, using the latent class posterior distribution obtained during the estimation; and step three, the most likely class variable is used as the latent class indicator variable with uncertainty rates prefixed at the probabilities obtained in step 2. All covariates were entered in one model; therefore, each covariate is adjusted for all other covariates.

Distributions were examined using SAS Survey Procedures 9.4. Estimates were weighted to represent the U.S. youth population; variances and Wilson confidence intervals (CIs) were estimated using the balanced repeated replication method (33) with Fay's adjustment set to 0.3 to increase estimate stability (34). Latent class analyses were conducted in Mplus, version 7.4 with weight, strata, and cluster variables to accommodate the complex sampling design. Two-sided p-values of <.05 were considered statistically significant. Estimates based on fewer than 50 observations in the denominator or the relative standard error greater than 0.30 were suppressed (35). Full Information Maximum Likelihood was used to handle missing data on indicators of the latent variable. However, individuals with missing data on any covariate were deleted from the analysis (n=526).

RESULTS

Past 12-month Tobacco, Alcohol, and Drug Use

Figure 1 shows the prevalence of past 12-month tobacco, alcohol, and drug use among U.S. youth ages 15–17 years. Approximately 43.5% of youth used at least one substance (i.e. at least one of the 17 tobacco products, alcohol, and drugs) in the past 12 months, and over a quarter (25.6%; 95% CI: 24.1, 27.2; n=1477) used two or more of these 17 substances in the past 12 months (results not shown). Alcohol (28.5%; 95% CI: 26.9, 30.2; n=1695) use was the most prevalent, followed by marijuana (17.2%; 95% CI: 15.9, 18.6; n=1044), e-cigarettes (14.1%; 95% CI: 13.1, 15.3; n=846), and cigarettes (14.0%; 95% CI: 13.0, 15.2; n=851). Hookah and cigarillos were used by 10.6% (95% CI: 9.5, 11.8; n=648) and 9.0% (95% CI: 8.2, 9.9; n=550) of youth, respectively. About 7.5% (95% CI: 6.8, 8.2; n=462) of youth used non-prescribed painkillers/sedatives in the past 12 months.

Latent Classes of Poly-substance Use

Fit statistics are presented in Table 1 for models with 1–6 latent classes. Pearson and likelihood ratio chi-square statistics were not significant for models with 1–6 classes, indicating good absolute model fit. The LMR test was not significant for the 4-class, 5-class, and 6-class models, thus failing to reject the 3-class model in favor of these models.

However, the 5-class solution had minimum values on the BIC and sample-size adjusted BIC and acceptable entropy (0.805) and ACP (0.777–0.931). The bootstrap likelihood ratio test (BLRT), the best performing of the likelihood ratio tests (including the LMR), is more consistent at identifying the correct number of classes than the BIC for categorical outcomes (31). However, the BLRT is not available for complex mixture models used in the current study. Therefore, the BIC was relied upon to determine the best model fit. Using the BIC as a guide, the 5-class solution was a better fit than either the 3-class or the 6-class solutions.

Figure 2 reports the class prevalence and item response probabilities of the 5-class model. Class 1 formed the largest group, 'abstainers' (67.3%), with very low probabilities (≤0.1) of using tobacco, alcohol, and drugs. Class 2 comprised the 'alcohol users' (19.2%), with a higher probability of using alcohol (0.62) than tobacco products and drugs. Classes 3 and 4 comprised of alcohol, marijuana, and tobacco (AMT) users; however, the two classes differed in the probabilities of endorsement of alcohol and marijuana versus tobacco use. Users in class 3 had higher probabilities of using alcohol (0.78) and marijuana (0.81) than tobacco products (cigarettes (0.68), e-cigarettes (0.61), and other tobacco products (≤0.50)) and were therefore labeled as '$AMT_{predominant\ AM}$ users' (8.2%). In contrast, users in class 4 had higher probabilities of using tobacco products (cigarettes (0.81), e-cigarettes (0.70), and cigarillos (0.79)) than alcohol (0.59) and marijuana (0.51). Users in this class also had higher probabilities of using snus pouches (0.33) and smokeless tobacco excluding snus pouches (0.47) compared to any other class. Therefore, class 4 was labeled the '$AMT_{predominant\ T}$ users' (3.9%). Class 5 was comprised of 'alcohol, marijuana, tobacco, and other drug (AMTOD) users' (1.4%) due to much higher probabilities of using alcohol (0.93), and marijuana (0.95), tobacco products [cigarettes (0.95), e-cigarettes (0.87), cigarillos (0.86), hookah (0.74)], non-prescribed painkillers/sedatives (0.68), and other drugs (0.63) compared to other classes.

Latent Classes of Poly-substance Use with Covariates

Class 1 was considered the reference class due to low probabilities of tobacco, alcohol, and drug use (Table 2). Adjusting for all other covariates in the model, higher sensation seeking scores, higher age, and lower academic grades were each associated with greater likelihood of membership in all user classes. Compared to females, males had a lower likelihood of membership in class 3 (AOR=0.6; 95% CI: 0.5, 0.8), but a higher likelihood of membership in classes 4 (AOR=4.0; 95% CI: 2.7, 6.1) and 5 (AOR=1.9; 95% CI: 1.0, 3.6) relative to class 1. Compared to non-Hispanic Whites, racial/ethnic minorities had lower likelihood of membership in classes 4 (non-Hispanic Blacks, non-Hispanic other races, and Hispanics) and 5 (non-Hispanic Blacks and Hispanics) versus class 1. The likelihood of membership in class 5 versus class 1 was lower for youth whose parents/guardians had a college degree (AOR=0.4 95% CI: 0.2, 1.0) compared to those with less than high school education. Compared to youth residing in urban PSUs, those in non-urban PSUs had higher odds (AOR=2.2, 95% CI: 1.3, 3.6) of membership in class 4 relative to class 1. Compared to no/low/moderate severity problems, high severity internalizing problems were associated with higher likelihood of membership in classes 2, 3, and 5 versus class 1, whereas high severity externalizing problems were associated with higher likelihood of membership in only classes 3 and 5 versus class 1. Compared to those of straight sexual orientation, those

identifying as lesbian, gay, bisexual, or something else had higher likelihood of membership in classes 4 and 5 relative to class 1.

DISCUSSION

In this nationally representative study, approximately half of U.S. youth ages 15–17 years used at least one tobacco product, alcohol, or drug in the past 12 months. Alcohol use was the most prevalent, followed by marijuana, e-cigarettes, and cigarettes; these findings largely align with other national studies (6). The current study also reports that one out of four youths in this age group used two or more substances, corroborating findings of multiple substance use, especially tobacco products among youth (7). Whether this finding represents substitution for other substances or more extended-range poly-substance use patterns among youth warrants further research.

The multi-class solution reveals several emerging patterns of poly-substance use among U.S. youth ages 15–17 years. Consistent with prior research (16), abstainers (class 1) made up the largest group of youth. Alcohol users (class 2) continued to make up the largest group of youth substance users, reinforcing the need for sustained alcohol prevention strategies for youth below the legal age of drinking in the U.S. This study also revealed three heterogenous poly-substance use classes. Similar to prior studies (16), alcohol, marijuana, and tobacco use was the most common poly-substance use class. However, the two distinct AMT classes observed in this study highlight important nuances in use patterns not observed in prior studies. Whereas class 3 had higher probabilities of alcohol and marijuana use compared to tobacco product use, class 4 had higher probabilities of multiple tobacco product (i.e. cigarettes, e-cigarettes, and cigarillos) use compared to alcohol and marijuana, reflecting the heterogeneity of tobacco products used by youth in the changing tobacco landscape. The AMTOD users (class 5) made up a small proportion of youth, a finding consistent with the literature (15). However, the extended range of substance use in this class, particularly non-prescribed painkillers/sedatives and other drugs (i.e. cocaine or crack, other stimulants, heroin, inhalants, solvents, or hallucinogens) was striking in comparison to other classes, suggesting the need for ongoing monitoring and interventions for substance use behaviors in this group over time.

Our findings confirm age and academic performance as important correlates of youth poly-substance use (16). Findings are also consistent with prior studies on sensation seeking and poly-substance use (20, 21) supporting the desire for intense and novel experiences as an important factor associated with poly-substance use. That older age, lower academic grades, and higher sensation seeking showed a strong and consistent association with all user classes points to these factors as important markers or risk profiles for poly-substance use. Future studies can build on these findings to determine whether traits such as sensation seeking and poor academic performance predict the progression of youth substance use behaviors or whether youth substance use influences personality development and academic engagement.

Sexual orientation also emerged as a significant correlate of poly-substance use, particularly for classes 4 and 5. Consistent with findings from a prior community-based cohort study of U.S. adolescents (22), these findings highlight the need for tailored interventions and

policies for sexual orientation minority youth, a group at high risk for poly-substance use. Interestingly, males, non-Hispanic Whites, and those residing in non-urban PSUs were more likely to belong to class 4 ($AMT_{predominant\ T}$). These findings suggest a potential difference in this class as a normative group of users driven by social and environmental factors (15) who may benefit from tailored substance use prevention programs that consider these factors.

Internalizing and externalizing problems were associated with membership in classes 2 (internalizing problems only), 3, and 5, supporting the growing body of literature regarding the concerning comorbidities between substance use and mental health problems among youth (15, 19). While longitudinal analyses can help determine the temporality of these associations across classes, research supporting the effectiveness of integrated or simultaneous treatment for substance use and psychiatric disorders (15) reinforces the need for comprehensive prevention, screening, and treatment efforts to address these comorbidities. Somewhat surprisingly, mental health problems were not associated with membership in class 4, revealing a previously unreported complexity that the association between mental health and poly-substance use does not hold across all types of polysubstance users. This class was characterized by higher use of smokeless tobacco compared to other classes. Poly-tobacco use is common among smokeless tobacco users and factors associated with membership in this class (i.e. male gender, non-Hispanic White race/ethnicity, and residence in nonurban areas) are consistent with those associated with smokeless tobacco use (36, 37). Furthermore, our findings are consistent with a recent PATH Study finding that neither internalizing nor externalizing problems were associated with onset of smokeless tobacco use. Although low statistical power cannot be ruled out as a possible explanation, future studies should explore why individuals with mental health problems do not appear to be drawn to smokeless tobacco products.

This study's strengths include its nationally representative sample of U.S. youth, assessment of a wide range of tobacco products, alcohol, and drugs, as well as inclusion of personality (sensation seeking), residence in urban area, sexual orientation, and mental health correlates of poly-substance use. However, factors such as differences in sampling frames and timing of tobacco and substance use assessments limit the comparison of findings with prior studies. Although we did not use recent (i.e. past 30-day) use to identify the latent classes, past 12-month use measures ensured sufficient cell sizes and statistical power for our analyses. Because the PATH Study does not include a measure of SUD, we were unable to examine SUDs directly. However, future studies can examine transitions in latent classes and risk for substance use problems via the GAIN-SS, which has been shown to be an indicator of SUD (29). Finally, temporality cannot be determined due to the cross-sectional analyses in this study. While a prior PATH Study paper demonstrated bidirectional longitudinal associations between tobacco use and other substance use between Waves 1 and 2 among youth (11), the current study's identification of patterns of contemporaneous use across tobacco and other substances among youth suggests that future studies incorporate polysubstance use in definitions of substance use. Furthermore, findings from this Wave 1 analysis establish baseline poly-substance use and longitudinal data from future waves will allow the examination of transitions in poly-substance use patterns and risk factors of poly-substance use among U.S. youth.

In summary, this nationally representative study revealed distinct poly-substance use patterns among U.S. youth ages 15–17 years. Findings point to youth poly-substance users as a sub-group with greater use of emerging tobacco products, marijuana and other drugs. Correlates of substance use included higher sensation seeking, poor academic performance, residence in urban area, minority sexual orientation, and mental health problems. Given the changing tobacco and substance-use landscape with respect to availability, use of emerging products, and regulatory environments, youth poly-substance use patterns are likely to shift over time. The heterogeneous patterns identified in this study support the need for ongoing research to inform targeted prevention strategies. Additionally, effective and resource-efficient interventions are needed for youth engaging in multiple substance use, particularly those with identified mental health concerns and poor school performance.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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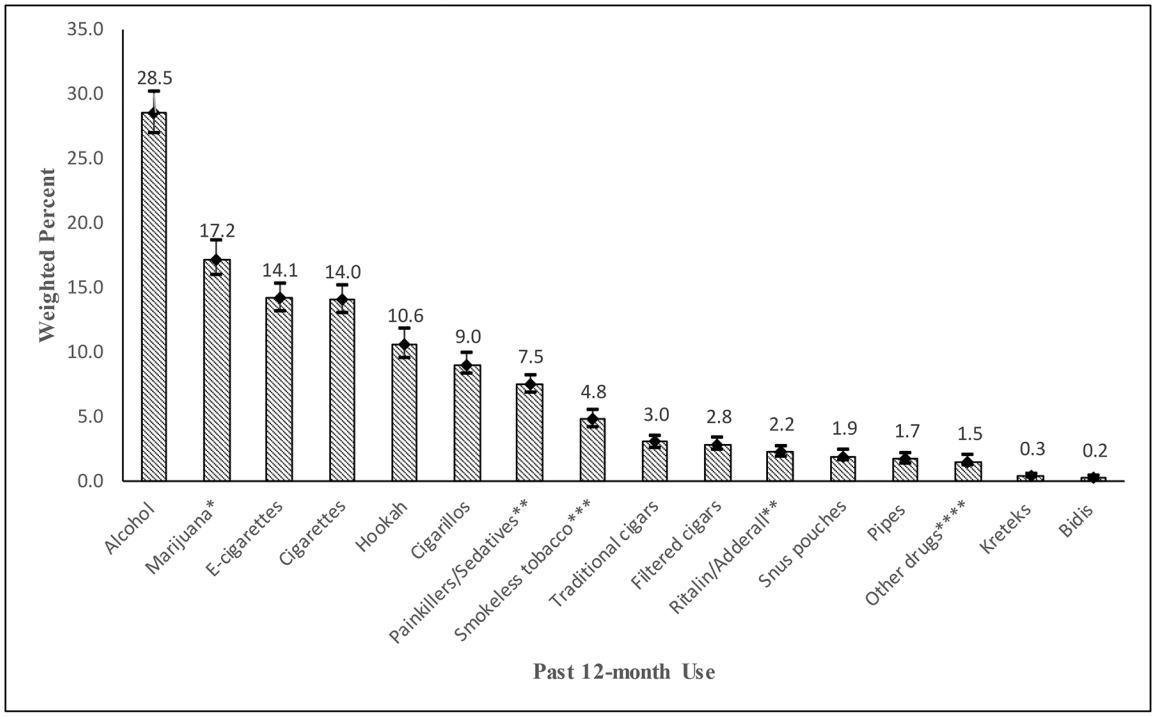

Figure 1.

Prevalence of Past 12-month Tobacco, Alcohol, and Drug Use among U.S. Youth (15–17 years), Wave 1 (2013–2014) of the Population Assessment of Tobacco and Health (PATH) Study.

* Includes past 12-month use of cigars as blunts.

** Refers to prescription drugs that were not prescribed for the participant or taken only for the experience or feeling they caused.

*** Excludes snus pouches.

**** Includes past 12-month use of cocaine or crack, stimulants (i.e. methamphetamine or speed), heroin, inhalants, solvents, or hallucinogens.

Estimates were weighted to represent the U.S. youth population; variances were estimated using the balanced repeated replication (BRR) method with Fay's adjustment set to 0.3 to increase estimate stability.

Proportions presented in the column graph are not mutually exclusive.

Estimates with a denominator <50 or a relative standard error >30% were suppressed, therefore proportions for dissolvable tobacco are not shown in the figure.

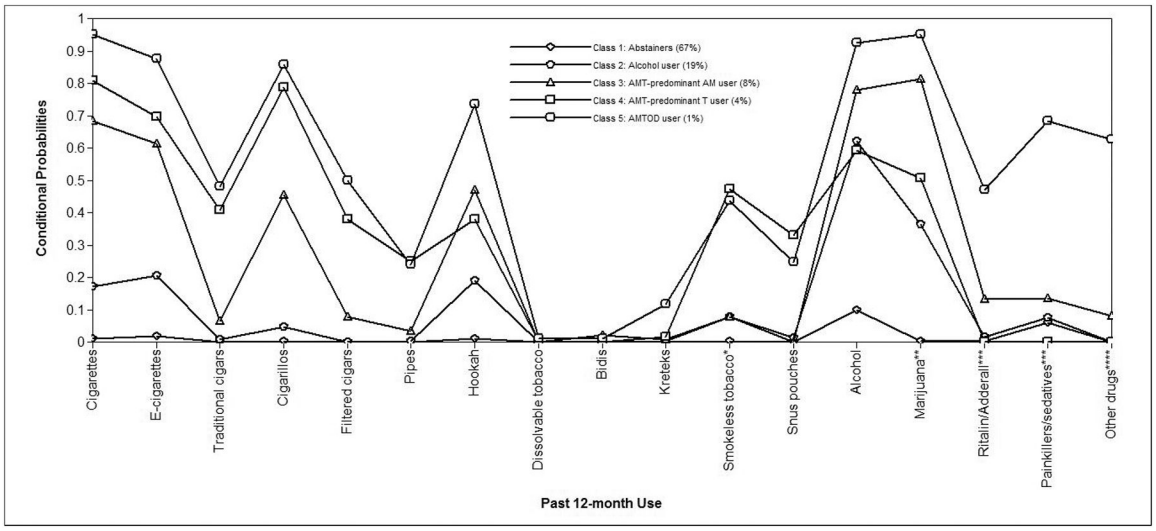

Figure 2.

Latent Classes of Past 12-month Poly-substance Use among U.S. Youth (15–17 years), Wave 1 (2013–2014) of the Population Assessment of Tobacco and Health (PATH) Study.

* Excludes snus pouches.

** Includes past 12-month use of cigars as blunts.

*** Refers to prescription drugs that were not prescribed for the participant or taken only for the experience or feeling they caused.

**** Includes past 12-month use of cocaine or crack, stimulants (i.e. methamphetamine or speed), heroin, inhalants, solvents, or hallucinogens.

Latent class analyses were conducted in MPlus, version 7.4 with weight, strata, and cluster variables to accommodate the complex sampling design.

Table 1.

Fit Statistics for 1–6 Latent Classes, Wave 1 (2013–2014) of the Population Assessment of Tobacco and Health (PATH) Study.

	Latent Classes					
Tests of Model Fit	**1**	**2**	**3**	**4**	**5**	**6**
# free parameters	17	35	53	71	89	107
General model fit						
Log-likelihood	−22166.131	−17718.294	−17280.716	−17150.655	−17062.982	−17013.859
Pearson χ^2	13927.719	12691.798	12147.637	11807.67	11872.673	11715.731
df	130778	130951	130946	130942	130936	130916
P-value	1.00	1.00	1.00	1.00	1.00	1.00
Likelihood ratio G^2	8325.443	9108.579	8915.121	8904.478	8878.676	8799.383
df	130778	130951	130946	130942	130936	130916
P-value	1.00	1.00	1.00	1.00	1.00	1.00
Incremental model fit						
Information Criteria						
AIC	44366.3	35506.6	34667.4	34443.3	34304.0	34241.7
BIC	44480.5	35741.8	35023.6	34920.5	34902.1	34960.8
Sample-size adjusted BIC	44426.5	35630.6	34855.2	34694.8	34619.3	34620.8
Lo-Mendell-Rubin test	N/A	8839.361	869.616	258.474	174.236	97.625
P-value	N/A	0.00	0.00	0.11	0.15	0.68
Quality of classification						
Entropy	N/A	0.91	0.85	0.87	0.81	0.81
Average class probabilities	1	0.980–0.954	0.879–0.959	0.809–0.963	0.777–0.931	0.686–0.933
Average posterior probabilities	1	0.990–0.915	0.792–0.986	0.719–0.984	0.581–0.988	0.369–0.984

AIC: Akaike information criterion; BIC: Bayesian information criterion

Table 2.

Correlates of Past 12-month Poly-substance Use among U.S. Youth (15–17 years), Wave 1 (2013–2014) of the Population Assessment of Tobacco and Health (PATH) Study.

	Class 2: Alcohol User				Class 3: $AMT_{predominant\ AM}$ User				Class 4: $AMT_{predominant\ T}$ User				Class 5: AMTOD User			
	OR	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**
Class proportions	19.2%				8.2%				3.9%				1.4%			
Mean sensation seeking score *	**1.7**	1.5	1.9	0.00	**2.6**	2.0	3.4	0.00	**2.4**	1.8	3.1	0.00	**3.2**	2.2	4.8	0.00
Age (years)																
15	referent				referent				referent				referent			
16	**1.6**	1.3	2.0	0.00	**2.3**	1.5	3.5	0.00	**2.3**	1.4	3.7	0.00	1.8	0.7	4.4	0.19
17	**2.3**	1.7	3.1	0.00	**5.4**	3.7	7.7	0.00	**4.4**	2.7	7.0	0.00	**5.9**	3.0	11.9	0.00
Sex																
Female	referent				referent				referent				referent			
Male	1.0	0.8	1.2	0.72	**0.6**	0.5	0.8	0.00	**4.0**	2.7	6.1	0.00	**1.9**	1.0	3.6	0.04
Race/ethnicity																
White, non-Hispanic	referent				referent				referent				referent			
Black, non-Hispanic	0.7	0.5	1.0	0.07	0.9	0.6	1.3	0.52	**0.1**	0.0	0.4	0.00	**0.1**	0.0	0.8	0.03
Other, non-Hispanic **	0.8	0.5	1.3	0.37	0.5	0.2	1.3	0.16	**0.5**	0.2	1.0	0.04	1.0	0.5	2.3	0.95
Hispanic	1.0	0.7	1.3	0.91	0.9	0.6	1.3	0.55	**0.3**	0.2	0.6	0.00	**0.4**	0.2	0.9	0.03
Urban PSU																
Urban																
Not urban	1.1	0.6	2.0	0.86	0.5	0.1	1.6	0.24	**2.2**	1.3	3.6	0.00	0.3	0.1	1.3	0.11
Grade																
at least some A’s																
B’s and C’s	**1.7**	1.3	2.2	0.00	**3.0**	2.2	4.0	0.00	**2.8**	1.8	4.5	0.00	**2.4**	1.3	4.5	0.01
C’s and D’s	**2.9**	2.0	4.2	0.00	**5.5**	3.5	8.8	0.00	**7.1**	4.3	11.7	0.00	**8.9**	3.9	20.2	0.00
D’s and F’s	**4.4**	2.0	9.7	0.00	**10.0**	4.8	21.1	0.00	**9.8**	3.9	24.4	0.00	**13.5**	4.7	39.3	0.00
Parent education																
Less than high school	referent				referent				referent				referent			
High school diploma or equivalent	1.1	0.8	1.5	0.60	0.9	0.5	1.4	0.59	1.3	0.8	2.2	0.32	0.9	0.3	2.5	0.88
Some college/technical program	1.0	0.7	1.4	0.97	1.0	0.6	1.6	0.98	1.2	0.6	2.4	0.68	0.8	0.3	1.9	0.61

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	Class 2: Alcohol User				Class 3: AMT$_{predominant\ AM}$ User				Class 4: AMT$_{predominant\ T}$ User				Class 5: AMTOD User			
	OR	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**
College/technical school/Associate's degree	0.8	0.5	1.1	0.12	1.1	0.7	1.6	0.78	0.6	0.3	1.2	0.16	**0.4**	0.2	1.0	0.04
Graduate/professional degree/some graduate school	1.0	0.6	1.7	0.95	1.0	0.6	1.9	0.93	0.8	0.3	1.8	0.55	0.8	0.3	2.2	0.73
Past-year internalizing problems***																
No/low/moderate severity	referent				referent				referent				referent			
High severity	**2.1**	1.5	3.0	0.00	**2.0**	1.4	2.8	0.00	1.0	0.6	1.5	0.85	**2.1**	1.0	4.0	0.04
Past-year externalizing problems***																
No/low/moderate severity	referent				referent				referent				referent			
High severity	1.3	1.0	1.8	0.07	**1.7**	1.2	2.4	0.00	1.4	0.9	2.0	0.13	**2.8**	1.5	5.3	0.00
Sexual orientation																
Straight					referent				referent				referent			
Lesbian, Gay, Bisexual, Something else	1.4	0.9	2.1	0.17	1.5	0.9	2.4	0.12	**2.6**	1.3	5.2	0.01	**3.9**	1.9	8.2	0.00

Class 1: Abstainers is the referent class.

*Measured via the modified Brief Sensation Seeking Scale.

**Includes non-Hispanic American Indian/Alaska Natives, Asian/Native Hawaiian/Other Pacific Islanders, or multiple races.

***Assessed via the Global Appraisal of Individual Needs-Short Screener (GAIN-SS) subscales,1 categorized into no/low/moderate severity (0–3 symptoms) and high severity (4/≥4 symptoms).

Odds ratios (ORs) and 95% confidence intervals (CIs) from multinomial regression models using the 3-step method to examine covariates that predict latent class membership.

Statistically significant associations at p<.05 indicated in bold text.

Latent class analyses were conducted in MPlus, version 7.4 with weight, strata, and cluster variables to accommodate the complex sampling design.