

# Early Trajectories of Alcohol and Other Substance Use Among Youth From Rural Communities Within the Cherokee Nation

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**ABSTRACT. Objective:** This research examines gender and racial/ethnic differences in substance use trajectories during early adolescence among American Indian and non-Native adolescents. **Method:** Substance use trajectories were evaluated among 684 adolescents (50% female, 51% American Indian) across five assessments over 9th and 10th grades. Youth were drawn from six rural towns within the Cherokee Nation, a nonreservation tribal jurisdiction that includes a high proportion of American Indians embedded within a predominantly White population. Past-month substance use was based on self-report and was dichotomized into “used” versus “did not use,” with the exception of alcohol, which was trichotomized into “none,” “1 or 2 days,” or “3–30 days.” **Results:** Using growth mixture modeling with full-information maximum-likelihood estimation, we determined that between two and three different trajectory classes best described the data for each

substance. Males had a higher probability compared with females of following a trajectory of chewing tobacco use (20% vs. 6%, respectively) and using multiple substances (24% vs. 19%, respectively). Females had a higher probability compared with males of following a trajectory of prescription drug misuse (11% vs. 6%, respectively). Individuals who followed trajectories of alcohol use or heavy drinking were also more likely to follow trajectories of other substance use. **Conclusions:** Identifying gender and racial/ethnic differences in patterns of substance use at this stage of development will inform gender-sensitive and ethnically sensitive prevention programs targeting specific substance use. These results will be particularly informative given the lack of evidence regarding trajectories of substance initiation within largely American Indian populations. (*J. Stud. Alcohol Drugs*, 77, 238–248, 2016)

ALCOHOL AND OTHER DRUG USE play an important role in the immediate and long-term health of youth. Rural youth, particularly racial/ethnic minorities in rural communities, are at increased risk for alcohol use (Swaim & Stanley, 2010). The Cherokee Nation is a nonreservation, 14-county jurisdictional service area located in northeastern Oklahoma where approximately half of the 300,000 Cherokee citizens reside. Given that the Cherokee Nation is not a reservation, communities within the Nation are multi-ethnic, rural communities comprising primarily American Indian (AI) and White populations (Komro et al., 2015). Longitudinal changes in substance use and multisubstance use have not been evaluated in these rural, diverse communities consisting

of a large population of AI youth. Investigating differences between AI and White youth in alcohol and other substance use initiation during early adolescence may inform future health disparities between AI and non-Native populations.

## *Early substance use: Nationally and in the Cherokee Nation*

Ninth to 10th grade is a high-risk period for early initiation of a variety of substances. Results from the 2013 Youth Risk Behavior Survey (YRBS), a nationally representative survey of risk behaviors and substance use among students in grades 9–12, revealed significant increases in current (e.g., past-30-day) cigarette use, alcohol use, heavy drinking, and marijuana use between 9th and 10th grades (Kann et al., 2014). There were also significant increases in having ever misused prescription drugs between 9th and 10th grades. The use of chewing tobacco did not show significant increases between 9th and 10th grades in this national survey.

Epidemiological surveys on risk behaviors among youth within the jurisdictional service boundaries of the Cherokee Nation (Cherokee Nation-YRBS) indicate that adolescent substance use is either comparable to or higher than results from the nationally representative YRBS with the exception of marijuana use (Cherokee Nation, 2013; Kann et al., 2014). Current (e.g., past-30-day) substance use among ninth graders

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as reported in the 2012 Cherokee Nation-YRBS was 25% for alcohol use, 17% for heavy drinking (five or more drinks on the same occasion), 15% for cigarette use, 12% for chewing tobacco use, and 12% for marijuana use. According to the nationally representative YRBS, current (e.g., past-30-day) substance use among ninth graders was 24% for alcohol use, 14% for heavy drinking, 10% for cigarette use, 7% for chewing tobacco use, and 18% for marijuana use. Twelve percent of ninth graders nationally and within the Cherokee Nation reported having ever misused prescription drugs. There were no sex differences in use of the aforementioned substances among ninth graders in the Cherokee Nation, with one exception: Males were significantly more likely than females to currently use chewing tobacco (19% vs. 4%, respectively). These findings emphasize the importance of evaluating each substance separately given differing patterns of initiation as well as differences in social acceptability and legality.

### *Trajectories of substance use*

Many studies of early substance use have focused on evaluating changes and demographic differences in average rates of use. However, methodological developments allow for the evaluation of population trends in trajectories of substance use. These developments have facilitated the testing of theories such as Moffitt's theory of adolescent-limited versus life course-persistent antisocial behavior (Moffitt et al., 2001). According to this theory, there are groups of individuals who differ in terms of the age at onset and developmental course of antisocial behaviors, including substance use. A small subgroup of the population is theorized to have an earlier age at onset and more persistent problem behaviors (life course-persistent) compared with individuals who may have later onset of problem behavior (adolescent-limited). Evaluating groups of individuals who follow similar trajectories of substance use across time helps to identify higher risk subgroups of the population, which can inform future prevention and intervention efforts.

*Review of group-based methods.* Analytic methods such as growth mixture models (GMM)/latent class growth analysis capture heterogeneity by identifying subgroups of the population that follow similar patterns of change (Muthén, 2001, 2004; Nagin, 2005). These models have the ability to differentiate those who abstain from other potential subgroups of substance users. Previous studies of adolescent substance use have identified between two and eight different trajectory classes of alcohol, tobacco, or marijuana use during adolescence (Cheadle & Sittner Hartshorn, 2012; Cheadle & Whitbeck, 2011; Eassey et al., 2015; Hampson et al., 2013; Huang et al., 2013; Juon et al., 2011; Lynne-Landsman et al., 2010, 2011; Whitesell et al., 2014). Variation in the number of classes identified is the result of differences in model specifications, age ranges evaluated, frequency of assessments, and other sample-specific factors. Despite this

variability, there is some consistency in the results of previous studies of trajectories of alcohol, tobacco, and marijuana use. All find a low- or no-use trajectory as well as evidence of increasing trajectories, some of which increase more rapidly and maintain high levels of use, whereas others may increase more gradually or subsequently decrease.

*Group-based methods with American Indian populations.* Three studies have specifically evaluated trajectories of substance use among AI populations. Two of these studies were based on the same sample but evaluated different substance use outcomes: alcohol (Cheadle & Whitbeck, 2011) and marijuana (Cheadle & Sittner Hartshorn, 2012). These youth were from reservations in the Northern Midwest of the United States as well as Canadian First Nation reserves, with annual data on substance use spanning ages 10–14 years. Both studies identified three classes of either alcohol or marijuana use: abstainers (64% and 66%, respectively), early onset (18% and 15%, respectively), and adolescent onset (18% and 19%, respectively). Among AI youth who followed trajectories of early-onset or adolescent-onset alcohol use, approximately 70% and 50%, respectively, met diagnostic criteria for alcohol abuse/dependence when they were older compared with 17% of the abstainer group. Similarly, approximately 60% of youth following a trajectory of early-onset marijuana use and 50% of adolescent-onset marijuana users met diagnostic criteria for marijuana abuse/dependence when they were older compared with 13% of the abstainer group. In addition, girls were more likely to follow trajectories of early-onset marijuana use and alcohol use. Unfortunately, the analysis of alcohol use and marijuana use separately precluded any comparisons of multisubstance use.

The third study evaluated trajectories of cigarette, alcohol, and marijuana use employing biannual longitudinal data from middle school students on a Northern Plains reservation across the course of 2 years (Whitesell et al., 2014). Three classes were identified as best representing the data for each of the substances. Alcohol and marijuana use were similar with classes of nonusers (62% and 58%, respectively), starters (12% and 17%, respectively), and users (25% and 26%, respectively). Classes of cigarette use were somewhat different and consisted of 62% nonusers, 30% occasional smokers, and 8% experimental smokers. This study was able to evaluate multisubstance use and found that approximately 40% of the sample followed trajectories of nonuse across all three substances. Twenty-two percent of the sample followed a single substance use trajectory, and 38% followed trajectories of use for more than one substance. In addition, girls were more likely to follow trajectories of use for all three substances.

### *Current study*

This study identifies group-based trajectories of substance use within a culturally diverse, rural area with a high propor-

tion of AI youth rather than focusing on AI youth living on reservations. It provides the first information to our knowledge on potential demographic differences in developmental patterns of early substance use and multiple substance use between rural non-Native and AI youth. In addition, to our knowledge, this is the first study to move beyond evaluation of alcohol, cigarette, and marijuana use by including evaluations of trajectories of chewing tobacco use, prescription drug misuse, and other illicit drug use across five assessments that occur within a single year. The inclusion of alcohol and other drugs in this study allowed for the evaluation of multiple substance use. Moreover, early initiation of substance use (e.g., 9th and 10th grades) is linked to higher risk for the development of substance use disorders that are associated with other medical and mental health problems (Mayes & Suchman, 2006), thus highlighting the importance of studying this developmental period. Given previous evidence of gender differences in specific substance use, we also evaluated gender differences in trajectory class membership and multiple substance use in addition to differences by race/ethnicity. Ultimately, these findings will inform avenues for substance use prevention and intervention to improve health outcomes among AI and rural youth.

## Method

### *Participants*

This study is part of a larger randomized controlled trial designed to evaluate a community-level intervention to prevent underage drinking and related harms within the boundaries of the Cherokee Nation (Komro et al., 2015). Participants were 684 adolescents (50% female) who provided longitudinal data across five baseline assessments over 9th grade (three waves in Study Year 1) and 10th grade (two waves in Study Year 2), before the implementation of any intervention activities. Schools in four communities participated in all five baseline assessments, with two additional communities/schools added for the final two baseline assessments. At the first assessment, 41% of participants were age 14 years or younger, 52% were 15 years old, and 7% were 16 years old. Fifty-one percent of the sample reported AI heritage at least once across the five assessments. Thirty-six percent of guardians attained a high school diploma or less, and 51% of youth received free or reduced-price lunch.

### *Procedure*

A passive consent procedure approved by the University of Florida and the Cherokee Nation Institutional Review Boards was used to inform parents about the nature of the survey and to provide them with an opportunity to disallow their child's participation at each time of assessment. Student assent was also obtained at each time of assessment. Percent-

ages of parental and student refusals to participate were very consistent across the five baseline assessments. One to two percent of parents/guardians requested that their child not take part in the survey across the five baseline assessments. Student refusals ranged from 0% to 1% across times of assessment. To maximize confidentiality, school staff and local community members were not involved in the survey data collection procedures. Moreover, each student had a unique study ID to enable linking individual survey responses over time while maintaining confidentiality. Additional details on study design and procedures are published in Komro et al. (2015).

### *Measures*

*Demographics.* Students self-reported race, ethnicity, gender, parental education, age, and whether they received free or reduced-price lunch. For the purposes of analyses, a single dichotomous variable was created to represent participants who reported AI or AI mixed heritage (1) compared with all other participants (0). Gender was a single dichotomous variable of males (1) compared with females (0).

*Substance use.* Survey items based on the national YRBS assessed past-month frequency of alcohol use, heavy drinking, cigarette smoking, chewing tobacco use, marijuana use, prescription drug misuse, and other illicit drug use (Kann et al., 2014). Response options ranged from *none* to *every day or more than once a day*. Given the low rates of reported substance use typical among adolescents on entry into high school, these variables were dichotomized into "used" versus "did not use," with the exception of alcohol use, which was recoded "none," "1 or 2 days," or "3–30 days."

### *Analyses*

GMM is a longitudinal analytic technique capable of estimating subgroups of individuals who differ in initial levels and/or rates of change for a given outcome over time (Muthén, 2004). A strength of this analytic technique is the ability to identify subgroups within the population based on the data rather than creating arbitrary groups based on cut-points. We conducted separate GMM analyses for each of the substance use outcomes of interest given evidence of potential gender differences in substance use as well as differences in social acceptability, legality, and long-term adjustment problems associated with each substance. This provided us with the ability to evaluate gender and racial/ethnic differences in patterns of substance use as well as evaluate multiple substance use.

Diagnostic criteria used to determine the best-fitting GMM model for each substance use outcome included the log likelihood values, Bayesian (and sample size-adjusted Bayesian) information criterion, Akaike information criterion, the likelihood ratio test, the Lo–Mendell–Rubin ad-

justed likelihood ratio test, and the bootstrapped likelihood ratio test (Muthén & Muthén, 1998–2015; Nylund et al., 2007). Entropy, an indicator of correct classification based on posterior probabilities, was also used to determine model fit.

GMM analyses were conducted using Mplus Version 7.3 (Muthén & Muthén, 1998–2015). Given dichotomous outcomes, a logit link function was used to estimate all models, including the alcohol use model, which was specified as an ordered categorical outcome. Most likely, class membership was then exported with each individual participant assigned to a trajectory class based on their posterior probability for each substance. Additional analyses using the assigned trajectory classes, including evaluations of gender and racial/ethnic differences, were conducted using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY).

*Missing data.* Some data during the first three assessments were missing by design, given that two additional schools were added beginning with the 10th-grade assessments. These data were considered missing completely at random, and full-information maximum-likelihood (FIML) parameter estimation with robust standard errors was used to impute missing values. FIML is widely accepted as an appropriate technique for handling missing data (Muthén & Shedden, 1999; Schafer & Graham, 2002) because it produces reliable effect estimates despite deviations from normality, assuming that data are missing at random (Muthén & Muthén, 1998–2015). As such, the GMMs are based on the full sample.

The bivariate covariance “coverage” matrix provides the proportion of available observations for each outcome and pair of outcomes for a specific GMM analysis, an indicator of the extent of missing data in the data set. The minimum coverage necessary for models to converge is 10% (Muthén & Muthén, 1998–2015). In the current study, coverage ranged from 56% to 78%, which is more than adequate for unbiased estimation.

## Results

### *Descriptive analysis*

There were no significant differences in the percentage of males compared with females among the demographic variables (e.g., AI race/ethnicity, parental education, and free/reduced-price lunch). Slightly more non-Native youth (57%) received free or reduced-price lunch compared with AI youth (46%),  $\chi^2(1, n = 428) = 4.99, p = .026$ .

Reported substance use was low overall among this early high school sample of youth and did not differ by gender or AI race/ethnicity; however, there were a few notable exceptions (Table 1). At each of the five longitudinal assessments, males (10%–16%) consistently reported significantly higher rates of chewing tobacco use compared with females (2%–

5%). Females (7%–14%) reported significantly higher rates of prescription drug misuse compared with males (3%–6%), except in the last assessment period. There was some limited, assessment-specific evidence of higher rates of chewing tobacco use and marijuana use by AI youth compared with non-Native youth.

### *Growth mixture models*

Table 2 provides model-fit statistics for each substance. For all models, estimating a two-class model significantly improved model fit and was superior to the one-class model. For marijuana use, cigarette use, and chewing tobacco use, the addition of a third class significantly improved model fit. The addition of the third class in these models resulted in small subgroups that may be of theoretical importance, particularly given that this study spans entry into high school. Figure 1 illustrates the selected trajectory models for each substance. All waves of data collection occurred over the course of a single year, encompassing 9th grade (Waves 1–3) and the beginning of 10th grade (Waves 4 and 5). The classes as discussed herein are meant to describe typical patterns of substance use within that specific class; however, there is individual variability within class, and, as such, caution should be taken not to reify the classes.

Interactions between sex and race/ethnicity were evaluated for those substances with sufficient sample sizes (e.g., alcohol use, heavy drinking, cigarette use, marijuana use, and multiple substance use). None of these interactions was statistically significant. Main effects of sex and race/ethnicity are reported below.

*Alcohol use.* A two-class model best represented trends in past-month alcohol use over time. Most of the sample (77%) followed a trajectory of none to minimal past-month alcohol use during early high school. However, almost 1 in 4 youth (23%) followed a trajectory of increasing past-month alcohol use. Among the increasing alcohol users, their estimated probability of past-month alcohol use was .52 on first assessment in ninth grade, and this probability increased significantly over time. There were no significant differences in probability of past-month alcohol use class membership by sex or race/ethnicity (Table 3).

*Heavy drinking.* Similar to alcohol use, past-month heavy drinking was also best represented by a two-class model over time. Eighty-four percent of the sample followed a trajectory of no heavy drinking in the past month. Sixteen percent of the sample followed a trajectory of increasing past-month heavy drinking. This is particularly problematic given the young age of these youth and the riskiness of heavy drinking for subsequent health outcomes. The estimated probability of past-month heavy drinking among the increasing trajectory group was .34 on first assessment in 9th grade, increasing significantly over time to more than .50 by early 10th grade. Similar to past-month alcohol use, there were no significant

TABLE 1. Descriptive information on self-reported substance use during past month, 2011–2012

Variable	Sex		Race/ethnicity		Total sample (n)
	Male (n)	Female (n)	Non-native (n)	Native (n)	
<b>Alcohol use</b>					
9th grade, W1	14% (33)	18% (46)	17% (40)	15% (39)	16% (79)
9th grade, W2	14% (33)	15% (40)	13% (30)	17% (43)	15% (73)
9th grade, W3	14% (32)	19% (48)	14% (33)	19% (47)	16% (80)
10th grade, W4	20% (53)	21% (57)	20% (48)	22% (62)	21% (110)
10th grade, W5	17% (42)	22% (59)	19% (46)	20% (55)	20% (101)
<b>Heavy drinking</b>					
9th grade, W1	6% (15)	9% (24)	9% (21)	7% (18)	8% (39)
9th grade, W2	8% (18)	7% (19)	7% (16)	8% (21)	8% (37)
9th grade, W3	8% (18)	12% (29)	7% (17)	12% (30)	10% (47)
10th grade, W4	14% (37)	14% (36)	13% (32)	15% (41)	14% (73)
10th grade, W5	8% (20)	14% (37)	12% (28)	11% (29)	11% (57)
<b>Cigarette use</b>					
9th grade, W1	7% (17)	12% (31)	8% (19)	11% (29)	9% (48)
9th grade, W2	9% (21)	11% (29)	9% (22)	11% (28)	10% (50)
9th grade, W3	11% (26)	12% (31)	11% (27)	12% (30)	12% (57)
10th grade, W4	14% (38)	15% (41)	15% (37)	15% (42)	15% (79)
10th grade, W5	16% (40)	17% (44)	13% (31)	19% (53)	16% (84)
<b>Chewing tobacco use</b>					
9th grade, W1	10% (25)***	2% (5)***	5% (12)	7% (18)	6% (30)
9th grade, W2	12% (28)***	2% (4)***	5% (11)	8% (21)	6% (32)
9th grade, W3	10% (23)**	4% (9)**	6% (14)	7% (18)	7% (32)
10th grade, W4	16% (41)***	5% (12)***	7% (17)*	13% (36)*	10% (53)
10th grade, W5	15% (38)***	4% (10)***	6% (15)*	12% (33)*	9% (48)
<b>Marijuana use</b>					
9th grade, W1	5% (12)	7% (19)	4% (10)	8% (21)	6% (31)
9th grade, W2	8% (20)	6% (15)	4% (9)**	10% (26)**	7% (35)
9th grade, W3	11% (25)	8% (20)	8% (18)	11% (27)	9% (45)
10th grade, W4	10% (27)	10% (26)	9% (21)	11% (32)	10% (53)
10th grade, W5	11% (27)	11% (30)	9% (22)	13% (35)	11% (57)
<b>Prescription drug misuse</b>					
9th grade, W1	3% (8)*	7% (19)*	7% (17)	4% (10)	5% (27)
9th grade, W2	4% (9)*	8% (21)*	6% (13)	7% (17)	6% (30)
9th grade, W3	3% (8)*	9% (22)*	8% (19)	4% (11)	6% (30)
10th grade, W4	6% (16)**	14% (38)**	9% (23)	11% (31)	10% (54)
10th grade, W5	7% (17)	10% (26)	9% (21)	8% (22)	8% (43)
<b>Other illicit drug use</b>					
9th grade, W1	2% (6)	3% (9)	2% (4)	4% (11)	3% (15)
9th grade, W2	3% (6)	3% (7)	3% (6)	3% (7)	3% (13)
9th grade, W3	3% (7)	4% (11)	3% (8)	4% (10)	4% (18)
10th grade, W4	4% (11)	3% (9)	5% (11)	3% (9)	4% (20)
10th grade, W5	3% (7)	5% (12)	3% (6)	5% (13)	4% (19)

Notes: W = wave.

\* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

differences in probability of past-month heavy drinking class membership by sex or race/ethnicity (Table 3).

*Cigarette use.* Past-month cigarette use was best characterized by a three-class model: none (82%), increasing (3%), and high (15%). The majority of youth followed a trajectory of no cigarette use across 9th and 10th grades. A substantial minority followed a trajectory of high cigarette use, with an estimated probability of past-month cigarette use at .75 on first assessment in ninth grade, which remained relatively stable across time. The smallest trajectory class consisted of youth who began ninth grade with an estimated probability of past-month cigarette use near zero, which subsequently increased to .93 by the last assessment. Although only a few youth followed the increasing cigarette use trajectory, this is

a substantively distinct pattern of early cigarette use. There were no significant differences by sex or race/ethnicity in cigarette use class membership (Table 3).

*Marijuana use.* Past-month marijuana use was also best characterized by a three-class model: none (82%), moderate (14%), and high (4%). None of these trajectory classes showed statistically significant increases over the course of 9th and 10th grades. The nonuser class consisted of the majority of the sample, with estimated probabilities of past-month marijuana use at zero across time. A substantial minority of youth followed a trajectory of moderate marijuana use. These youth had estimated probabilities of past-month marijuana use that ranged from .31 to .47 across time. Four percent of the sample followed a trajectory of high marijuana

TABLE 2. Model-fit statistics for fitting a growth mixture model

Model	Log likelihood	No. of free parameters	BIC	SSA BIC	AIC	VLMR LRT <i>p</i> value	LMR-adjusted LRT <i>p</i> value	BLRT	Entropy	Smallest class % ( <i>n</i> )
Alcohol use										
1 class	-1,470.70	3	2,960.98	2,951.45	2,947.40	–	–	–	–	100% (682)
<b>2 class</b>	<b>-1,308.79</b>	<b>6</b>	<b>2,656.74</b>	<b>2,637.69</b>	<b>2,629.59</b>	<b>&lt;.0001</b>	<b>&lt;.0001</b>	<b>&lt;.0001</b>	<b>.75</b>	<b>23% (156)</b>
3 class	-1,297.66	9	2,654.05	2,625.48	2,613.33	.248	.261	<.0001	.74	3% (21)
Heavy drinking										
1 class	-814.50	2	1,642.05	1,635.70	1,633.00	–	–	–	–	100% (681)
<b>2 class</b>	<b>-722.63</b>	<b>5</b>	<b>1,477.88</b>	<b>1,462.00</b>	<b>1,455.26</b>	<b>&lt;.0001</b>	<b>&lt;.0001</b>	<b>&lt;.0001</b>	<b>.71</b>	<b>16% (107)</b>
3 class	Nonconvergence									
Marijuana use										
1 class	-745.36	2	1,503.77	1,497.42	1,494.72	–	–	–	–	100% (682)
2 class	-577.71	5	1,188.05	1,172.18	1,165.43	<.0001	<.0001	<.0001	.85	16% (107)
<b>3 class</b>	<b>-571.43</b>	<b>8</b>	<b>1,195.06</b>	<b>1,169.66</b>	<b>1,158.86</b>	<b>.016</b>	<b>.019</b>	<b>&lt;.0001</b>	<b>.84</b>	<b>4% (27)</b>
4 class	Nonconvergence									
Cigarette use										
1 class	-949.86	2	1,912.78	1,906.43	1,903.73	–	–	–	–	100% (682)
2 class	-709.24	5	1,451.10	1,435.22	1,428.47	<.0001	<.0001	<.0001	.89	18% (123)
<b>3 class</b>	<b>-701.72</b>	<b>8</b>	<b>1,455.64</b>	<b>1,430.24</b>	<b>1,419.44</b>	<b>.006</b>	<b>.008</b>	<b>&lt;.0001</b>	<b>.85</b>	<b>3% (20)</b>
4 class	Nonconvergence									
Chewing tobacco use										
1 class	-683.67	2	1,380.34	1,374.04	1,371.34	–	–	–	–	100% (682)
2 class	-499.07	5	1,030.76	1,014.88	1,008.13	<.0001	<.0001	<.0001	.91	9% (62)
<b>3 class</b>	<b>-487.39</b>	<b>8</b>	<b>1,026.98</b>	<b>1,001.58</b>	<b>990.78</b>	<b>.0001</b>	<b>.0002</b>	<b>&lt;.0001</b>	<b>.84</b>	<b>4% (28)</b>
4 class	Nonconvergence									
Prescription drug misuse										
1 class	-655.59	2	1,324.22	1,317.87	1,315.17	–	–	–	–	100% (682)
<b>2 class</b>	<b>-529.07</b>	<b>5</b>	<b>1,090.76</b>	<b>1,074.89</b>	<b>1,068.14</b>	<b>&lt;.0001</b>	<b>&lt;.0001</b>	<b>&lt;.0001</b>	<b>.88</b>	<b>8% (57)</b>
3 class	Nonconvergence									
Other illicit drug use										
1 class	-371.69	2	756.43	750.08	747.38	–	–	–	–	100% (682)
<b>2 class</b>	<b>-319.65</b>	<b>5</b>	<b>671.92</b>	<b>656.05</b>	<b>649.30</b>	<b>&lt;.0001</b>	<b>&lt;.0001</b>	<b>&lt;.0001</b>	<b>.97</b>	<b>3% (20)</b>
3 class	Nonconvergence									

Notes: **Bold** indicates selected model. No. = number; BIC = Bayesian Information Criteria; SSA BIC = Sample size-adjusted Bayesian Information Criteria; AIC = Akaike Information Criteria; VLMR LRT = Vuong–Lo–Mendell–Rubin Likelihood Ratio Test; LMR-Adjusted LRT = Lo–Mendell–Rubin Adjusted Likelihood Ratio Test; BLRT = Bootstrapped Likelihood Ratio Test.

use. These youth began ninth grade with an estimated probability of past-month marijuana use of .65, which stabilized near 1 across waves. There were no significant differences by sex or race/ethnicity in marijuana use class membership (Table 3).

*Chewing tobacco use.* A three-class model best characterized patterns of past-month chewing tobacco use over time. The majority of youth followed a trajectory of no chewing tobacco use (87%). The estimated probability of past-month chewing tobacco use remained near zero across all waves of assessment for the nonuser class. Nine percent of the sample followed a trajectory of moderate/increasing chewing tobacco use. These youth had a .25 estimated probability of past-month chewing tobacco use at the first assessment in early 9th grade, increasing to .50 by the final assessment in 10th grade. The smallest user class (4% of the sample) consisted of youth with a high estimated probability of past-month chewing tobacco use (.97 or greater across waves). Significantly more males followed trajectories of moderate/increasing or high chewing tobacco use (13% and 7%, respectively) compared with females (5% and 1%, respectively). There

were no significant differences in chewing tobacco trajectory class membership by race/ethnicity (Table 3).

*Prescription drug misuse.* A two-class model best represented trends in past-month prescription drug misuse over time. Ninety-two percent of the sample followed a nonuser trajectory with estimated probabilities of prescription drug misuse near zero across all waves of assessment. Eight percent of youth followed a trajectory of increasing past-month prescription drug misuse. The estimated probability of prescription drug misuse among the user class was .50 at the first assessment, significantly increasing to .77 by the last assessment. Females were significantly more likely to follow a trajectory of prescription drug misuse (11%) compared with males (6%). There were no significant differences in prescription drug misuse class membership by race/ethnicity (Table 3).

*Other illicit drug use.* Other illicit drug use was also best represented by a two-class model. The vast majority of the sample followed a trajectory of no other illicit drug use (97%). Three percent of the sample followed a trajectory of illicit drug use, with an estimated probability of having used

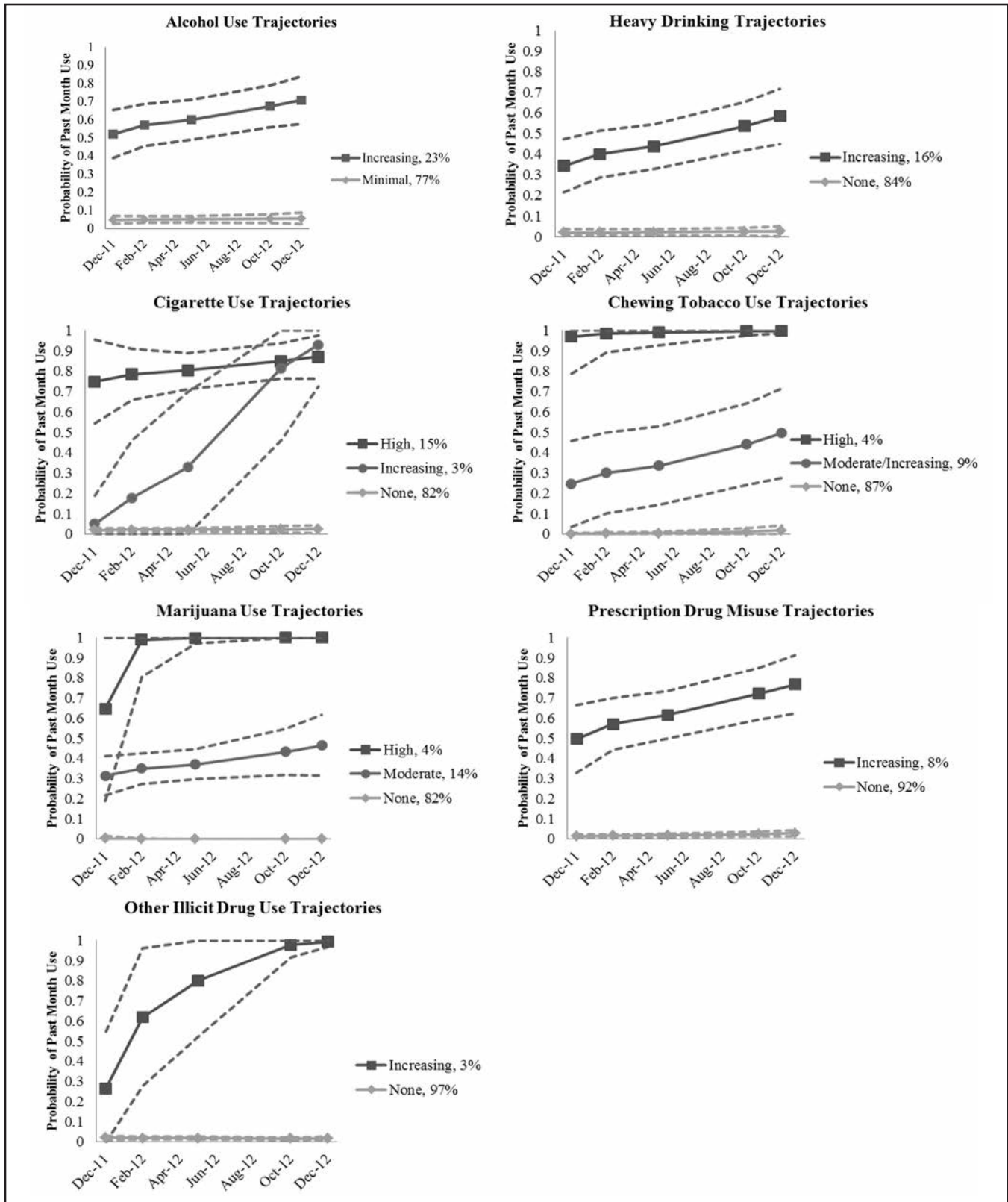


FIGURE 1. Past-month substance use trajectories over 9th and 10th grades. Solid lines represent observed data. Dashed lines represent 95% confidence intervals. The legend provides the label and percentage of the sample that follow a specific trajectory. X-axis represents when assessments occurred over the course of a single calendar year, with assessments 1–3 occurring in the 9th grade and assessments 4 and 5 occurring in the 10th grade. Y-axis represents the probability of reporting past-month substance use.

TABLE 3. Sex and racial/ethnic differences within trajectory group

Variable	Sex		Race/ethnicity	
	Male	Female	Non-native	Native
Alcohol use				
Minimal	78%	76%	77%	78%
Increasing	22%	24%	23%	22%
Heavy drinking				
None	85%	84%	85%	84%
Increasing	15%	16%	15%	16%
Cigarette use				
None	83%	81%	83%	82%
Increasing	3%	3%	2%	4%
High	14%	16%	15%	14%
Marijuana use				
None	82%	83%	84%	81%
Moderate	15%	12%	12%	15%
High	3%	5%	4%	4%
Chewing tobacco use				
None	80%	94%	89%	85%
Moderate/increasing	13%	5%	8%	10%
High	7%	1%	3%	5%
Prescription drug misuse				
None	94%	89%	90%	93%
Users	6%	11%	10%	7%
Other illicit drug use				
None	97%	97%	98%	97%
Users	3%	3%	2%	3%

\* $p < .05$ ; \*\*\* $p < .001$ .

an illicit drug in the past month of .27 at the first assessment, significantly increasing to an estimated probability of .99 by the last assessment in 10th grade. Although this is a small subgroup of the sample, this is an extremely high-risk group of individuals with early onset and escalation of illicit drug use. There were no significant differences in probability of past-month illicit drug use class membership by sex or race/ethnicity (Table 3).

*Multiple substance use*

Although each of the substances shows different patterns of change over time and different prevalence within this population, we also wanted to investigate the occurrence of multiple substance use, particularly overlap of alcohol use with other substances. For the initial evaluation of multiple substance use, individuals who followed trajectories of alcohol use and heavy drinking were combined into a single alcohol user category, as these groups represent different severity of use of the same substance rather than multiple substance use. We also consolidated the user trajectories for those substances that had three class models. Hence, the following analysis of multiple substance use evaluated trajectories of use versus trajectories of nonuse for all six substances.

*Overall multiple substance use.* Figure 2 illustrates the percentage of the sample, separated by sex, engaged in multiple substance use. The *x*-axis represents the number of substance use trajectories followed by an individual (e.g., 0

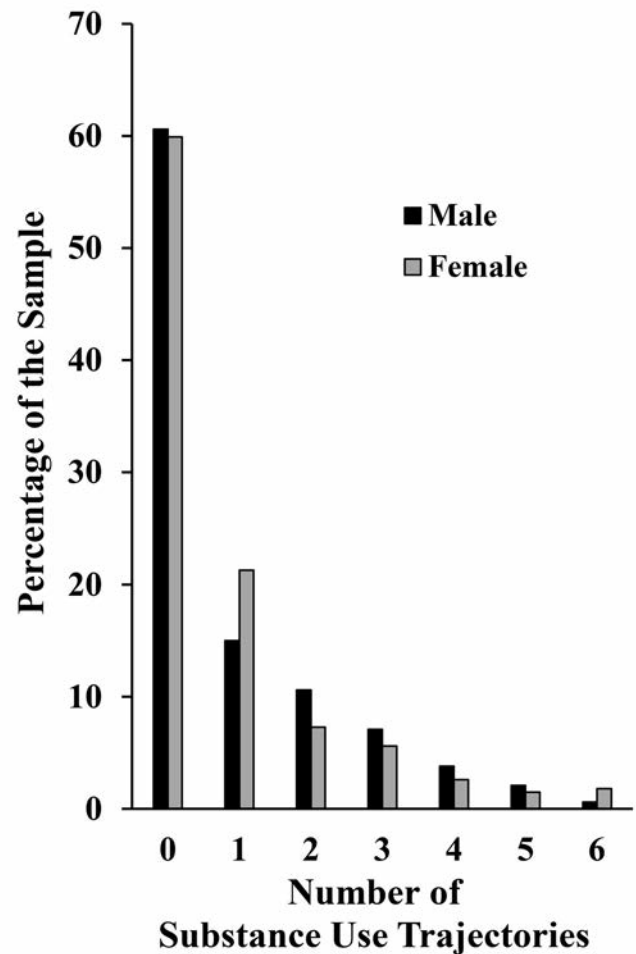


FIGURE 2. Distribution of multiple substance use by sex. *X*-axis represents the number of substances for which an individual followed a trajectory of use.

= followed trajectories of nonuse, 1 = followed a trajectory of use for one substance, 2 = followed a trajectory of use for two substances). Sixty percent of the sample followed trajectories of nonuse across all categories. Eighteen percent of the sample followed one substance use trajectory only, the majority of whom engaged in alcohol use only (38%), followed by cigarette use only (19%), chewing tobacco use only (18%), marijuana use only (16%), and prescription drug misuse only (9%). Other illicit drug use did not occur alone. Twenty-two percent of the sample engaged in multiple substance use as indicated by following two or more trajectories of substance use. Among the subgroup of youth who engaged in multiple substance use, 80% engaged in alcohol use, 69% engaged in marijuana use, 67% engaged in cigarette use, 46% engaged in chewing tobacco use, 32% engaged in prescription drug misuse, and 14% followed a trajectory of other illicit drug use along with at least one other substance use trajectory. There was a significant difference by sex for multiple substance use. Females were more likely to engage in single substance use compared with males (21%



TABLE 4. Dual trajectories of alcohol with other substance use

Variable	Alcohol		Heavy drinking	
	Minimal	Increasing	None	Increasing
Probability of substance use group conditional on alcohol/heavy drinking group				
Cigarettes				
None	91%	53%	90%	41%
Users	9%	47%	10%	59%
Marijuana				
None	91%	54%	90%	44%
Users	9%	46%	10%	56%
Chewing tobacco				
None	93%	67%	91%	65%
Users	7%	33%	9%	35%
Prescription drug misuse				
None	96%	76%	96%	69%
Users	4%	24%	4%	31%
Other drug use				
None	100%	88%	99%	85%
Users	0%	12%	1%	15%
Probability of alcohol/heavy drinking group conditional on substance use group				
Cigarettes				
None	85%	15%	92%	8%
Users	40%	60%	48%	52%
Marijuana				
None	85%	15%	92%	8%
Users	41%	59%	50%	50%
Chewing tobacco				
None	82%	18%	88%	12%
Users	43%	57%	58%	42%
Prescription drug misuse				
None	81%	19%	88%	12%
Users	35%	65%	41%	59%
Other drug use				
None	79%	21%	86%	14%
Users	10%	90%	20%	80%

vs. 15% respectively), whereas males were significantly more likely to engage in multiple substance use compared with females (24% vs. 19%, respectively),  $\chi^2(2, n = 681) = 6.11$ ,  $p = .047$ . There were no significant differences in multiple substance use by race/ethnicity.

*Alcohol and other substance use.* Given that trajectories of alcohol use were the most common individual substance use trajectory and the most common trajectory reported by multiple substance users, we evaluated dual trajectories of alcohol (use and heavy drinking) with all other trajectories of individual substance use (Table 4). The most consistent trend across all comparisons is that individuals who followed a trajectory of minimal alcohol use or no heavy drinking had a high probability of abstaining from other substance use over the course of this study. Another consistent trend, following a trajectory of other substance use (e.g., cigarette, marijuana, chewing tobacco, prescription drug misuse, other illicit drug use), was associated with a higher probability of also following a trajectory of increasing alcohol use.

Patterns of other substance use and heavy drinking were somewhat different than patterns of other substance use

and alcohol use. Following a trajectory of increasing heavy drinking was not associated with a higher probability of either cigarette or marijuana use. Nor were trajectories of cigarette or marijuana use associated with higher probabilities of following a trajectory of increasing heavy drinking. Following a trajectory of chewing tobacco use was associated with a lower probability of increasing heavy drinking. Trajectories of prescription drug misuse and other illicit drug use were both associated with a higher probability of following a trajectory of increasing heavy drinking.

## Discussion

Results from the dual-trajectory models support the idea that early alcohol use and early heavy drinking show differential associations with other early substance use. Although any early other substance use was linked to a higher probability of increasing past-month alcohol use, this was not the case for heavy drinking. Chewing tobacco use was the least linked to problematic heavy drinking, whereas more serious substance use (prescription drug misuse and other

illicit drug use) was linked to higher probabilities of increasing past-month heavy drinking. Also of note, trajectories of increasing alcohol use/heavy drinking were not predictive of either cigarette or marijuana use trajectories, whereas cigarette and marijuana use trajectories were predictive of alcohol use. Hence, alcohol prevention is a logical first step in preventing other substance use, particularly more serious forms of substance use; however, specific prevention efforts should continue to be made regarding tobacco and marijuana prevention.

The overall lack of differential effects by race/ethnicity in this study is consistent with previous population surveys within the Cherokee Nation, indicating that AI youth may not necessarily be at higher risk for engaging in substance use compared with non-Native peers (Cherokee Nation, 2013). However, given that the Cherokee Nation is not a reservation, the results of this study may not reflect differences between AI and non-Native youth from other contexts, particularly given that other studies have found higher levels of substance use among AI youth compared with White youth (Beauvais, 1996; Wallace et al., 2002). AI youth did report higher chewing tobacco use and marijuana use compared with non-Native youth at a few of the individual times of assessment, although these may be artifacts of multiple testing. Although the lack of racial disparities is encouraging in this study, it is important to acknowledge that AI youth may suffer disproportionate negative effects associated with substance use (Indian Health Service, 2015; Szlemko et al., 2006).

In addition, there was a general lack of sex differences in substance use with a few notable exceptions. Females were more likely to misuse prescription drugs. Males were more likely to use chewing tobacco and engage in multiple substance use. This is contrary to previous research on trajectories of alcohol, marijuana, and cigarette use conducted with AI middle school youth on reservations, which found higher probabilities for females to follow trajectories of substance use compared with males (Cheadle & Sittner Hartshorn, 2012; Cheadle & Whitbeck, 2011; Whitesell et al., 2014). This highlights the importance of targeting both males and females in substance use prevention efforts as well as the need for more research on substance-specific differences in risk for use as well as longer term health outcomes. Moreover, this calls attention to potential differences in substance use outcomes between AI youth on reservations compared with those living in culturally diverse communities.

Last, these results highlight the importance of studying different substances individually given different patterns of initiation, different prevalence within the population, and evidence of some sex-specific effects. In addition, it is important to evaluate multiple substances within a single study because these behaviors do not occur in isolation, and factors related to multiple substance use may be different than those for individual substance use.

### *Strengths and limitations*

Strengths of this study include the ability to evaluate longitudinal changes in the use of individual substances as well as multisubstance use that occur over a relatively short time frame, the transition from 9th to 10th grades. However, this introduces the limitation that the data are restricted to a single year. In addition, this research was conducted in a largely understudied population of rural youth with a high proportion of AI youth. Although this is a strength, as it expands our understanding of substance use initiation within this population, these same characteristics can be considered a limitation because the results are not generalizable to youth in general or other AI youth from different tribal communities. Another limitation is the reliance on self-reported data for substance use, which may not accurately reflect actual substance use.

### *Implications and future directions*

Findings support the need for more research on youth substance initiation, use, and the transition to abuse and dependence while emphasizing the importance of also evaluating how use of individual substances is related to one another or cluster together. Without the evaluation of multiple substance use conducted in this study, it would have been plausible to conclude that adolescent females were potentially equal to or at higher risk for substance use compared with males. However, adolescent males were significantly more likely to engage in early multiple substance use. This is a very serious risk for future substance abuse and dependence problems as well as other negative social and health outcomes. Future research should determine if targeted intervention efforts are needed for multisubstance use prevention among adolescents, above and beyond those for individual substances.

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