Trajectories of risk behaviors across adolescence and young adulthood: The role of race and ethnicity

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Abstract:

Introduction: Despite important advances of longitudinal research in substance use behaviors, most studies stratify analyses by gender or race, which limits the ability to directly compare the likelihood of a particular developmental pathway across demographic groups. Thus, there is critical need for well-designed research to examine the associations of race/ethnicity with developmental trajectories of substance use behaviors across adolescence through adulthood.

Methods: Using an accelerated longitudinal design, we examined behaviors across ages 12–31 from Waves I–IV of the National Longitudinal Study of Adolescent to Adult Health. We performed growth mixture modeling, resulting in estimated trajectories over time. Next, we assessed the association between race/ethnicity and trajectory membership using multinomial logistic regression.

Results: Five trajectories resulted for marijuana use, four for cigarette smoking, three for smokeless tobacco use and number of days drunk, and two trajectories for heavy episodic drinking. Controlling for gender and family socioeconomic status, African Americans and Hispanics were less likely than non-Hispanic Whites to use cigarettes or smokeless tobacco early or to use alcohol heavily.

Conclusions: Substance use behavior development follows different pathways for US adolescents and young adults, with some individuals experimenting earlier in adolescence and others beginning to use later in adolescence or in early adulthood. We extend developmental knowledge about these behaviors by demonstrating that the patterns of behavior vary by race/ethnicity; members of lower-risk trajectories (those involving later or no initiation of substance use) are more likely to be African American or Hispanic than to be non-Hispanic White.

Keywords: Substance use behavior | Adolescent behavior | National Longitudinal Study of Adolescent to Adult Health (Add Health) | Race/ethnicity | Developmental trajectory

Article:[1]

1. Introduction

Adolescence is a vulnerable time for the development of risk behaviors associated with disease and premature death (CDC, 2013). Substance use behaviors are initiated and established from adolescence to adulthood (Mahalik et al., 2013). In a recent study, about 31.4% of high school students use tobacco products; 63.2% have drunk alcohol; and 38.6% have used marijuana (CDC, 2013). Since these behaviors can lead to disease and death and often start in adolescence, it is important to understand their patterns of development. There is not one common trajectory of development; rather, subgroups of adolescents initiate and maintain risk behaviors at different times and to varying degrees (Frech, 2012). It is important to analyze these trajectory patterns to design more effective prevention policies and programs, tailored to specific subgroup needs and characteristics.

According to Life Course Theory, trajectories of health behaviors change across life stages and vary depending on social factors and cultural context (Elder, 1998). Further, risk or protective factors and experiences tend to accumulate over time, across an individual's life course. Cumulative advantage and disadvantage is defined as a "systemic tendency for interindividual divergence in a given characteristic with the passage of time" (Dannefer, 2003, p. S327). In other words, over time individuals with certain risk or protective characteristics tend to become more like others who share those characteristics, and distinct from others who do not share those characteristics. This is important for behavioral outcomes because it allows identifying persons more likely to embark on a riskier developmental trajectory.

Recent advanced longitudinal research provides an important understanding of the patterns of trajectories for tobacco, alcohol, and marijuana use. Prior research suggests there are 4–6 different trajectory classes of smoking behavior: early stable smokers, late stable smokers, experimenters, and quitters (Audrain-McGovern et al., 2004, Chassin et al., 2000, Costello et al., 2008, Fergus et al., 2005). For alcohol and marijuana use, most studies identify four categories of trajectories, typically categorized as early high users, light/moderate stable users, steady increasers, and occasional light users (Maggs and Schulenberg, 2004, Passarotti et al., 2015, Tucker et al., 2005). However, there are some gaps and inconsistencies in the identified patterns among these studies (Nelson et al., 2015), potentially as a result of sampling differences, measurement issues, and/or modeling differences. Thus, the current study aims to improve on prior research by using a nationally-representative longitudinal data set covering a wide developmental period, and by using an up-to-date modeling methodology.

[1] Abbreviations: ADD Health, The National Longitudinal Study of Adolescent to Adult Health; US, United States; GMM, growth mixture modeling; ALD, accelerated longitudinal study design; AIC, Akaike information criteria; SSA-BIC, Bayesian information criteria; LMR-LRT, Vuong-Lo-Mendell Rubin unadjusted test; LMR-A-LRT, Vuong-Lo-Mendell Rubin adjusted test; HED, heavy episodic drinking; SES, socio-economic status.

One important modeling choice is the treatment of racial/ethnic groups. Most prior studies stratify analyses by race/ethnicity, thereby limiting the ability to directly compare the likelihood of a particular developmental pathway across groups (Chen and Jacobson, 2012, Finlay et al., 2012). Such an approach may lead readers to assume that race/ethnicity can serve as a proxy for exposure to determinants of risk behavior development. Moreover, there is indication that different racial and ethnic groups have unique patterns of development of substance use behaviors (Chen and Jacobson, 2012, Pampel, 2008). Most studies show African American or Hispanic youth engage in lower levels of tobacco, drug, and alcohol use, and tend to begin these behaviors at older ages than White youth (Evans-Polce et al., 2015, White et al., 2004). However, relatively few studies have quantified the associations of race/ethnicity with developmental trajectories of substance use behaviors across adolescence and into adulthood.

1.1. Goals of the study

A better understanding of similarities and differences between trajectory classes of behavioral development can help health care professionals develop more tailored intervention approaches. To achieve this, we use a latent modeling approach to explore whether there are unique subgroups distinguishable within the developmental trajectories of different risk behaviors by examining deviations from each trajectory. To provide more nuanced insight into the relationship between race/ethnicity and substance use outcomes, we examine whether and how race/ethnicity is a significant predictor of subgroup membership for each substance use behavior. The goals of this study are to (1) identify subgroups of adolescents and young adults in the transition to adulthood with distinct trajectories of change over time for each of type of behavior: tobacco, alcohol, and marijuana use; and (2) examine how race/ethnicity is associated with subgroup membership. This approach advances the field of risk behavior research focused on the transition to adulthood by allowing for unobserved, latent classes of substance use behavior trajectories to emerge.

2. Methods

2.1. Sample

This study analyzes data from the National Longitudinal Study of Adolescent to Adult Health (Add Health), a nationally representative sample of U.S. adolescents and young adults (Add Health, 2016, Harris, 2009). We employed growth mixture modeling (GMM) that allows us to distinguish subpopulations defined by their patterns of change over time and characterize subgroups of individuals based on their substance use patterns (Ram & Grimm, 2009). The 9421 participants interviewed at all four waves of data collection were included in data analysis while others were handled with subpopulation analyses and weighting accounting for longitudinal attrition. Trajectory classes were modeled in adolescents and young adults from ages 12 to 31. Participants without sample weights were removed. The subpopulation of participants who did not have missing race/ethnicity or were not Native American and had valid, non-missing data on each dependent variable of interest, calculated age, as well as dates of interviews and birth were analyzed in each model with subpopulation analysis (Chantala & Tabor, 2010). The university institutional review board approved this study.

2.2. Measures

Age was calculated by subtracting the respondent's date of birth (reported at Wave I or IV, respectively) assuming the 15th day of month and year from the date of interview.

Race/ethnicity was categorized from Wave I self-report as Hispanic, non-Hispanic Black or African American, non-Hispanic Asian, non-Hispanic White, or non-Hispanic other (not including non-Hispanic Native American in subpopulation analysis).

We examined three domains of substance use behavior available at each wave: cigarette use, alcohol use, and marijuana use. Days of cigarette smoking or chewing tobacco in the past 30 days ranged from zero to 30. Number of cigarettes smoked in the past 30 days ranged from 0 to 100. Number of days in the past year of drinking 5 or more drinks in a row if male and 4 or more drinks in a row if female (heavy episodic drinking) and getting drunk were conservatively considered as 0 days for responding never, 1 day for once or twice, 3 days for once a month or less (3–12 times in the past 12 months), 24 days for 2 or 3 days a month, 52 days for 1 or 2 days a week, 156 days for 3 to 5 days a week, and 365 days for every day or almost every day (cf. Table SM1 in Supplemental material is an example of frequencies of responses by wave for heavy episodic drinking). Dichotomous outcomes were any marijuana use in the past 30 days (dichotomized to any times vs. none due to low prevalence).

2.3. Statistical analysis

Analyses were performed under an accelerated longitudinal study design (ALD) framework (Galbraith, Bowden, & Mander, 2017). All analyses took into account the complex survey design of Add Health according to Chantala and Tabor (2010). GMM was performed to estimate trajectories (latent classes) of health risk behaviors over time and to compare groups while accounting for classification uncertainty (Wang and Bodner, 2007). Counts were modeled using negative binomial regression GMMs while binary outcomes were similarly modeled using logistic GMM. Non-planned missing data were handled through subpopulation indicators (i.e., domain analysis) and weighting adjustments (Graubard & Korn, 1996). Planned missing data due to ALD were accounted for using full information maximum likelihood estimation (Enders, 2010).

The closer entropy is to one the better the classification accuracy of placing participants into classes based on the model posterior probabilities (Celeux & Soromenho, 1996), with an entropy > 0.80 considered desirable. AIC and SSA-BIC are relative fit information criteria that help decide if one model fits better relative to another. In particular, a difference ≥ 4 in information criteria values for a given model and the minimum value of all considered models has less empirical support (Burnham & Anderson, 2010). More parsimonious models (i.e., fewer latent classes) with similar empirical support were preferred. The LMR-LRT and LMR-A-LRT are hypothesis tests with the same null hypothesis: that the model with the given number of classes (c) fits equally well relative to a model with c-1 classes (one less latent class). Thus, $p < 0.05$ for these tests imply $c$classes fit better than c-1, and if nonsignificant implies the more parsimonious c-1 solution is equally desirable. The LMR-A-LRT test performs an additional adjustment that improves the rate of convergence of the test statistic to its limiting distribution (Lo, Mendell, & Rubin, 2001).

Quadratic growth curves fit best across modeling. Multinomial logistic regression using automatic 3-step methods were performed to estimate and test for race/ethnicity differences while accounting for classification uncertainty (Asparouhov and Muthén, 2014). Gender, parental education level (less than high school graduate, high school graduate, college, college graduate), and household income from parent interview was controlled for in all modeling (Humensky, 2010). Analyses were performed using M*plus* v7.31 (Muthén and Muthén, 2015) and SAS v9.4 (SAS Institute, Cary, NC). A two-sided p-value < 0.05 was considered statistically significant.

Table 1. Descriptive statistics for behaviors by race/ethnicity over time.[a]

Outcome	African American	Asian/PI	Hispanic	Other	White
No. days cigs					
Wave I	0 (0, 0)	0 (0, 4.2)	0 (0, 0)	0 (0, 0)	0 (0, 1.0)
Wave II	0 (0, 0)	0 (0, 9.4)	0 (0, 1.4)	0 (0, 1.8)	0 (0, 6.5)
Wave III	0 (0, 0)	0 (0, 28.5)	0 (0, 4.9)	0 (0, 25.2)	0 (0, 29.1)
Wave IV	0 (0, 4.2)	1.6 (0, 29.3)	0 (0, 5.0)	0 (0, 15.5)	0 (0, 29.1)
No. cigs p30					
Wave I	0 (0, 0)	0 (0, 1.0)	0 (0, 0)	0 (0, 0.1)	0 (0, 0.4)
Wave II	0 (0, 0)	0 (0, 1.6)	0 (0, 0.4)	0 (0, 0.9)	0 (0, 1.5)
Wave III	0 (0, 0)	0 (0, 9.8)	0 (0, 0.9)	0 (0, 1.8)	0 (0, 9.1)
Wave IV	0 (0, 1.5)	0.3 (0, 8.7)	0 (0, 1.3)	0 (0, 3.2)	0 (0. 7.3)
No. days chew					
Wave I	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Wave II	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Wave III	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Wave IV	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
No. days binge					
Wave I	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, < 0.1)
Wave II	0 (0, 0)	0 (0, 0.1)	0 (0, 0.8)	0 (0, 0.5)	0 (0, 0.7)
Wave III	0 (0, 0)	0.3 (0, 2.7)	0 (0, 1.9)	0.3 (0, 2.8)	0.6 (0, 11.9)
Wave IV	0 (0, 0.5)	0.7 (0, 11.2)	0 (0, 1.9)	0 (0, 1.1)	0.4 (0, 2.9)
No. days drunk					
Wave I	0 (0, 0)	0 (0, 0)	0 (0, < 0.1)	0 (0, 0)	0 (0, 0.2)
Wave II	0 (0, 0)	0 (0, 0.6)	0 (0, 0.6)	0 (0, 0.4)	0 (0, 0.6)
Wave III	0 (0, 0.3)	< 0.1 (0, 2.2)	0 (0, 1.2)	0.4 (0, 6.7)	0.6 (0, 5.8)
Wave IV	0 (0, 0.4)	0.4 (0, 2.1)	0 (0, 0.9)	0 (0, 0.8)	0.4 (0, 2.2)
Any marijuana					
Wave I	12.4%	14.8%	12.4%	6.9%	12.2%
Wave II	14.6%	20.5%	19.2%	18.2%	15.8%
Wave III	20.9%	26.8%	20.5%	38.7%	26.3%
Wave IV	16.3%	18.8%	15.6%	12.0%	19.0%

[a] Note. All numbers are median (25th percentile, 75th percentile), except weighted % given for any marijuana. Statistics are computed for the subdomain of participants with available data and are weighted and adjust for complex survey sampling design and attrition. PI = Pacific Islander; No. days cigs = number of days smoked cigarettes in past 30 days; No. cigs p30 = number of cigarettes smoked in past 30 days; No. days chew = number of days using chewing tobacco/snuff in past 30 days; No. days binge = number of days drinking 5 + drinks in a row if male/4 + drinks in a row if female in past 12 months; No. days drunk = number of days getting drunk in past 12 months; and Any marijuana = any marijuana use in past 30 days.

3. Results

3.1. Sample description

Using Wave I data, 50.0% of the sample was female (weighted). The weighted race/ethnicity breakdown was: 15.5% African American, 2.1% Asian/Pacific Islander, 12.0% Hispanic, 0.9% other, and 65.9% White. From parent interview data, 15% had an education level less than high school graduate, 32% were a high school graduate, 29% had attended some college, and 23% graduated college. The median family income was $39,009 and 17.0% were below the federal poverty level ($15,600) in 1995 for a household size of four. Table 1 provides descriptive statistics adjusting for the sampling design by wave and race/ethnicity. Generally, the 75th percentiles for counts of behaviors either increased for each wave for White participants relative to others (e.g., number of days smoked cigarettes in past 30 days) or peaked at Wave III and then waned at Wave IV (e.g., heavy episodic drinking and days drunk in past 12 months). A similar waning pattern was found for any marijuana use in the past 30 days.

3.2. Tobacco use behavior

The developing patterns of tobacco-related behaviors are categorized into different classes, where the predicted trajectories are shown in Fig. 1. For number of days smoking cigarettes in the past 30 days, a four-class solution was best where entropy = 0.941, lowest AIC and SSA-BIC, and the LMR-LRT ($p = 0.003$) and LMR-A-LRT ($p = 0.004$) were significant for the four-class solution but not for the five-class solution (both $p > 0.90$). Here, the four trajectory classes were: (a) adolescent-initiated adult smokers (29.4%), (b) adolescent experimenters (16.5%), (c) occasional smokers (7.2%), and (d) never smokers (46.9%). In Table 2, we present the associations (adjusted odds ratios [AORs]) between race/ethnicity and trajectory class membership for each outcome. This table describes the odds of being in a particular trajectory class versus a designated reference class for a particular racial/ethnic group relative to White participants. For days smoking, African American participants were significantly less likely than Whites to be members of the adolescent experimenter class (AOR = 0.35, $p < 0.001$) and the adolescent-initiated adult smoker class (AOR = 0.38, $p < 0.001$) relative to being a never smoker, adjusting for gender, parental education level, household income and classification uncertainty. Similar findings were revealed for Hispanics versus Whites, but AORs were not as extreme (AOR = 0.42, $p < 0.001$) for adolescent-initiated adult smokers.

For number of cigarettes smoked in the past 30 days, entropy was adequate (0.821) with AIC and SSA-BIC at their lowest relative for a four class solution to all other solutions with both the LMR-LRT and LRM-A-LRT significant for the four-class solution (both $p < 0.001$) but not for the five-class solution ($p = 0.080$ and $p = 0.087$, respectively). “Never smokers” represented the largest proportion of the weighted sample (49.1%). Twenty-three percent were adult smokers who initiated during adolescence while 18% of participants are adult initiators who tended to smoke lightly until approximately age 21 (cf. Fig. 1). Almost 10% are experimenters during adolescence, peaking at 19 years old in cigarettes smoked and then tending to quit smoking in young adulthood.

Compared to White participants, African Americans had significantly lower odds for being in the “adolescent experimenters” class relative to being in the “never smokers” class, adjusting for

gender, parental education level, household income and classification uncertainty (AOR = 0.21, $p < 0.001$). Effects for similar comparisons were even stronger for being in the "adolescence-initiated adult smokers" class relative to being in the never smokers class (AOR = 0.13, $p < 0.001$ for African American vs. White and AOR = 0.27, $p < 0.001$ for Hispanic vs. White).

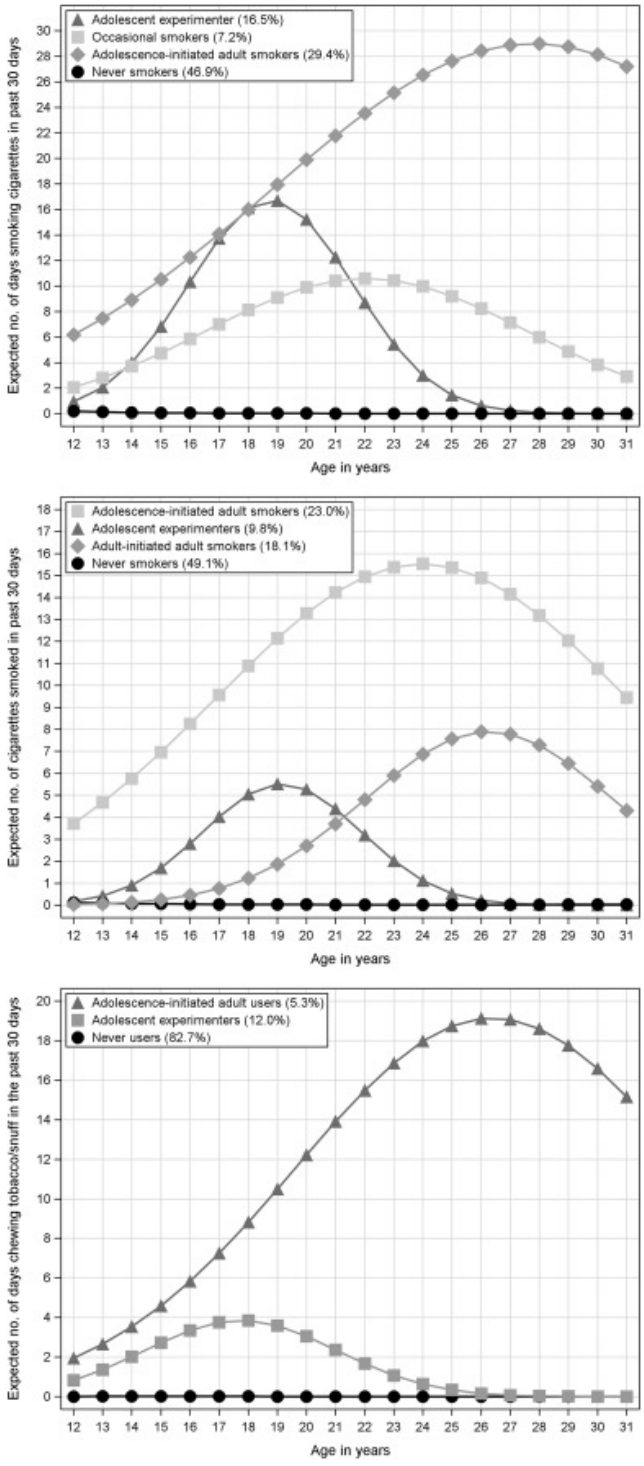

Figure 1. Trajectories of smoking and tobacco use behaviors.

Table 2. Multinomial logistic regression of latent class trajectories.[a]

	African American	Asian/Pacific Islander	Hispanic	Other
No. days smoked cigarettes in past 30 days				
1. Adolescent experimenters (16.5%)	**0.35** **(0.24, 0.49)** **<0.001**	0.64 (0.29, 1.43) 0.277	0.72 (0.48, 1.08) 0.109	0.64 (0.21, 2.21) 0.525
2. Occasional smokers (7.2%)	1.02 (0.71, 1.46) 0.916	1.75 (0.86, 3.55) 0.122	1.40 (0.99, 1.98) 0.058	1.49 (0.46, 4.88) 0.506
3. Adolescent-initiated adult smokers (29.4%)	**0.38** **(0.29, 0.49)** **<0.001**	1.37 (0.79, 2.39) 0.260	**0.42** **(0.28, 0.63)** **<0.001**	0.81 (0.30, 2.16) 0.403
4. Never smokers (46.9%)	RC	–	–	–
No. cigarettes smoked in past 30 days				
1. Adolescence-initiated adult smokers (23.0%)	**0.13** **(0.09, 0.18)** **<0.001**	1.34 (0.67, 2.69) 0.407	**0.27** **(0.16, 0.43)** **<0.001**	1.01 (0.40, 2.52) 0.992
2. Adolescent experimenters (9.8%)	**0.21** **(0.11, 0.42)** **<0.001**	0.30 (0.04, 2.00) 0.213	0.72 (0.41, 1.28) 0.265	0.49 (0.03, 8.88) 0.629
3. Adult-initiated adult smokers (18.1%)	0.96 (0.74, 1.26) 0.793	1.34 (0.68, 2.64) 0.395	0.94 (0.71, 1.23) 0.633	1.03 (0.38, 2.76) 0.958
4. Never smokers (49.1%)	RC	–	–	–
No. days chewing tobacco/snuff in past 30 days				
1. Adolescence-initiated adult users (5.3%)	**0.12** **(0.05, 0.26)** **<0.001**	0.55 (0.21, 1.42) 0.217	**0.29** **(0.12, 0.66)** **0.004**	0.17 (0.02, 1.70) 0.131
2. Adolescent experimenters (12.0%)	0.65 (0.42, 1.00) 0.051	0.93 (0.32, 2.72) 0.892	0.54 (0.28, 1.06) 0.073	0.69 (0.18, 2.58) 0.579
3. Never users (82.7%)	RC	–	–	–
No. days drinking 5 + drinks in a row in past year				
1. Heavy episodic drinkers (HED) (49.8%)	**0.32** **(0.25, 0.40)** **<0.001**	1.05 (0.63, 1.76) 0.859	**0.74** **(0.58, 0.94)** **0.016**	0.60 (0.25, 1.46) 0.260
2. No HED (50.2%)	RC	–	–	–
No. days getting drunk in past year				
1. Early excessive drinkers (25.0%)	**0.22** **(0.15, 0.33)** **<0.001**	0.89 (0.44, 1.79) 0.742	**0.63** **(0.47, 0.85)** **0.002**	0.69 (0.23, 2.05) 0.502
2. Late excessive drinkers (20.6%)	**0.38** **(0.28, 0.51)** **<0.001**	1.01 (0.53, 1.92) 0.981	0.77 (0.54, 1.10) 0.146	0.68 (0.21, 2.14) 0.506
3. Non-excessive drinkers/non-drinkers (54.4%)	RC	–	–	–
Any marijuana use in past 30 days				
1. Late adolescence-initiated adult users (22.8%)	0.96 (0.70, 1.33) 0.817	1.29 (0.65, 2.55) 0.466	0.76 (0.46, 1.25) 0.277	0.40 (0.11, 1.51) 0.175
2. Early adolescence-initiated users (3.2%)	0.38 (0.07, 1.99) 0.254	0.03 (< 0.01, 137.8) 0.678	1.95 (0.48, 7.92) 0.352	1.29 (0.30, 5.54) 0.736
3. Adolescent experimenters (14.8%)	1.06 (0.63, 1.81) 0.819	1.34 (0.52, 3.46) 0.552	1.42 (0.83, 2.45) 0.202	1.43 (0.35, 5.79) 0.618
4. Early adolescence-initiated adult quitters (1.9%)	0.97 (0.44, 2.12) 0.943	2.18 (0.31, 15.4) 0.434	0.82 (0.21, 3.17) 0.773	0.56 (0.03, 11.0) 0.705
5. Non-users (57.3%)	RC	–	–	–

[a] Note. Adjusted odds ratios (AOR) with White as referent group, adjusted for gender, parental education, family income and classification uncertainty using automatic 3-step methods for growth mixture modeling. Numbers provided are AOR, (95% CI for AOR), *p*-value. Numbers in **bold** denote effects with $p < 0.05$. RC = Reference class.

For frequency of chewing tobacco/snuff in the past 30 days, Hispanic and African American participants were also less likely to be members of "adolescence-initiated adult users" classes compared to a non-user class relative to Whites (cf. Table 2 and bottom panel of Fig. 1). Specifically, African Americans had 88% lower odds of being an adolescent-initiated adult user relative to White participants. Findings for Hispanic vs. White were similar in magnitude for being an adolescent-initiated adult user (AOR = 0.29, $p < 0.004$) but were only marginally significant for being an adolescent experimenter (AOR = 0.54, $p = 0.073$).

3.3. Alcohol use

A two-class trajectory solution was found for heavy episodic drinking (HED), with 49.8% in the HED class for number of days drinking 5 + drinks in a row if male and 4 + drinks in a row if female in the past year and 50.2% in the no HED class (Fig. 2). Again, Hispanic (AOR = 0.74, $p < 0.016$) and African American (AOR = 0.32, $p < 0.001$) adolescents were significantly less likely to be in the HED class relative to Whites.

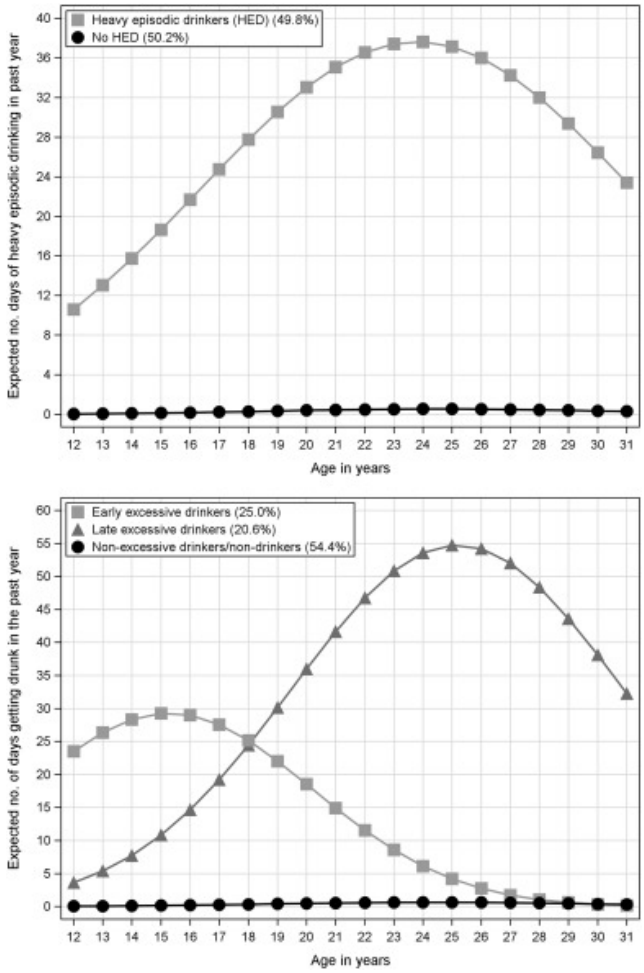

Figure 2. Trajectories of alcohol use.

Early excessive drinkers (25.0%), late excessive drinkers (20.6%), and non-excessive drinkers/non-drinkers (54.4%) were the three trajectory classes found for number of days getting

drunk in the past year (Fig. 2). African American participants had less than half the odds of being in either the early excessive drinkers class relative to Whites (AOR = 0.22, $p < 0.001$) or the late excessive drinkers class (AOR = 0.38, $p < 0.001$) compared to being in the non-excessive drinkers/non-drinkers class. Similarly, Hispanic participants also had significantly lower odds (AOR = 0.63 for early excessive drinkers $p < 0.001$) compared to Whites, adjusting for gender, parental education level, household income, and classification uncertainty.

3.4. Marijuana use

There were no significant differences regarding any marijuana use in the previous 30 days between race/ethnicity groups (all $p \geq 0.10$) (See Fig. 3).

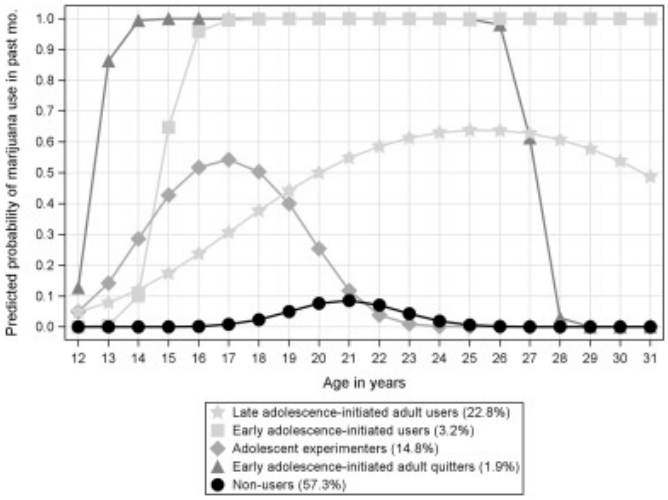

Figure 3. Trajectories of marijuana use.

4. Discussion

The area of longitudinal studies of substance use across adolescence and into adulthood is growing. These studies have the potential to inform those involved in prevention science how best to intervene to reduce problem substance use. Our findings, using a nationally-representative sample across ages 12–31, reinforce prior study findings that distinct patterns of behavioral development do exist. Importantly, our findings extend research in this field by demonstrating and quantifying an association between race/ethnicity and behavioral trajectories of substance use.

The findings of this study provide important insights. African-American and Hispanic adolescents and adults were more likely than their White peers to be members of lower-risk trajectories, those involving later or no initiation of substance use, except marijuana use. Because our modeling technique allowed the trajectories to emerge from the data independently of respondents' race/ethnicity, we are able to quantify the association of race/ethnicity with substance use behavior over time. These findings are consistent with previous studies that showed differences in the level of engagement in risky behaviorsamong minority youth compared to White youth (Evans-Polce et al., 2015, Finlay et al., 2012, Pampel, 2008, White et al., 2004). There may be positive peer influence, parental expectations, or other social norms that

support substance use avoidance, particularly in early adolescence, for African American and Hispanic youth and young adults (Li et al., 2000).

The findings of this study also have theoretical implications, as they support the idea that there are distinct pathways of substance use behavior development. This is consistent with Life Course Theory, which posits that social and biological influences at distinct periods in individuals' life courses contribute to differential developmental trajectories. Further, our findings that after controlling for baseline family socioeconomic status, race/ethnicity associated with developmental trajectories of substance use suggest a need to investigate how social influences on substance use development vary by race/ethnicity. Research suggests that social factors such as peer influence, family relationships, school connectedness, and religion may influence health behavior trajectories (Umberson, Crosnoe, & Reczek, 2010); differences in these social and cultural characteristics among different racial/ethnic groups may have resulted in distinct developmental patterns of substance use behaviors.

There are some limitations to this study. Although we analyzed developmental trajectories across several substance use behaviors, we did not examine combined behaviors. We used demographic characteristics from Wave 1 and treated those variables as static. Each of those characteristics could be argued to be time-varying concepts, limiting the interpretation of our findings. We also made choices about collapsing response categories for race and ethnicity, resulting in a combined "other race/ethnicity" category that includes Native Americans, Asians, and other races and ethnicities. This limited our ability to distinguish the uniqueness of these youth from Hispanics and non-Hispanic African Americans and Whites. We only controlled gender and family socioeconomic status and did not examine other potential confounders of outcomes, mediators, or moderators that would provide insights into the influence of social context on the development of trajectories. Finally, although this longitudinal dataset provides a nationally-representative sample of adolescents well into adulthood, the data were collected from 1994 to 2008. Given the rapidly changing social environment influences on adolescent health behaviors, we need to be cautious when interpreting results.

In spite of these limitations, the GMM using Add Health data builds on prior research in an important manner. First, we did not treat race and ethnicity as a fixed-effect variable, assuming there are unique subgroups distinguishable within the trajectories of different risk behaviors; this allowed us to examine deviations from each trajectory. Prior studies have only compared the prevalence of risk behaviors or used race and ethnicity by conducting stratified analyses, instead of modeling longitudinal trajectories and assessing the association between classes of risk behavior development and race/ethnicity. Second, we modeled multiple substance use behaviors independently, which allows us to qualitatively compare development of the different behaviors, as there are likely different influences on each behavior. Third, we extended modeling of the trajectories well into adulthood, which has often been missed in previous studies. Fourth, this study provides findings generalizable to the population of adolescents and young adults. Most previous studies that address substance use trajectories and race/ethnicity have been conducted in a limited area or with specific groups, e.g., urban population (White et al., 2004). Our extensions offer a unique contribution to the literature and critically advance adolescent substance use behavioral research.

In light of our findings showing the unique trajectories of development of adolescent substance use behaviors including onset, levels, and patterns associated with different racial and ethnic groups, our study has the potential to inform public health practice and policy. The likelihood of specific racial and ethnic groups to follow one trajectory more than another provide important insights into young people's substance use behavior development. Assuming only one trajectory across 12–31 year-olds for substance use behaviors was not tenable. With this knowledge, health education and public health programs may be able to more effectively tailor their interventions to the needs of the population of interest. For example, different racial and ethnic groups have unique cultural strengths on which to build in the design of prevention programs. Among Latino immigrants, cultural strengths including strong families may mitigate economic and social challenges (Cardoso & Thompson, 2010). Thus, different programs and supports may be necessary to aid different groups in achieving desired outcomes. Further, policies aimed at preventing substance use among adolescents and young adults that incorporate current research findings revealing different risk trajectories for different groups may have greater potential to yield positive outcomes.

Based on these findings, future studies should explore the different development of risk behaviors based on racial/ethnic group and the interactions among the combinations of different risk behaviors. Also, interaction with potential confounders, such as personal psychological factors, family characteristics, partner relationships, friendships, and criminal behaviors, that are known to be influencing factors of trajectories, should be explored (Brook, Lee, Brown, Finch, & Brook, 2011). Moreover, it would be important to conduct studies that examine factors that may account for the differences in substance use behavior development among different racial and ethnic groups. Further, the use of joint modeling, such as a parallel process model or composite analysis, may be valuable to understand the likelihood of engaging in combined risk behaviors. This type of modeling would provide results on the possible effect of the co-occurring behaviors and identify specific trajectory classes.

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Contributors
All authors have materially participated in the research and/or the manuscript preparation. Park conceptualized the study, developed the research questions, assisted with interpretation of results, wrote sections of and revised the manuscript. McCoy contributed to conceptualization of the study, performed data analysis, contributed to writing the manuscript. Toller contributed to conceptualization of the study, revised the research questions, assisted with interpretation of results, wrote sections of and revised the manuscript. Bartlett contributed to conceptualization of the study, assisted with interpretation of results, revised the manuscript.

Conflict of interest
There are no conflicts of interest for any author on this paper.

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Appendix A. Supplementary data

Table SM1. Frequency of number of days drinking 5 or more drinks in a row during the past 12 months by wave (N = 9,421)*

Response	Wave I	Wave II	Wave III	Wave IV
None/never	1,951 (21)	1,549 (16)	2,265 (24)	2,343 (25)
1 or 2 days in past 12 months	70 (1)	99 (1)	1,533 (16)	1,596 (17)
Once a month or less (3-12 times/days)	136 (1)	175 (2)	963 (10)	1,044 (11)
2 or 3 days a month	302 (3)	420 (4)	820 (9)	826 (9)
1 or 2 days a week	373 (4)	456 (5)	836 (9)	677 (7)
3 to 5 days a week	517 (5)	578 (6)	302 (3)	252 (3)
Every day or almost every day	813 (9)	882 (9)	69 (1)	87 (1)
Refused	6 (<1)	9 (<1)	5 (<1)	10 (<1)
Legitimate skip	5,241 (56)	5,229 (56)	2,595 (28)	2,564 (27)
Don't know	12 (<1)	24 (<1)	21 (<1)	22 (<1)
Not applicable	0	0	7 (<1)	0
missing	0	0	5 (<1)	0

**Note*. All numbers are *n* (%) where percentage is unweighted and not adjusted for complex survey sampling design. For growth mixture modeling (GMM) analysis, Refused/Don't know/missing were set to missing values, None/never/Legitimate skip/Not applicable = 0, 1 or 2 days in past 12 months = 1, Once a month or less (3-12 times/days) = 3, 2 or 3 days a month = 24, 1 or 2 days a week = 52, 3 to 5 days a week = 156, and Every day or almost every day = 365 and modeled using negative binomial count GMM adjusting for sampling design and attrition and using full-information maximum likelihood.

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