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Developmental trajectories of substance use from early adolescence to young adulthood: Gender and racial/ethnic differences

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Abstract

Purpose—The current study examined gender and racial/ethnic (Hispanics, Non-Hispanic Caucasians, Non-Hispanic African Americans, and Non-Hispanic Asians) differences in developmental trajectories of alcohol use, heavy drinking, smoking, and marijuana use from early adolescence to young adulthood using a nationally representative sample.

Methods—Participants from the National Longitudinal Study of Adolescent Health (N=20,160) reported rates of alcohol use, heavy drinking, smoking and marijuana use between the ages of 12 and 34. Data analyses were completed using longitudinal multilevel modeling analyses.

Results—Levels of substance use increased from early adolescence to middle 20s, and then declined thereafter. Females showed higher levels of substance use in early adolescence, although males exhibited greater changes overtime and higher levels of use in mid-adolescence and early adulthood. Overall, Hispanic youth had higher initial rates of substance use, while Caucasian adolescents showed higher rates of change and had the highest levels of substance use from mid-adolescence through the early 30s. Racial/ethnic differences largely disappeared after age 30, except that African Americans showed higher final levels of smoking and marijuana use than the other racial/ethnic groups. Results provide evidence for both similarities and differences in general patterns of development and in gender and racial/ethnic differences across different forms of substance use.

Conclusion—Findings from the current study suggest that the critical periods for intervention and prevention of substance use may differ across gender and race/ethnicity, and that future research needs to identify common and unique mechanisms underlying developmental patterns of different forms of substance use.

Keywords

Substance use; Developmental trajectory; Adolescence; Young adulthood; Gender; Race/Ethnicity

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Implications and Contribution: The current study contributes to the literature by examining and comparing general developmental patterns of alcohol use, heavy drinking, smoking and marijuana use from early adolescence to young adulthood as well as gender and racial/ethnic differences in these patterns across forms of substance use using a nationally representative sample.

I. Introduction

Substance use among American adolescents and adults remains a serious public health concern. According to the most recent National Survey on Drug Use and Health[1], rates of substance use during the past 30 days among individuals aged 12 and older were: 51.9% (alcohol); 23.7% (binge drinking); 23.3% (cigarettes); and 6.6% (marijuana). Data from Monitoring the Future indicate that substantial proportions of 12th graders report current alcohol (44%), cigarette (20%), and marijuana (21%) use, and binge drinking (27%).[2] Given the prevalence of substance use behaviors and their considerable health and social consequences[1,3,4–9], developing effective prevention and intervention programs to reduce these behaviors is of high priority. Comparing developmental trajectories of different substance use behaviors and examining gender and racial/ethnic differences in these trajectories may provide insights into critical periods and help to identify target populations for prevention and intervention programs.

Longitudinal studies across adolescence demonstrate increases in substance use from early to late adolescence.[10–15] Research focusing on adolescence to young adulthood has found that levels of substance use increase during middle/late adolescent years, peak around early or middle 20s, and then decline thereafter.[16–18] However, the samples used in many of these prior longitudinal studies were not nationally representative, limiting generalizability.[11,13–17] Of the longitudinal studies that have used nationally representative samples[10,12,18], most have focused solely on changes in substance use across adolescence[10,12], or between late adolescence and young adulthood.[18] Thus, nationally representative longitudinal studies examining substance use patterns from early adolescence through adulthood are lacking. Moreover, studies investigating gender and racial/ethnic differences in developmental patterns of substance use from early adolescence to young adulthood are scarce.

National statistics[1, 2] and cross-sectional studies[19–21] have consistently supported higher mean-levels of substance use in males than in females. However, longitudinal studies have found that girls report higher or similar levels of substance use than boys during early adolescence, while boys have greater increases in substance use over time, and therefore exhibit higher levels of substance use during middle and late adolescence.[10,11,14] These findings highlight the need to explore gender differences in substance use more explicitly using a developmental perspective across a longer period of time (i.e. from early adolescence to young adulthood).

Previous national surveys[1,2] and other cross-sectional studies[19,21–24] have provided evidence for racial/ethnic differences in mean levels of substance use. Caucasians generally report the highest levels of substance use, followed by Hispanics and African Americans, while Asians report substantially lower levels of substance use than other racial/ethnic groups. While a handful of longitudinal studies have provided evidence for racial differences in trajectories of substance use (e.g., African Americans have lower initial levels and lower increasing rates of substance use than their Caucasian counterparts), these comparisons have primarily been made without considering other racial/ethnic minority groups. In addition, longitudinal research investigating racial/ethnic variations in changes in substance use have generally been focused on adolescence, and have not systematically evaluated differences in trajectories at later developmental periods.[11, 25–27]

Finally, previous studies have rarely examined patterns of alcohol use, binge drinking, smoking, and marijuana use simultaneously. Consequently, it remains unclear whether developmental trajectories of substance use, and gender and racial/ethnic differences in these patterns, differ across forms of substance use. Although one prior study that compared

developmental patterns of alcohol use, smoking, and marijuana use identified smoking as the most persistent substance use behavior with the smallest gender differences[17], this study was based on retrospective and non-nationally representative data.

To address these limitations, the current study explores developmental trajectories of four of the most prevalent substance use behaviors (i.e., alcohol use, heavy drinking, smoking, and marijuana use) in a large, nationally representative longitudinal sample ranging in age from 12 to 34. Our primary aim is to investigate developmental trajectories of substance use from early adolescence to young adulthood, and to examine gender and racial/ethnic (Hispanics, Non-Hispanic Caucasians, African Americans, Asians) differences in these trajectories. In addition, developmental patterns of substance use, as well as gender and racial/ethnic differences in these patterns, are compared across different forms of substance use.

Methods

Sample

Data for this study are from a nationally representative sample of participants in the National Longitudinal Study of Adolescent Health (Add Health).[28] The initial in-school survey of Add Health (Wave I; 1994–1995) included a random sample of ~90,000 7^{th}–12^{th} graders. Wave I also included in-depth, at-home interviews with a subsample of N=20,745 students. In-home interviews were conducted on ~15,000 students one year later (1996, Wave II). Wave III (2001–2002) and Wave IV (2007–2008) in-home interviews consisted of N=15,170 and N=15,701 of the original Wave I respondents, respectively.

The present sample includes participants who provided reports for substance use measures in at least one of the four in-home interviews and who had no missing data on age, gender, or race/ethnicity. We excluded Wave I data for 10 participants younger than age 12, and Wave IV data for 4 participants older than age 34, as sample sizes were too small to be representative of the relevant age cohorts. We eliminated N=394 participants identified as "Non-Hispanic Other" race/ethnicity, given the small size of this subgroup. Thus, the final sample for the current study is N=20,160 (97% of the original sample) participants aged 12.01 to 33.94 during the course of Add Health study. The cohort-sequential design[29, 30] of Add Health provided the ideal opportunity to explore developmental trajectories of substance use by linking participants' ages with their levels of substance use. Final samples sizes by age are reported in Table1.

Measures

Age—Ages were calculated by subtracting participants' birth date from the interview date at each of the four waves.

Gender—Gender was coded as: *1=male* (49.4%); *0=female* (50.6%).

Race/Ethnicity—Participants reported both ethnicity and race. If they provided more than one response to their racial background (5% of the sample), they indicated one category that best described their race. Four mutually exclusive groups were created: Hispanic (N=3519; 17.3%); Non-Hispanic Caucasian (N=10829; 53.2%); Non-Hispanic African American (N=4603; 22.6%); and Non-Hispanic Asian (N=1407; 6.9%).

Alcohol Use—In each wave, participants reported the number of days they drank alcohol in the past 12 months (frequency) using a Likert scale ranging from *0=never to 6=everyday or almost everyday*, and the number of drinks (amount) they usually had each time in the past 12 months. Responses for this latter item ranged from 1 to over 90 drinks in Waves I

and II, and from 1 to 18 drinks in Waves III and IV. Responses >18 drinks in Wave I and Wave II (<5% of the sample) were recoded as missing.a The remaining responses were recoded into a 7-point Likert scale ranging from *0=had not used alcohol* to *6=drank 10 to 18 drinks* each time. An alcohol use score was computed by averaging the frequency and amount items.

Heavy drinking—In each wave, participants were asked: a) how many days they drank five or more drinks in a row; and b) how many days they had gotten drunk or very high on alcohol in the past 12 months. Responses for both items range from *0=never* to *6=everyday or almost everyday* for all four waves. A heavy drinking score was created using the mean of the two items. The heavy drinking score was positively skewed (skewness=1.59) and was log transformed for analyses.

Smoking—In each wave, participants reported the number of days in the past month that they had smoked (ranging from 0 to 30 days) and the average number of cigarettes they had smoked each day in the past month (ranging from 0 to 100). For the "number of cigarettes" question, responses >40 (<1% of the sample) were coded as missing. Responses for the two items were multiplied to obtain a single measure of total cigarettes smoked in a month (range=0 to 1200). The distribution of cigarette use was skewed (skewness=2.91), and was log transformed for analyses.

Marijuana Use—During Waves I–III, participants reported how many *times* they used marijuana during the past 30 days (range = 0 to 30). Responses >30 (<2% of the sample) were coded as missing. During Wave IV, participants were asked how many *days* they used marijuana during the past 30 days, based on a 7-point scale, ranging from *0=none* to *6=everyday or almost everyday*. To be consistent with the scale used in Wave IV, the responses of the "number of times" question from Waves I–III were recoded into a 7-point scale ranging from *0=none* to *6=26 to 30 times*. Marijuana use was log transformed due to skewness (skewness=2.72).

Descriptive statistics for unadjusted substance use scores are reported in Table 1.

Analytic Plan

Longitudinal multilevel modeling was used to examine developmental trajectories of substance use.[31] Three models were fitted for each measure of substance use using multi-level hierarchical regression analyses in SPSS:[32] an unconditional means model estimating within-individual and between-individual variance of substance use (Model 1); an unconditional growth model testing both the liner and quadratic change in substance use by including both age and age^2 as predictors in the model (Model 2); and a conditional model examining effects of gender and race/ethnicity on both the initial status and rates of change of substance use (Model 3). For initial data analyses (Table 2), age was centered at 12.01 to explore significant gender and racial/ethnic differences in initial use (i.e., model intercept), and dummy variables for race/ethnicity were created using Caucasians as the reference group. Analyses were also re-run using age centered at 33.94 to test for significant gender and racial/ethnic differences in final levels of substance use, and differences in the initial status, rate of change, and final levels of substance use were further tested in follow-up analyses by systematically using different racial/ethnic groups as the comparison group. Standardized scores for each substance use measure were used in analyses so that findings

[a]Extreme values of some items assessing alcohol use, cigarette use, and marijuana use were coded as missing due to their unknown legitimacy. We repeated analyses of the currents study recoding extreme values of these items as the maximum value of their scales. Findings from these analyses were consistent with the ones reported. Detailed results are available upon request from the first author.

could be compared across outcomes. Missing data in outcome variables were handled utilizing the Maximum Likelihood (ML) method. Comparisons across models were based on the differences in −2LL between models (Δ-2LL) which is distributed as a chi-square statistic, with degrees of freedom equal to the differences in degrees of freedom between the models compared.

Results

Unconditional Means Model and Unconditional Growth Model

Results from the hierarchical models for each substance use variable are shown in Table 2. Based on the intraclass correlations (ICC) from the unconditional means models (Model 1), 28% (alcohol use) to 49% (smoking) of the variance of substance use existed between individuals, while the remaining variance (51% to 72%) was due to with-person factors including age.

Model 2 had a significantly better fit than the Model 1 for all measures of substance use. Fixed effects for the linear and quadratic function of age were both significant for all forms of substance use. Findings indicate that levels of substance use increased from age 12, reached a stationary point (i.e., the highest level) at about age 25, and then declined thereafter.

Conditional Growth Curve Models

For all measures of substance use, Model 3 testing for differences due to gender and race/ethnicity had a significantly better fit than Model 2. For ease of interpretation, developmental trajectories of substance use are graphed by gender (Figure 1) and by racial/ethnic groups (Figure 2). In addition, the initial status, rate of change, stationary point, and final levels of substance use for each gender and racial/ethnic group are reported in Table 3.

Gender Differences—Overall, females exhibited significantly higher initial levels of substance use than males. Males had significantly higher rates of linear and quadratic change than females. This pattern resulted in significantly higher levels of substance use in males from middle adolescence to young adulthood. Males were also more likely to reach the stationary point at slightly later ages than females.

Racial/ethnic differences—The initial status of each substance use differed significantly across racial/ethnic groups. At age 12, Hispanic adolescents exhibited significantly higher levels of all forms of substance use than other racial/ethnic groups, except for comparisons of initial levels of smoking between Hispanics and Caucasians. In contrast, Asian adolescents reported significantly lower initial levels of alcohol use and heavy drinking, although levels of smoking did not differ significantly between Asian and African American participants. Caucasians had significantly higher initial levels of smoking than African American adolescents, although African American adolescents had significantly higher initial levels of heavy drinking than Caucasians. No significant racial differences were found among Caucasian, African American, and Asian adolescents in initial levels of marijuana use.

Rates of change of substance use differed across racial/ethnic groups. Caucasians had significantly higher rates of linear and quadratic change of substance use than individuals from other racial/ethnic groups. In contrast, African American individuals generally had the lowest rates of change in alcohol use, heavy drinking, and smoking, although the linear rate of change in smoking did not differ significantly between African Americans and Hispanics. For marijuana use, African Americans had a significantly higher rate of linear change than

Hispanics and Asians, whereas the quadratic change did not differ significantly among African American, Hispanic, and Asian participants.

There were observed racial/ethnic differences in levels of substance use over time and in stationary points of substance use. Caucasians generally exhibited the highest levels and African Americans the lowest levels of alcohol use and heavy drinking from early/middle adolescence to young adulthood, although final levels of alcohol use and heavy drinking did not differ significantly across racial/ethnic groups. However, different patterns were observed for smoking and marijuana use. Specifically, while Caucasians reported the highest levels of smoking throughout most of adolescence and young adulthood, levels of smoking were higher for African Americans than for participants from other racial/ethnic groups after age 30. Similarly, African Americans reported the highest levels of marijuana use after the late 20s. In comparison to individuals from other racial/ethnic groups, African Americans consistently had the latest stationary points of substance use. In particular, levels of marijuana use and smoking for African Americans did not start to decline until they were about 29 and 32 years old, respectively.

Comparison across substances—Alcohol use exhibited the highest rates and marijuana use the lowest rates of both linear and quadratic change across all four forms of substance use. Patterns of gender differences in rates of change were generally consistent across different forms of substance use (i.e., males exhibited higher rates of change for all four forms of substance use examined). However, findings indicated greater gender differences in rates of linear change for alcohol use and heavy drinking than for smoking and marijuana use. Racial/ethnic differences in rates of change were largely similar for alcohol use, heavy drinking, and smoking. In contrast, racial/ethnic differences in rates of change in marijuana use were smaller in comparison to other forms of substance use. While racial/ethnic differences in alcohol use and heavy drinking disappeared by young adulthood, patterns of racial/ethnic differences in smoking and marijuana use persisted, and in fact reversed, with African Americans showing higher levels of these behaviors in young adulthood.

Discussion

The current study examined gender and racial/ethnic differences in developmental trajectories of alcohol use, heavy drinking, smoking, and marijuana use from early adolescence to young adulthood. All four forms of substance use increased from early adolescence, reached the highest level around middle 20s, and declined thereafter. While trends from the current study parallel patterns found in previous longitudinal research, our study is based on a nationally representative sample and is the first to examine development patterns in substance use across a twenty-two year period. Moreover, differences observed across gender, race/ethnicity, and among different types of substances highlight the need for different prevention and intervention programs for preventing substance use during adolescence and young adulthood.

Females exhibited higher levels of substance use than males during early adolescence. In contrast, males exhibited higher rates of change over time which resulted in their higher levels of substance use from middle adolescence to early adulthood. This pattern supports gender differences reported in prior longitudinal studies focusing on adolescence.[10,11,14] At the same time, our study is the first to demonstrate using a nationally representative sample that higher levels of substance use in males persist from middle/late adolescence through young adulthood. Gender differences observed in the current study imply that intervention programs need to pay special attention to girls during early adolescence. Additional research

is needed to identify risk factors that explain higher levels of substance use in males from middle adolescence to young adulthood.

Likewise, while developmental patterns of substance use were generally similar across racial/ethnic groups (i.e., increased from early adolescence to middle or late 20s and then declined thereafter), differences were observed in both levels of use and rates of change. Previous longitudinal studies on racial differences in substance use have generally not considered Hispanic youths. Findings from the current study indicate that Hispanics exhibited the *highest* levels of substance use during early adolescence, suggesting the importance of conducting research on etiology of substance use in early adolescence for Hispanics. On the other hand, levels of substance use increased most rapidly from early adolescence to emerging adulthood for Caucasians, indicating that early intervention may be especially important in the prevention of substance use among Caucasians. Finally, levels of substance use among African Americans peaked at later ages than among other racial/ethnic groups, and African Americans continued to show higher levels of smoking and marijuana use after age 30. Previous research has found that early-adolescent substance use is more strongly associated with adult dysfunction (e.g., psychiatric disorders) among African Americans than among Caucasians, despite the fact that African Americans typically report lower levels of substance use during adolescence.[3] Moreover, African Americans generally receive less drug treatment than their Caucasian counterparts.[33,34] Taken together, findings from the current study and previous work highlight the need to develop treatment programs targeted towards African American young adults. In addition, future research should investigate *why* the long-term consequences of substance use are more severe for African Americans, given that they generally report lower levels of use compared to other racial/ethnic groups prior to adulthood.

Finally, the current study compared general developmental patterns of substance use as well as gender and racial/ethnic differences in these patterns across different forms of substance use. Although shapes of developmental trajectories were similar across forms of substance use, different rates of change were found. Alcohol-related substance use showed higher levels of *change* and marijuana use higher levels of *stability* over time. While gender and racial/ethnic differences in rates of change were generally consistent across forms of substance use, gender differences in rates of linear change in smoking and marijuana use were smaller than in alcohol use and heavy drinking. Racial/ethnic differences in rates of change were also smallest for marijuana use. Previous studies have found that developmental trajectories of substance use are shaped by life events such as school transitions or assumption of adult roles.[35,36] Gender and racial/ethnic differences in substance use may therefore result from sociocultural differences in opportunities for young adults.[37,38] The higher stability and smaller gender and racial/ethnic differences in marijuana use may imply that contextual/environmental factors have weaker influences on marijuana use than on other forms of substance use examined. Additional longitudinal work needs to identify common and unique mechanisms underlying different forms of substance use that account for the observed similarities and differences in their developmental patterns. For example, behavioral genetic studies have found that different forms of substance use are influenced by both common and substance-specific genetic and environmental factors[39,40], but these studies have not been longitudinal. To gain more insight into the etiology of substance use, future studies need to compare risk and protective factors across different forms of substance use and to develop general and substance-specific models to explain these behaviors.

A number of study limitations should be noted. First, measures of substance use were based on responses to a limited number of questions, and it is unclear how variations in measures across forms of substance use and changes in marijuana use item wording/responses across

waves may have influenced the findings. Second, our study did not consider potential heterogeneity of developmental patterns of substance use. Third, we did not have longitudinal data on clinical substance misuse; therefore, patterns of substance use observed in the current study may not generalize to substance abuse/dependence. Finally, the current study did not specifically examine factors that might account for individual differences in substance use trajectories and/or account for the racial/ethnic differences observed in this study. Using the same sample, we are currently exploring whether differences in patterns of substance use can be explained by differences across racial/ethnic groups in specific risk or protective factors (e.g., college attendance). Nevertheless, the present study provides the first analysis of gender and racial/ethnic differences in patterns of substance use using longitudinal data from a nationally representative sample across more than 20 years.

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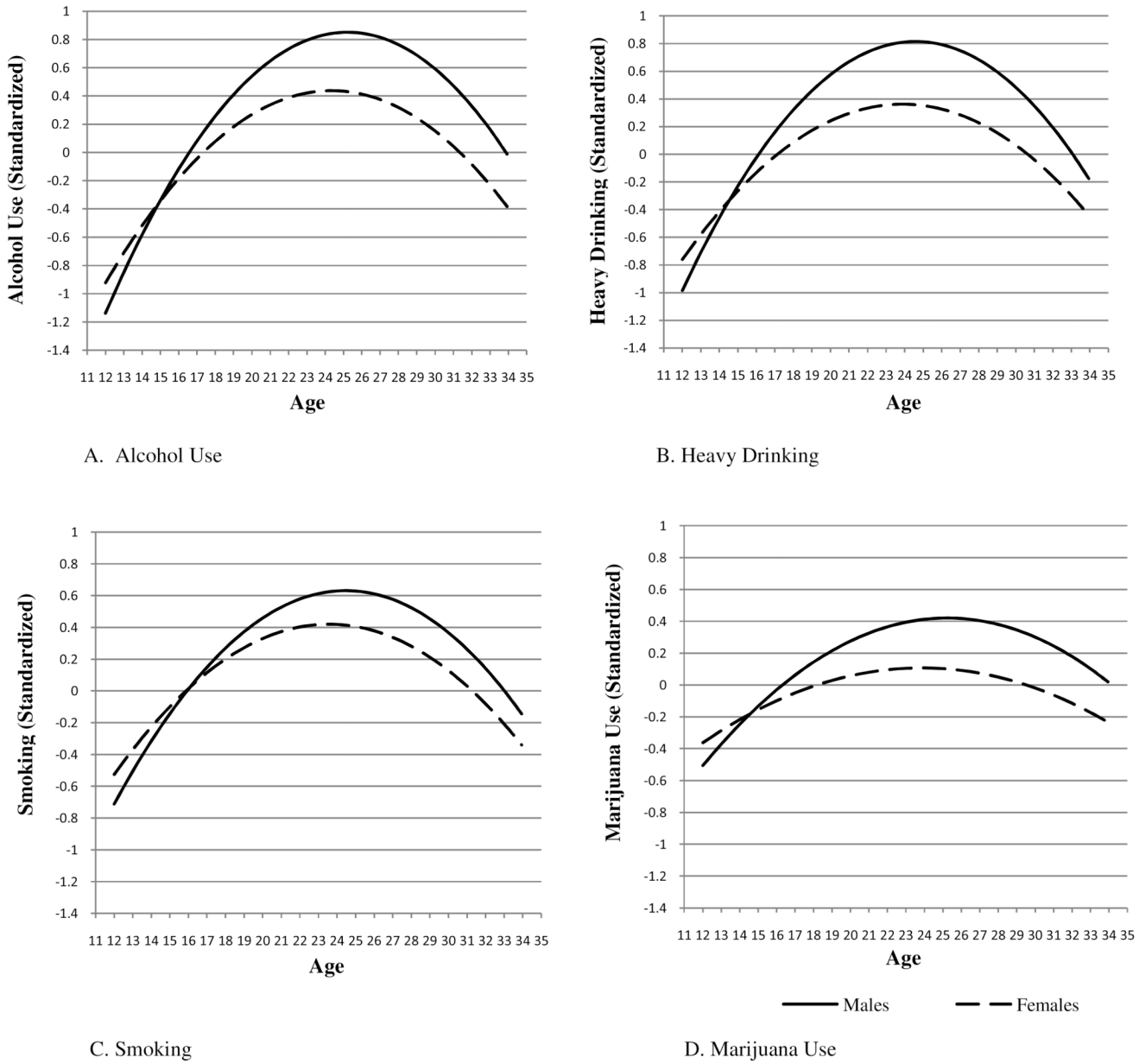

Figure 1.
Developmental Trajectories for Measures of Substance Use by Gender
Note. Developmental trajectories by gender were plotted controlling for race/ethnicity (i.e., for Caucasian individuals as race/ethnicity = 0 for this group).

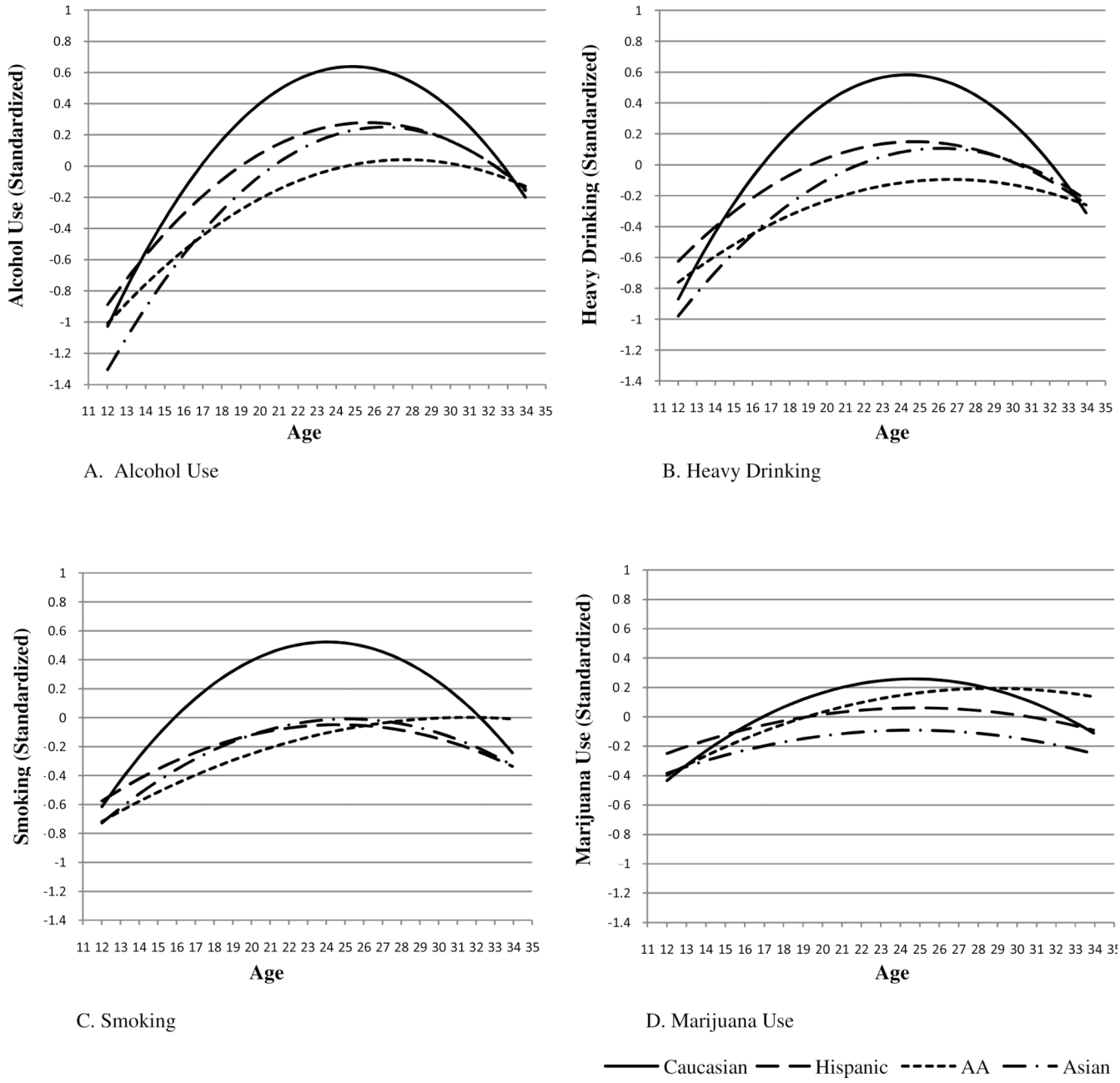

Figure 2.

Developmental Trajectories for Measures of Substance Use by Race/Ethnicity

Note. Developmental trajectories by race/ethnicity were plotted controlling for gender (i.e., for gender = .49, namely the mean of gender which indicates that 49% of the samples were males).

Table 1

Descriptive statistics.

		Alcohol Use[a]				Heavy Drinking[a]				Smoking[b]				Marijuana Use[b]	
		Number of day[c]		Ave. number of drinks		Number of days drink > 5 drinks[c]		Number of days gotten drunk[c]		Actual number of days		Avg. daily cigarettes		Number of days[d]	
Age	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
12	592	.26	.78	.41	1.51	.09	.49	.09	.50	.74	3.69	.19	1.02	.05	.42
13	2,871	.44	1.01	.63	1.76	.18	.75	.17	.68	1.57	5.64	.48	2.08	.12	.61
14	4,592	.68	1.22	1.10	2.41	.35	1.00	.34	.94	2.81	7.67	.93	3.23	.24	.86
15	5,857	.96	1.38	1.72	2.91	.55	1.22	.55	1.16	4.12	9.27	1.45	4.04	.39	1.13
16	6,918	1.12	1.47	2.08	3.25	.71	1.34	.69	1.28	5.02	10.24	1.96	4.95	.47	1.27
17	6,981	1.32	1.57	2.43	3.41	.86	1.45	.84	1.38	5.62	10.72	2.26	5.29	.50	1.30
18	5,249	1.53	1.67	2.71	3.52	1.03	1.58	.97	1.47	6.41	11.38	2.68	5.84	.55	1.37
19	2,788	1.77	1.74	3.00	3.64	1.12	1.59	1.08	1.48	8.18	12.66	3.55	6.61	.68	1.57
20	2,206	1.90	1.74	3.33	3.91	1.12	1.55	1.13	1.49	9.85	13.41	4.19	7.02	.78	1.68
21	2,433	2.23	1.76	3.33	3.69	1.24	1.59	1.19	1.47	10.13	13.54	4.68	7.70	.75	1.65
22	2,811	2.28	1.76	3.19	3.45	1.20	1.56	1.15	1.42	9.92	13.49	4.37	7.32	.69	1.61
23	2,862	2.27	1.75	3.20	3.51	1.21	1.56	1.09	1.40	9.78	13.35	4.51	7.55	.63	1.54
24	2,432	2.21	1.71	3.06	3.35	1.11	1.51	1.01	1.34	8.94	13.02	3.90	7.08	.60	1.54
25	1,456	2.23	1.76	3.02	3.34	1.17	1.53	1.01	1.31	7.98	12.65	3.66	6.99	.68	1.63
26	1,904	2.38	1.78	2.80	2.86	1.26	1.55	1.14	1.39	8.60	12.83	3.55	6.45	.98	1.95
27	2,242	2.27	1.82	2.82	3.19	1.17	1.55	1.06	1.38	8.68	12.80	3.81	7.02	.87	1.82
28	2,782	2.25	1.79	2.71	3.04	1.13	1.51	.97	1.29	8.12	12.68	3.63	6.84	.83	1.84
29	2,903	2.22	1.81	2.64	2.99	1.09	1.51	.93	1.29	7.70	12.42	3.45	6.69	.78	1.78
30	2,821	2.16	1.82	2.55	2.99	1.07	1.50	.86	1.25	7.41	12.29	3.33	6.67	.72	1.72
31	1,791	2.13	1.87	2.48	2.94	1.03	1.52	.82	1.25	7.14	12.25	3.15	6.46	.64	1.63
32	327	1.70	1.76	2.40	3.07	.90	1.48	.65	1.08	7.14	11.96	3.26	6.24	.50	1.49
33	48	.98	1.61	1.30	2.42	.45	1.14	.40	1.01	5.83	10.40	2.89	6.17	.39	1.24

Note. Descriptive statistics are provided for unadjusted variables.

[a]Substance use during past 12 months.

[b] Substance use during past month.

[c] Response codes: 0 = never; 1 = 1–2 days during the past year; 2 = 3–12 days in past 12 months (i.e., once a month or less); 3 = 2–3 days per month; 4 = 1–2 days per week; 5 = 3–5 days per week; 6 = daily or almost every day.

[d] Response codes for Wave I to Wave III: 0 = none, 1 = 1 time, 2 = 2–3 times, 3 = 4–5 times, 3.5 = 6–7 times, 4 = 8–9 times, 4.5 = 10–11 times, 5 = 12–25 times, 6 = 26–30 times; responses codes for Wave IV: 0 = none; 1 = 1 day; 2 = 2–3 days; 3 = 1 day a week; 4 = 2 days a week; 5 = 3–5 days per week; 6 = daily or almost every day.

Table 2

Parameter estimates from hierarchical longitudinal multilevel models for each substance.

	Alc Use	Heavy Drinking	Smoking	Marijuana Use
Model 1				
Intercept	−.003	−.005	−.016**	.005
ICC	.28	.30	.49	.32
Goodness-of-fit				
χ^2	174005.86	175674.90	157881.63	163577.03
Model 2				
Intercept	−1.009***	−.806***	−.638***	−.387***
Linear Change (Age)	.211***	.177***	.139***	.085***
Quadratic Change (Age^2)	−.008***	−.007***	−.006***	−.003***
Goodness-of-fit				
χ^2	163782.95	169011.33	150474.89	159600.69
Comparison Model	1	1	1	1
Δ-2LL (Δdf)	10222.91(4)***	6663.57(4)***	7406.74(4)***	3976.34(4)***
Model 3				
Intercept	−.921***	−.760***	−.525***	−.362***
Male	−.216***	−.224***	−.187***	−.144***
Hispanic	.140***	.244***	.041	.184***
African American	.019	.108***	−.102***	.036
Asian American	−.277***	−.109*	−.112*	.050
Linear Change (Age)	.220***	.189***	.164***	.079***
Male* Age	.081***	.097***	.052***	.061***
Hispanic* Age	−.089***	−.114***	−.106***	−.061***
AA* Age	−.125***	−.145***	−.115***	−.039***
Asian* Age	−.045***	−.083***	−.080***	−.063***
Quadratic Change (Age^2)	−.009***	−.008***	−.007***	−.003***
Male* Age^2	−.003***	−.003***	−.002***	−.002***
Hispanic* Age^2	.004***	.005***	.005***	.002***
AA* Age^2	.006***	.007***	.006***	.002***
Asian* Age^2	.003***	.004***	.004***	.003***
Goodness-of-fit				
χ^2	160591.98	165618.98	147882.42	158937.83
Comparison model	2	2	2	2
Δ-2LL (Δdf)	3190.97(12)***	3392.35(12)***	2592.47(12)***	662.86(12)***
Pseudo R^2				

	Alc Use	Heavy Drinking	Smoking	Marijuana Use
R_ε^2 (within-person)	30.0%	25.4%	31.8%	17.0%
R_0^2 (level 2 initial status)	7.8%	6.4%	13.0%	0.2%
R_1^2 (level 2 age)	9.9%	7.4%	4.1%	4.9%

Note. ICC = Intraclass correlation.

* $p < .05$,

** $p < .01$,

*** $p < .001$

Table 3

Developmental trajectory estimates for each measure of substance use calculated from final models

	Intercept	Linear Slope	Quadratic Slope	Stationary point	Final Level
Alcohol use					
Total sample	−1.0091	.2110	−.0079	25.36	−.1710
Male	−1.1373	.3007	−.0114	25.23	−.0118
Female	−.9213	.2202	−.0089	24.36	−.3813
Caucasian	−1.0271	.2596	−.0101	24.84	−.2002
Hispanic	−.8874	.1706	−.0062	25.67	−.1485
African American	−1.0077	.1343	−.0043	27.64	−.1286
Asian	−1.3044	.2143	−.0074	26.52	−.1564
Heavy Drinking					
Total sample	−.8055	.1771	−.0070	24.66	−.2838
Male	−.9837	.2859	−.0114	24.6	−.1754
Female	−.7598	.1887	−.0079	23.89	−.4409
Caucasian	−.8695	.2364	−.0096	24.3	−.3108
Hispanic	−.6251	.1219	−.0048	24.73	−.2556
African American	−.7611	.091	−.0031	26.65	−.2602
Asian	−.9788	.1538	−.0054	26.13	−.2256
Smoking					
Total sample	−.6383	.1389	−.0055	24.64	−.2142
Male	−.7118	.2157	−.0087	24.47	−.1437
Female	−.5248	.1635	−.0071	23.58	−.3387
Caucasian	−.6164	.1891	−.0078	24.06	−.2432
Hispanic	−.5754	.0835	−.0033	24.62	−.3359
African American	−.7186	.0737	−.0019	31.55	−.0095
Asian	−.7285	.1094	−.0042	25.17	−.3291
Marijuana Use					
Total sample	−.3869	.0846	−.0032	25.23	−.0578
Male	−.5063	.1402	−.0053	25.24	.0194
Female	−.3623	.0793	−.0034	23.85	−.2333

	Intercept	Linear Slope	Quadratic Slope	Stationary point	Final Level
Caucasian	−.4328	.1092	−.0043	24.69	−.1095
Hispanic	−.2458	.0481	−.0019	24.91	−.0902
African American	−.3973	.0705	−.0021	28.76	.1372
Asian	−.3831	.0463	−.0018	24.62	−.2504

Note. Coefficients by gender were calculated for Caucasian individuals as race/ethnicity = 0 for this group. Coefficients by race/ethnicity were calculated for gender = .49 (i.e., the mean of gender which indicates that 49% of the samples were males). Stationary point refers to the moment when the quadratic trajectory curve flips over. It was calculated for each group using the equation: − Linear Slope / 2*Quadratic Slope + 12.01. The constant 12.01 was added as age was centered at 12.01 in analyses. Gender differences across substances: As shown in Table 2, gender differences in initial levels and both linear and quadratic rates of change were statistically significant for all four substance use measures. In addition, when analyses were re-run with age centered at 33.94, there were statistically significant gender differences in final levels of use as well. Racial/ethnic differences in alcohol use: racial/ethnic differences in initial levels of alcohol use were statistically significant for all comparisons except between Caucasians and African Americans. Racial/ethnic differences in the rate of linear change were statistically significant for all group comparisons. Racial/ethnic differences in the rate of quadratic change were statistically significant for all comparisons except between Hispanic and Asian groups. No statistically significant racial/ethnic differences were found in final levels of alcohol use. Racial/ethnic differences in heavy drinking: racial/ethnic differences in the rate of quadratic change were not statistically significant between Hispanic and Asian groups. No statistically significant racial/ethnic differences were found in final levels of heavy drinking. All the other racial/ethnic differences were statistically significant. Racial/ethnic differences in smoking: racial/ethnic differences in initial levels of smoking were not statistically significant between Caucasians and Hispanics or between African Americans and Asians. Racial/ethnic differences in the rate of linear change were not statistically significant between Hispanic and African American groups. Racial/ethnic differences in the rate of quadratic change were not statistically significant between Hispanics and Asians. Racial/ethnic differences in final levels of smoking were not statistically significant between Caucasian and Asian groups or between Hispanic and Asian groups. All the other racial/ethnic differences were statistically significant. Racial/ethnic differences in marijuana use: racial/ethnic differences in initial levels of marijuana use were not statistically significant among Caucasians, African Americans, and Asians. Racial/ethnic differences in the rate of linear change were not statistically significant between Hispanic and Asian groups. Racial/ethnic differences in the rate of quadratic change were not statistically significant among Hispanics, African Americans, and Asians. Racial/ethnic differences in final levels of marijuana use were not statistically significant among Caucasian, Hispanic, and Asian groups. All the other racial/ethnic differences were statistically significant.