Longitudinal changes in alcohol use and binge-drinking among young-adult college students: Analyses of predictors across system levels

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HIGHLIGHTS

- Young-adult drinking vs. binge-drinking had common and distinct predictors.
- Being White, men, and early-onset substance use predicted alcohol use/misuse.
- Parental use and private college/rural setting were also risk factors for use/misuse.
- Depressive and ADHD symptoms predicted higher risk use trajectories.

ARTICLE INFO

ABSTRACT

Background: Longitudinal research regarding young-adult college student alcohol use behaviors is needed to identify risk factors and inform interventions, particularly with regard to binge-drinking.
Methods: Data from 3,418 US college students (aged 18–25) in a two-year, six-wave panel study (64.6% female, 63.4% White) were used to examine alcohol use and binge-drinking trajectories, as well as predictors of differing trajectories across individual (sociodemographics, depressive symptoms, ADHD symptoms, early-onset substance use), interpersonal (adverse childhood events, social support, parental substance use), and community factors (college type, rural/urban).
Results: Baseline alcohol use was associated with being White, higher parental education, early-onset use of alcohol, cigarettes, and marijuana, greater social support, parental alcohol use, attending private institutions, and rurality (p's < 0.01). Greater alcohol use over time was predicted by being White and attending private institutions (p's < 0.01). Multivariable regression indicated that predictors of binge-drinking at any assessment included older age, sexual minority, greater ADHD symptoms, early-onset substance use, parental alcohol use, attending private institutions, and rurality (p's < 0.01). GMM indicated 4 binge-drinking trajectory classes: Dabblers (89.94% of the sample), Slow decelerators (7.35%), Accelerators (1.86%), and Fast decelerators (0.84%). Fast and Slow decelerators were older; Dabblers and Fast decelerators were more likely female; Accelerators reported more depressive symptoms; Dabblers were less likely early-onset substance users; and those from rural settings were more likely Slow decelerators vs. Dabblers (p's < 0.05).
Conclusions: Intervention efforts should be informed by data regarding those most likely to drink, binge-drink, and escalate use (e.g., Whites, men, early-onset users, parental use, private college students, rural).

1. Introduction

In the US, young adults demonstrate among the highest rates of alcohol use and binge-drinking (≥4/5 drinks for women/men within 2 hours (National Institute on Alcohol Abuse and Alcoholism, 2004; Hingson et al., 2017; Substance Abuse and Mental Health Services Administration. Key substance use and mental health indicators in the United States: Results from the, 2018) Alcohol use is typically initiated in adolescence, drinking and binge-drinking increases from age 18 to 22, and then decreases throughout the twenties. (Hingson et al., 2017;

Substance Abuse and Mental Health Services Administration, 2018) However, some individuals continue to drink at risky levels or exhibit progression. (Gotham et al., 1997) Moreover, research generally suggests that college students drink more than non-college-attending young adults. (Johnston et al., 2007; Patrick & Terry-McElrath, 2017; Quinn & Fromme, 2011) Binge-drinking in particular poses a broad range of short-term (e.g., motor vehicle accidents, unwanted sexual behavior, disruptive behaviors), and long-term risks (e.g., cognitive impairment, (Whelan et al., 2014) psychiatric symptomatology/disorders, (Bhochhibhoya et al., 2015; Sylvers et al., 2011) poor health-related quality of life (Luquiens et al., 2016). Therefore, identifying risk factors for drinking and sustained binge-drinking is critical for informing early intervention efforts, particularly for young-adult college students.

The current study draws from a socioecological developmental perspective (McLeroy et al., 1988) to examine trajectories of young-adult alcohol use and binge-drinking. Socioecological models emphasize complex, dynamic interplay between multilevel influences (e.g., individual, interpersonal, organizational, community, policy) on individual outcomes. The developmental perspective is critical in understanding physical, mental, social, and emotional development over the life course. Collectively, this perspective suggests that alcohol use and use trajectories are shaped during this developmental period by multilevel influences.

Regarding individual sociodemographic and psychological factors, men are more likely to drink, binge-drink, and continue drinking over time, (Substance Abuse and Mental Health Services Administration, 2018) which – according to a socioecological developmental perspective – may result from and contribute to sociocontextual influences on alcohol use (e.g., social norms regarding alcohol use). Sexual minorities and certain racial/ethnic subgroups (e.g., American Indians/Alaskan Natives) show evidence of increased alcohol use risk. (Goldbach et al., 2014) In addition, people with higher socioeconomic status (SES) versus lower SES may consume similar or greater amounts of alcohol, although lower SES groups may experience disproportionate burden of alcohol-related consequences (e.g., accidents, health problems), (Collins, 2016) particularly among low SES of further marginalized communities (e.g., racial/ethnic minorities). (Collins, 2016) Psychological factors – in particular, depression and attention deficit hyperactive disorder (ADHD) – are positively associated with alcohol use. (Bevilacqua et al., 2018; Pedrelli et al., 2016) Other substance use (e.g., tobacco, marijuana) is also positively correlated with alcohol use. (Blavos et al., 2017; Ramo et al., 2012; Substance Abuse and Mental Health Services Administration, 2015) Furthermore, early-onset alcohol use is associated with greater risk of developing dependence. (Boden et al., 2019; Chassin et al., 2013; Nelson et al., 2015)

Regarding interpersonal factors, risk factors for drinking and binge-drinking include experiencing adverse childhood events (ACEs) (Chassin et al., 2013; Simpson & Miller, 2002) and parental alcohol consumption. (Rossow et al., 2016) On the other hand, social support is a protective factor against substance use. (Coulter et al., 2019; Rogers et al., 2018)

In terms of community settings, those living in rural versus urban areas are more likely to drink and binge-drink, potentially attributable to various underlying mechanisms (e.g., cultural acceptance, easy access). (Lenardson et al., 2014) While college students have higher rates of alcohol use and binge-drinking than their non-college attending peers, (Johnston et al., 2007) less research has examined alcohol use with regard to type of college setting (e.g., public or private college, historically Black colleges/universities [HBCUs], technical/community colleges).

Examining drinking and binge-drinking trajectories is critical for understanding what trajectories exist and characteristics of high-risk young adults. Several risk factors for persistent drinking and binge-drinking have been examined in individual studies, (Fernie et al., 2013; Gotham et al., 1997; Patrick et al., 2010) but less well-studied are the factors related to use trajectories during the young adulthood period. (Chassin et al., 2013; Verges et al., 2013) Role transitions and life events predict decreases in problematic drinking (e.g., getting married, having children) or increases in drinking (e.g., divorce), (Brodbeck et al., 2013; Kretsch & Harden, 2013) which might reflect shifts in social connectedness/support. (Uchino, 2006) More recent evidence implicates other alcohol use risk factors, such as psychological traits (e.g., impulsivity (Kuntsche et al., 2017) – a key ADHD symptom). Longitudinal findings suggest that, in early young adulthood, role transitions are more influential, while psychological traits play greater roles in later young adulthood. (Gates et al., 2016; Lee & Sher, 2018) Despite this literature, more prospective studies are needed to better understand trajectories during emerging adulthood. (Montes et al., 2017)

This study extends the literature regarding drinking and binge-drinking trajectories during young adulthood from a socio-developmental perspective (McLeroy et al., 1988) using data from young-adult college students in a two-year longitudinal study. The first research aim was to examine *1a)* alcohol use trajectories over time; and *1b)* predictors of alcohol use trajectories across the socioecological framework, from intrapersonal-level (i.e., sociodemographics, depressive symptoms, ADHD symptoms, early-onset substance use) to interpersonal-level (i.e., ACEs, social support, parental substance use) to community-level factors (i.e., college type, rural vs. urban). The second research aim was to examine *2a)* binge-drinking trajectories over time; and *2b)* predictors of binge-drinking trajectories across the socioecological framework. Based on the aforementioned literature, we hypothesized that higher-risk drinking and binge-drinking trajectories would be correlated with being male, being sexual minority, greater symptoms of depression and ADHD, early-onset substance use, greater ACEs, lower social support, parental substance use, and residing in rural settings.

2. Materials & methods

2.1. Procedures & participants

The current study was conducted as part of Project DECOY (**D**ocumenting **E**xperiences with **C**igarettes and **O**ther Tobacco in **Y**oung Adults), which was a two-year, six-wave longitudinal cohort study involving 3,418 racially/ethnically diverse students (ages 18 to 25) from seven colleges and universities in Georgia. Project DECOY was approved by the Emory University and ICF Institutional Review Boards as well as those of the participating colleges/universities. Data collection began in fall 2014 and consisted of self-report assessments via online surveys every four months for two years (fall, spring, summer) for all participants (regardless of subsequent enrollment as students).

Project DECOY's sampling/recruitment are described elsewhere (Berg et al., 2016) and summarized here. Lists of eligible students (ages 18–25, able to read English) were obtained from each institutional registrar's office. One public and two private colleges/universities had 3,000 students randomly selected from those eligible; the remaining colleges/universities had eligible student bodies < 3,000, so all eligible students were recruited. Invitation emails were sent describing the study and incentives for participating. Those interested clicked on a link embedded in the email, which launched them to the consent form. Those who consented (clicked a link) were then launched to the baseline (Wave 1) survey.

Recruitment at each school was closed after recruitment goals were reached. Response rates ranged from 12.0% to 59.4%, with an overall response rate of 22.9% (N = 3,574/15,607) observed within 72 h at each school. A week after baseline survey completion, participants were emailed to ask them to re-read the consent form and then click a link to "confirm" their consent. They were then provided their first gift card ($30). The confirmation rate was 95.6% (N = 3,418/3,574). The baseline sample was largely representative of each school's demographic profile, although respondents were disproportionately female.

To facilitate retention (and solicit updates to contact information), participants were emailed and text-messaged prior to each wave of data collection. Retention across waves exceeded 70%.

2.2. Measures

Below we provide detail on measures used in these analyses. Note that: 1) to minimize participant burden, not all measures were included in the baseline assessment nor at every wave; 2) the current analyses only included multiple timepoints of data regarding alcohol use and binge-drinking outcomes; and 3) we included the first assessment of other factors if assessed more than once.

2.2.1. Outcomes: Alcohol use and binge-drinking

Participants were asked at Wave 1 to indicate age of first alcohol use, with response options including "never use" and "refuse". Those who reported age at first use were then asked, "In the past four months: On how many days have you used alcohol? did you drink 4/5 [female/male] or more drinks on a single occasion?" These questions were repeated at each wave, thus providing data for 24 months (i.e., 2 years).

2.2.2. Individual-level predictors

Sociodemographic data (age, sex, sexual orientation, race/ethnicity, parental education) were obtained at Wave 1. *Depressive symptoms* were assessed at Wave 1 using the Patient Health Questionnaire – 9 item (PHQ-9), (Kroenke et al., 2003) assessing symptoms in the past two weeks (0 = not at all to 3 = nearly every day; score range 0–27). Cronbach's alpha was 0.87. *ADHD symptoms* were assessed at Wave 2 using the six screening items from the Adult ADHD Self-Report Scale Symptom Checklist (Kessler et al., 2005) assessing symptoms (e.g., "difficulty getting things in order when a task requires organization") in the past six months (0 = never to 4 = very often; score range 0–24). Cronbach's alpha was 0.74. Age of first use of alcohol, cigarettes, and marijuana was assessed at Wave 1; *early-onset users* were defined as those reporting use initiation of alcohol and cigarettes at ≤ 16 years old and marijuana at ≤ 18 years old (informed by National Survey on Drug Use or Health (Survey, 2016) data).

2.2.3. Interpersonal-level factors

Adverse childhood experiences (ACEs) were assessed at Wave 2 using the CDC-developed Adverse Childhood Experiences, (Centers for Disease Control and Prevention National Center of Injury Prevention and Control, 2014; Felitti et al., 1998) which assess events (e.g., parents with mental health or substance use problems, parental interpersonal violence, childhood maltreatment or abuse) occurring prior to age 18 (0 = no, 1 = yes; score range 0–10). The internal consistency was 0.75. *Social support* was assessed at Wave 2 using the Interpersonal Support Evaluation List – 12 item (ISEL-12), (Cohen et al., 1985) assessing perceived social support on a four-point scale (0 = definitely false to 3 = definitely true). Items are summed to yield a total score (range 0–36). Cronbach's alpha was 0.85. *Parental substance use* was assessed at Wave 1 by asking participants if any parent currently used alcohol, cigarettes, and marijuana, respectively. (Berg et al., 2015)

2.2.4. Community-level factors

At Wave 1, participants were characterized based on the type of school they attended (private, public, HBCU, technical college) and whether the school was located in a *rural or urban setting.*

2.3. Data analysis

To characterize our sample and drinking outcomes, we first calculated descriptive statistics and the proportions of participants reporting alcohol use and binge drinking and number of days of these behaviors (among all participants and among users) at each wave.

To examine alcohol use trajectories and related predictors (*aim 1*),

we utilized data from all participants regarding how many days they used alcohol in the past 4 months across the 6 waves of data collection. We initially attempted to use growth mixture modeling (GMM) to identify trajectories across ages by coding alcohol use at participants' age, thus covering ages 18–28 in this sample (i.e., 18–25 at baseline and with aging during the study) and then examining across 4-month periods by age. This approach yielded no clear classes. Thus, we explored alcohol use over waves of assessment (across the academic year) using a Gompertz model, a growth model with free time scores (i.e., where shape of the trajectory is not imposed). Given that linear or other parametric shapes for the alcohol growth model could not be assumed, we used this approach where two timepoints are fixed. In our model, Wave 1 is fixed at 0, Wave 6 is fixed at 1, and all other waves are freely estimated. After we conducted the unconditional Gompertz model (i.e., using only alcohol use data across waves; *aim 1a*), we explored predictors (*aim 1b*). We entered sociodemographics into the model. Next, we only modeled substantive variables of interest (i.e., depression/ADHD symptoms, ACEs, social support, early-onset use, parental use) that were significantly related (p < .05), in order to reduce suppression due to multicollinearity issues. We used traditional SEM fit indices to assess model fit: Chi-square p > .05; RMSEA [< 0.08 (adequate), < 0.05 (good)]; CFI < 0.95; TLI < 0.95; and SRMR < 0.08. (Mueller & Hancock, 2018)

To examine binge-drinking trajectories over time and related predictors (*aim 2*), first, we compared those who ever versus never reported binge-drinking. This was done initially through bivariate analyses and then through multivariable logistic regression. Then, to determine longitudinal trajectories during ages 18–28 using GMM (*aim 2a*), we used only data from the ever binge-drinkers (i.e., excluding those who might have used alcohol or not, but never reported any binge-drinking throughout the study). As initially attempted in *aim 1a*, responses were age coded in four-month intervals that corresponded with the data collection (and binge-drinking assessments) spacing/assessing four-month intervals. We fitted linear trajectories, accounting for clustering of students in schools. Quadratic models did not yield a solution for ≥ 3 class models following over 48 h of computing and thus were abandoned. Data from age 18 were excluded due to small number of observations and model convergence issues. This led to excluding 18 participants from the GMM who only provided baseline data at age 18. This yielded an analytic sample of N = 2,257 for the GMM and post-GMM analyses. The final number of trajectories was determined using several criteria: lowest Akaike Information Criterion (AIC), lowest Bayesian Information Criterion (BIC), non-significant likelihood ratio test, entropy above 0.95, and meaningfully large class sizes. We then used bivariate comparison to assess associations between trajectory class and participant characteristics (*aim 2b*). (Note: Due to small cells, we were not able to conduct a multinomial logistic regression analysis to determine correlates of trajectory class membership in a single model, which would have been preferred.)

Descriptive and bivariate analyses were conducted using SAS 9.4. All other analyses were conducted in Mplus 8.3. Missing data were handled with full information maximum likelihood estimation for endogenous variables and with multiple imputations ($N_{imputed}$ = 100) for exogenous variables.

3. Results

Table 1 shows the proportion of participants indicating any past 4-month use of alcohol and binge-drinking and the average number of days of use and binge-drinking at each wave.

Aim 1a) Alcohol use trajectories

Fig. 1 shows changes in alcohol use over time, specifically across the academic year (fall, spring, summer), per the unconditional and final Gompertz models. The unconditional model indicated decreased alcohol use from fall to spring but increased alcohol use from spring to summer. The final model indicated an overall trend of alcohol use

Table 1
Alcohol use and binge-drinking characteristics across waves.

	Wave											
	1 N = 3,380		2 N = 2,968		3 N = 2,867		4 N = 2,922		5 N = 2,689		6 N = 2,401	
All participants	N	%	N	%	N	%	N	%	N	%	N	%
Any alcohol use	2393	70.80	2080	70.08	2040	71.15	2164	74.06	1953	72.63	1823	75.93
Any binge-drinking	1565	45.78	1241	41.81	1179	41.11	1267	43.36	1132	42.10	1018	42.40
All participants	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Number of days drinking alcohol	11.18	18.53	9.56	16.27	11.77	18.93	11.71	18.62	11.12	17.41	12.76	18.66
Number of days binge-drinking	5.52	11.11	4.00	9.05	4.02	8.12	3.81	8.65	2.76	7.88	3.24	7.14
Among only alcohol users at a wave												
Number of days drinking alcohol	15.79	20.30	13.65	17.95	16.54	20.61	15.81	20.09	15.31	18.80	16.80	19.76
Number of days binge-drinking	8.45	12.81	6.69	10.92	6.97	9.68	6.51	10.49	6.56	11.07	5.80	8.74

increases from Wave 2 to Wave 6, with the rate of increase leveling over time.

Aim 1b) predictors of alcohol use trajectories

Table 2 shows predictors of alcohol use at baseline and increases in use over time. Baseline alcohol use was associated with being White (vs. Asian or other race: p < .001 and p = .006, respectively), higher parental education (p = .001), early-onset use of alcohol, cigarettes, and marijuana (p's < 0.001), greater social support (p = .001), parental alcohol use (p < .001), attending private institutions (vs. others, p's < 0.01), and rural setting (p < .001). Greater increased alcohol use over time was predicted by being White (vs. Black, p = .008) and attending private institutions (vs. others, p's < 0.05).

Aim 2a) Binge-drinking trajectories

Table 3 indicates that 66.71% (N = 2,280) of participants reported binge-drinking at any wave of assessment across the 2-year period. The GMM indicated 4 binge-drinking trajectory classes across age (as data was analyzed by age rather than by wave of assessment and thus mapped by age; Fig. 2). Supplemental Table A provides statistics regarding GMM fit. The largest class was Dabblers (89.94% of the sample, n = 2030), characterized by low levels of binge-drinking over time (e.g., reporting one or several days of binge drinking only once, reporting a single to a few days twice or three times). The second class was Slow decelerators (7.35%, n = 166), showing moderate levels of binge-drinking in the early years and then slow declines over time. The third group was Accelerators (1.86%, n = 42), showing low rates of

binge-drinking in the early years and then rapid increases over time. The final group was Fast decelerators (0.84%, n = 19), reporting the highest level of binge-drinking in the early years but quick declines (Table 4).

Aim 2b) Predictors of binge-drinking trajectories

Table 3 provides bivariate and multivariable binary logistic regression results indicating predictors of binge-drinking reported at any wave. Per multivariable binary logistic regression, predictors included older age (p < .001), being sexual minority (p = .002), greater ADHD symptoms (p = .003), early-onset use of alcohol, cigarettes, and marijuana (p's < 0.001), parental alcohol use (p < .001), attending private institutions (vs. public or technical colleges, p = .003 and p < .001, respectively), and rural setting (p = .001).

4. Discussion

This study leveraged a socioecological developmental (McLeroy et al., 1988) perspective and sophisticated modeling to identify behavioral trajectories of 1) alcohol use and 2) binge-drinking. Regarding **aim 1a**, the Gompertz model suggested seasonality of *alcohol use* throughout the year, with decreases from fall to spring but increases from spring to summer. Some prior research has also documented decreases in fall and summer versus spring, (Chulia et al., 2016; Juth et al., 2010) with other findings suggesting reductions in alcohol use in the summer among college students, particularly those living with
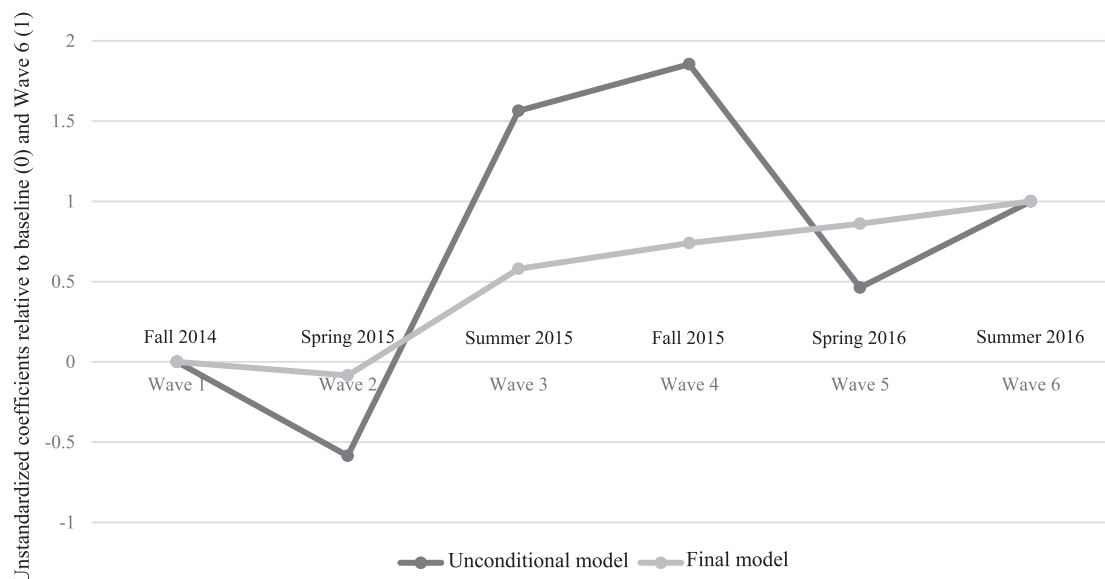

Fig. 1. Change in alcohol use over time using the Gompertz Model Note: Baseline (Wave 1) and Wave 6 coefficients were fixed at 0 and 1, respectively, to create a metric which allows the model to estimate the shape of the alcohol use over time function.

Table 2
Multivariable regression results examining predictors of alcohol use at baseline and increases over time.

Variable	Baseline			Increases over time		
Individual-level factors	beta	SE	p-value	beta	SE	p-value
Age	1.560	0.14	< 0.001	–	–	–
Sex (ref = male)	−2.35	0.57	< 0.001	–	–	–
Race (ref = White)						
Black	−1.64	0.87	0.058	−2.28	0.86	0.008
Asian	−5.49	1.19	< 0.001	−2.21	1.18	0.061
Other race	−3.19	1.16	0.006	−1.02	1.19	0.393
Parental	2.30	0.70	0.001	–	–	–
education ≥ Bachelor's						
(ref = less than college)						
Early-onset substance use						
Alcohol (≤16)	4.76	0.69	< 0.001	–	–	–
Cigarettes (≤16)	3.76	0.97	< 0.001	–	–	–
Marijuana (≤18)	4.15	0.85	< 0.001	–	–	–
Interpersonal-level factors						
Social support	0.17	0.05	0.001	–	–	–
Parental use of alcohol	3.75	0.53	< 0.001	–	–	–
Community-level factors						
School type (ref = private university)						
HBCU	−4.07	1.31	0.002	−3.03	1.25	0.015
Public university	−3.24	0.69	< 0.001	−1.64	0.72	0.023
Technical college	−5.81	0.83	< 0.001	−2.41	0.83	0.003
Rural (ref = urban)	3.12	0.60	< 0.001	–	–	–

Note: – not included in model. Model fit for earlier models in the sequence was comparable to the final model, i.e. we had good fit except for chi-square.
Model fit:
chi-square(76) = 245.8, p < .0001.
RMSEA = 0.029 (90%CI = [0.025;0.033]).
CFI = 0.984.
TLI = 0.979.
SRMR = 0.020.

parents/guardians in the summer. (Miller et al., 2016)

Addressing **aim 2a**, GMM indicated 4 trajectory classes of *binge-drinking* across the young adulthood period, with those dabbling in binge-drinking at very low levels over time representing roughly 90%, decelerators representing about 8%, and those increasing in their binge-drinking representing about 2%. These trajectories mirror those previously documented (heavy, moderate, light, escalating to heavy, legal age onset). (Coulter et al., 2018) However, the current sample included a large proportion of dabblers, which may reflect cohort effects or – more likely – the nature of the sample recruited in this study; that is, in order to participate, they may have needed to respond quickly to the study invitation and thus may be relatively conscientious.

Regarding **aims 1b** and **2b**, we hypothesized that predictors of greater alcohol use and binge-drinking over time would include being male and sexual minority, greater symptoms of depression and ADHD, early-onset substance use, greater ACEs, lower social support, parental substance use, and residing in rural settings. Results supported some sociodemographic hypotheses. For example, women were more likely to only dabble or quickly reduce their binge-drinking throughout young adulthood. (Substance Abuse and Mental Health Services Administration, 2018) Being White predicted baseline alcohol use and greater increases in use over time. (Substance Abuse and Mental Health Services Administration, 2018) Additionally, rural residence predicted baseline alcohol use and binge-drinking at any wave. (Lenardson et al., 2014) Interestingly, those from rural settings were more likely to slowly decrease their binge-drinking over time rather than dabble in binge-drinking, which might reflect "regression to the mean" as students from various urban/rural settings influence one another's alcohol use. Two potential markers of higher SES – higher parental education and attending private institutions – also correlated with alcohol use behaviors. Specifically, both predicted baseline drinking behaviors, and the

latter also predicted increased alcohol use over time and binge-drinking at any wave. (Collins, 2016) This might suggest the role of higher SES peers in influencing high-risk alcohol use behaviors over time.

Additionally, while depressive symptoms did not predict any alcohol use outcome at a single time point, those with higher depressive symptoms were more likely to increase their binge-drinking over time. (Bevilacqua et al., 2018; Pedrelli et al., 2016) Moreover, higher levels of ADHD symptomatology predicted binge-drinking at any time point. (Bevilacqua et al., 2018; Pedrelli et al., 2016) Also, a potential indicator of higher stress levels (per Minority Stress Theory[13]), sexual minorities were more likely to report binge-drinking over time; prior research indicated that while heterosexuals were more likely to use alcohol, sexual minorities were more likely to indicate symptoms of alcohol use disorder. (Coulter et al., 2018)

Early-onset use of alcohol, cigarettes, and marijuana also predicted baseline alcohol use and binge-drinking at any wave. (Boden et al., 2019; Chassin et al., 2013; Nelson et al., 2015) Moreover, relative to those dabbling in binge-drinking, those who decreased their binge-drinking across waves were more likely to report early-onset alcohol use, which likely reflects their higher rates at early ages. Additionally, parental use of alcohol predicted baseline alcohol use and binge-drinking at any wave. (Rossow et al., 2016) Contrary to the literature, (Coulter et al., 2019; Rogers et al., 2018) greater social support predicted baseline alcohol use – but with no other alcohol use outcome. Alcohol use is not necessarily a high-risk behavior but rather may reflect differences in peer networks/selection and socialization processes that may be more or less conducive to alcohol use and/or binge-drinking.

Current findings have implications for research and practice. Intervention efforts should be informed by characteristics of those at highest risk, in particular those likely to binge-drink and escalate binge-drinking over time. However, while several risk factors were generally identified (e.g., White, male, early-onset users), even those not considered to be in the high-risk profiles warrant attention, particularly given some nuances identified (e.g., similar risk profiles over time among men and women). Furthermore, the broader sociocontextual factors influencing high-risk use must be addressed. According to the NIAAA Task Force on College Drinking, "successful interventions [must] occur at three distinct levels … [and] operate simultaneously to reach individual students, the student body as a whole, and the greater college community." (NIAAA, 2007) The College Alcohol Intervention Matrix (CollegeAIM) is an evidence-based decision tool designed to help college stakeholders select individual and environmental alcohol use prevention strategies best suited for their campuses. (Cronce et al., 2018) This is particularly important given consistent findings that private colleges and rural settings continue to show higher rates of alcohol use and binge-drinking. Finally, parental influences are critical – and parents should be engaged in alcohol use prevention efforts, both in their role modeling and in reducing early-onset use behaviors.

4.1. Limitations

The sample is limited in generalizability but represents diversity in terms of race/ethnicity, SES, school types, and urban/rural. Second, while a socioecological perspective (McLeroy et al., 1988) emphasizes a broad range of factors/potential constructs and interactions across levels, our analyses were limited to key sociodemographics, psychosocial, and community-level factors and did not consider cross-level interactions (due to including a large number of predictors and limited power to test for interactions). Third, the alcohol use behavior data was limited to number of days of alcohol use and binge-drinking, and data was self-reported. Finally, interpreting some results is complicated by the age range of participants upon study enrollment (i.e., 18–25 years old). However, all multivariable analyses accounted for age in some way (e.g., as a covariate), and the GMM anchored assessments/trajectories to age.

Table 3

Bivariate and multivariable binary logistic regression results indicating predictors of reporting binge-drinking at any wave of assessment.

| Variable	Total N = 3,418 (100%)		Ever Binge-Drinker N = 2,280 (66.71%)		Never Binge-Drinker N = 1,138 (33.29%)		Bivariate models	Multivariable binary logistic regression models			
Individual-level factors	Mean	SD	Mean	SD	Mean	SD	p-value	OR	95% CI		p-value
Age	20.55	1.97	20.68	1.92	20.29	2.03	< 0.001	1.13	1.08	1.18	< 0.001
Sex	N	%	N	%	N	%					
Male	1215	35.59	831	36.50	384	33.77		ref			
Female	2199	64.41	1446	63.50	753	66.23	0.117	1.06	0.89	1.26	0.527
Sexual minority (ref = heterosexual)	271	7.99	213	9.41	58	5.25	< 0.001	1.65	1.20	2.28	0.002
Race/Ethnicity											
White	2133	63.18	1450	64.33	683	60.87	0.050	ref			
Black	832	24.64	509	22.58	323	28.79	< 0.001	0.91	0.72	1.16	0.449
Asian	213	6.31	145	6.43	68	6.06	0.675	0.96	0.68	1.35	0.814
Other	198	5.86	150	6.65	48	4.28	0.006	1.39	0.95	2.03	0.094
Hispanic (ref = non-Hispanic)	255	7.51	182	8.04	73	6.46	0.100	1.10	0.79	1.53	0.575
Parent education ≥ Bachelor's (ref = less than college)	2784	82.54	1893	83.91	891	79.77	0.003	1.16	0.94	1.44	0.159
Psychological factors	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**					
Depressive symptoms	6.34	5.38	6.57	5.48	5.88	5.15	< 0.001	1.01	1.00	1.03	0.131
ADHD symptoms	9.53	4.36	9.81	4.41	8.91	4.20	< 0.001	1.03	1.01	1.05	0.003
Early-onset substance use											
Alcohol (≤16)	495	14.84	430	19.45	65	5.78	< 0.001	2.15	1.50	3.08	< 0.001
Cigarettes (≤16)	369	10.80	321	14.08	48	4.22	< 0.001	2.30	1.69	3.12	< 0.001
Marijuana (≤18)	702	20.76	596	26.57	106	9.31	< 0.001	2.34	1.84	2.99	< 0.001
Interpersonal-level factors	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**					
ACEs	1.33	1.82	1.38	1.82	1.21	1.84	0.014	0.97	0.92	1.02	0.243
Social support	36.87	5.04	36.91	5.06	36.77	5.02	0.494	1.01	0.99	1.03	0.353
Parental substance use	N	%	N	%	N	%					
Alcohol	1855	54.27	1378	60.44	477	41.92	< 0.001	1.75	1.49	2.05	< 0.001
Tobacco	1107	32.39	773	33.90	334	29.35	0.007	1.10	0.92	1.31	0.319
Marijuana	215	6.29	165	7.24	50	4.39	0.001	1.21	0.84	1.75	0.311
Community-level factors											
Type of institution											
Private	1321	38.65	945	41.45	376	33.04	< 0.001	ref			
HBCU	410	12.00	275	12.06	135	11.86	0.866	0.79	0.54	1.14	0.209
Public	936	27.38	627	27.50	309	27.15	0.830	0.73	0.59	0.90	0.003
Technical college	751	21.97	433	18.99	318	27.94	< 0.001	0.40	0.32	0.52	< 0.001
Rural (ref = urban)	2008	58.75	1389	60.92	619	54.39	< 0.001	1.36	1.13	1.63	0.001
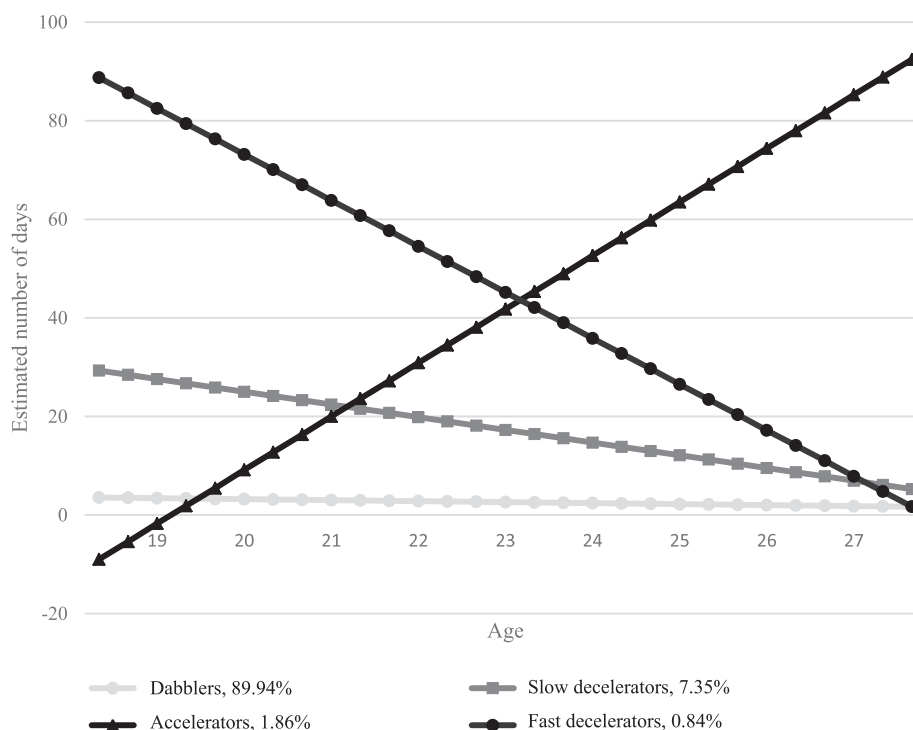
Fig. 2. Binge-drinking trajectories from GMM analysis, N = 2,257 Note: The minimum age of those included in the analysis is 18.33 years. The trajectories estimate a linear relationship and thus should be interpreted with caution at the lower and higher ends where fewer participants were in the study.

Table 4

Bivariate comparison of binge-drinking trajectory membership characteristics, N = 2,257.

	Dabbler N = 2,030 (89.94%)		Slow decelerators N = 166 (7.35%)		Accelerators N = 42 (1.86%)		Fast decelerators N = 19 (0.84%)			
Individual-level factors	Mean	SD	Mean	SD	Mean	SD	Mean	SD	p-value	Test
Age	20.63	1.89	21.38	1.98	20.45	1.66	22.53	2.14	< 0.001	ANOVA
Sex	N	%	N	%	N	%	N	%		
Male	690	34.04	98	59.04	22	52.38	9	47.37		
Female	1337	65.96	68	40.96	20	47.62	10	52.63	< 0.001	chi-square
Sexual minority (ref = heterosexual)	190	9.41	14	8.64	4	9.52	2	11.11	0.938	Fisher's
Race										
White	1265	63.06	128	77.58	32	78.05	14	73.68		
Black	478	23.83	17	10.3	4	9.76	4	21.05		
Asian	131	6.53	9	5.45	1	2.44	1	5.26		
Other	132	6.58	11	6.67	4	9.76	0	0.00	0.003	Fisher's
Hispanic (ref = non-Hispanic)	159	7.89	14	8.43	7	16.67	1	5.26	0.232	Fisher's
Parent education ≥ Bachelor's (ref = less than college)	1678	83.52	141	85.98	36	85.71	17	89.47	0.742	chi-square
Psychological factors	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Depressive symptoms	6.54	5.44	6.19	5.08	9.02	6.83	6.32	6.54	0.025	ANOVA
ADHD symptoms	9.74	4.42	10.21	4.19	10.61	4.57	11.73	3.92	0.128	ANOVA
Early-onset substance use										
Alcohol (≤16)	485	24.27	74	44.58	15	35.71	12	63.16	< 0.001	chi-square
Cigarettes (≤16)	255	12.56	44	26.51	10	23.81	5	26.32	< 0.001	chi-square
Marijuana (≤18)	336	17.03	62	38.51	13	30.95	9	50.00	< 0.001	chi-square
Interpersonal-level factors										
ACE	1.37	1.80	1.48	1.87	1.63	1.91	1.20	2.60	0.730	ANOVA
Social support	36.84	5.07	37.78	4.79	36.43	5.17	37.33	4.78	0.161	ANOVA
Parental substance use	N	%	N	%	N	%	N	%		
Alcohol	1215	59.85	111	66.87	31	73.81	12	63.16	0.097	chi-square
Tobacco	682	33.60	59	35.54	15	35.71	10	52.63	0.345	chi-square
Marijuana	141	6.95	16	9.64	5	11.90	2	10.53	0.220	Fisher's
Community-level factors										
Type of institution									0.008	chi-square
Private	826	40.69	91	54.82	19	45.24	5	26.32		
HBCU	258	12.71	11	6.63	3	7.14	1	5.26		
Public	566	27.88	39	23.49	9	21.43	6	31.58		
Technical college	380	18.72	25	15.06	11	26.19	7	36.84		
Rural (ref = urban)	1222	60.02	118	71.08	25	59.52	8	42.11	0.015	chi-square

Note. Those who reported binge-drinking at age 18 (N = 23) were excluded from the GMM due to sparsity of data.

4.2. Conclusions

Distinct but overlapping factors were associated with greater risk for alcohol use, binge-drinking, and related longitudinal trajectories among college students. Intervention efforts should be informed by characteristics of those most likely to use and escalate use (e.g., men, higher SES); prevention efforts might also consider these characteristics, as well as earlier alcohol use and parental influences. Given that private college students demonstrated greater risk, further research is needed to understand the characteristics of college settings that might influence the use and progression of alcohol use.

5. Author disclosures

5.1. Role of funding source

5.2. Contributors

Berg, Haardörfer, and Windle designed the study and wrote the protocol. Haardörfer led the analysis and the writing of the methods and results sections. Berg wrote the first draft of the manuscript, with Windle, Haardörfer, and Fairman contributing additional components to the manuscript. All authors contributed to and have approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2020.106619.

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