

# Drinking beyond the binge threshold in a clinical sample of adolescents

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## ABSTRACT

**Background and aims** Nearly all the research conducted on high-intensity drinking has focused on college and school-based samples, with recent calls for research to understand this risky drinking pattern in non-school-based samples and across time. This study aimed to characterize predictors and consequences of non-binge drinking, age- and gender-adjusted binge drinking (level I) and drinking at levels representing two or more times (level II) and three or more times the level I binge threshold (level III) in a clinical sample of adolescents followed into young adulthood. **Design** Cross-sectional associations between non-binge drinking, binge levels, and negative alcohol-related consequences were examined during adolescence; prospective analyses tested whether adolescent non-binge drinking and binge levels predicted alcohol use disorder (AUD) symptoms in young adulthood and whether changes in drinking motives over time were associated with binge levels in young adulthood. **Setting** US clinical settings. **Participants** A total of 432 adolescents (aged 12–18 years) with alcohol-related problems followed into young adulthood (aged 19–25 years). **Measurements** Life-time drinking history, Structured Clinical Interview for DSM AUDs, and Inventory of Drinking Situations. **Findings** Results were generally consistent with a distinction between binge level I versus levels II–III on various negative alcohol-related consequences in adolescence ( $P_s < 0.05$ ) that were maintained in young adulthood ( $P_s < 0.01$ ). The maintenance of relatively high endorsement of enhancement and social motives over time was associated with binge levels II–III in young adulthood ( $P_s < 0.001$ ); decreases in coping motives were associated with less risky drinking in adulthood ( $P = 0.003$ ). **Conclusions** Among US adolescents with alcohol-related problems who were followed-up in young adulthood (aged 19–25 years), standard threshold binge drinking (five or more drinks per occasion; level I) was generally associated with fewer alcohol-related consequences and problem behaviors than binge drinking at two or more times (level II) or three or more times (level III) the standard binge threshold.

**Keywords** Adolescents, alcohol use disorder, binge drinking, drinking motives, high-intensity drinking, longitudinal methods.

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## INTRODUCTION

Binge drinking has been commonly defined in national surveys as consuming five or more standard drinks during a single occasion [1,2], and by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) as five or more/four or more drinks for males/females within a time-frame that produces blood alcohol concentrations (BACs) of approximately 0.08 g/dL [3]. These binge drinking levels are highly prevalent in adolescents in the United States [1,4–7], Europe [8–10], New Zealand [11], and Australia [12].

There is growing interest in examining adolescent alcohol use that involves double or triple the 'standard' binge threshold of five or more drinks per occasion [13–15]. Hingson, Zha and White [16] use the terms binge levels I (standard threshold), II (two or more times the standard threshold) and III (three or more times the standard threshold) to describe these patterns of heavy drinking. Binge levels II–III can increase BACs far beyond the 0.08% legal limit for driving [16,17]. Consumption of these very large quantities of alcohol is also common among adolescent drinkers [18–21].

While binge drinking thresholds are somewhat arbitrary, research has demonstrated the utility of a categorical binge drinking variable of five or more drinks in predicting adverse drinking-related outcomes [22]. Binge drinking status also aids in the identification and communication of a particularly risky drinking pattern [14,15]. Notably, adolescents who drink well beyond the traditional five-drink cut-off may be particularly vulnerable to significant negative alcohol-related consequences (e.g. blackouts, arrests, risky sexual behaviors) compared to adolescent level I binge drinkers [13,17]. Further, while rates of adolescent standard binge drinking have declined over the past 10 years [23], the prevalence of level III binge drinking has remained stable, suggesting that this type of episodic high quantity consumption may be less affected by changing norms and more entrenched in a specific high-risk adolescent subculture [20], such as youth referred for clinical care.

Nearly all the research conducted on levels II–III binge drinking has focused on college and school-based samples, with recent calls for research to understand this risky drinking pattern in non-school-based samples [15,17] and across time [16,24]. Following recommendations made by the NIAAA High Intensity Drinking Working Group Meeting [14], we examined a sample of 432 clinical adolescents to compare non-binge drinking and binge levels I–III on drinking frequency and intensity, drug use, and negative alcohol-related consequences in adolescence and young adulthood. To our knowledge, this is the first study to do so in a sample of clinical adolescents. As an important innovation, we used age- and gender-adjusted binge drinking definitions in younger adolescents to avoid underestimation of BACs produced when using adult-based definitions of binge drinking [25,26].

During adolescence (ages 12–18 years), we hypothesized that we would find differences among successive binge levels, such that we would observe increases in drinking frequency and intensity, proportion of drinking episodes leading to intoxication, alcohol-related problems, and drug use with increasing binge levels. These findings would be in line with Problem Behavior Theory [27], which describes a syndrome of adolescent problem behavior in which heavier drinking patterns increase the risk of engaging in other problem behaviors. Longitudinally, we hypothesized that increasing binge levels observed during adolescence would predict alcohol use disorder (AUD) symptoms in young adulthood. While studies have linked adolescent binge drinking as traditionally defined to increased rates of young adult AUD disorders (e.g. [28–33]) and alcohol problems [34], we are unaware of prior studies examining the association between different adolescent binge levels and young adult AUD outcomes.

We also examined what motivates drinking at binge levels II–III. We focused on the purposes that drinking serves, as this will likely be useful for identifying alternative reinforcement

options to target in treatment and prevention programs [14]. According to motivational theories of alcohol use [35,36], individuals make choices to drink in order to attain certain valued outcomes [37]. Although a good deal of research has examined motives for binge drinking as traditionally defined (i.e. binge level I), little is known about what motivates levels II–III binge drinking. Two recent longitudinal studies in non-clinical samples highlight the importance of particular motives in potentially driving binge drinking beyond standard thresholds. Patrick and colleagues [38], using a nationally representative sample of US high school students, showed that enhancement and coping motives demonstrated stable positive associations with binge drinking and drinking at two times the binge threshold (10+ drinks) among young adult drinkers who provided data at age 18 and in young adulthood (until age 26). However, differences in these motives did not distinguish high-intensity (10+ drinks) from lower-intensity (five to nine drinks) binge drinkers. White and colleagues [39], using a large sample of college students, examined drinking motives across three levels of drinking: extreme drinkers (eight or more/10 or more drinks for women/men), binge drinkers (four to seven/five to nine drinks for women/men) and non-binge drinkers. Social, enhancement, and coping motives were successively greater for each drinking status. Further, using change scores for drinking motives over 6 months, they showed that increases in social and enhancement motives predicted the emergence of extreme drinking and decreases in enhancement and coping motives predicted the cessation of extreme drinking [39]. The present study will advance this work by systematically comparing three binge levels, defined using age- and gender-adjusted drinking thresholds, in adolescents.

We also extend these prior findings to a clinical sample. We examined cross-sectional associations (during the adolescent baseline session) between motives for drinking and binge drinking status, and we leveraged a rich prospective sample to determine whether changes in binge drinking status over a longer time-frame, from adolescence (i.e. ages 12–18 years) to young adulthood (i.e. ages 19–25 years), were associated with changes in motives for drinking, similar to White *et al.* [39]. At baseline, we expected to find differences among successive binge drinking levels on motive scores. We hypothesized that increased endorsement of drinking to enhance positive emotions and pleasant times with others from adolescence to young adulthood would be associated with binge levels II–III, and decreased endorsement of drinking to alleviate negative emotions would be associated with less risky drinking.

## METHODS

### Participants

Participants were 432 adolescents with alcohol-related problems (61.1% male), first seen between the ages of

12–18 years [mean = 16.5 years, standard deviation (SD) = 1.4 years], participating in a longitudinal study. Individuals were recruited from the following clinical programs in Pittsburgh: hospital-based out-patient (15.3%) and in-patient (25.5%) addictions and psychiatric programs, free-standing addictions programs (47.2%) and residential programs for youth (12%). A recruiter presented study information to families or therapists who obtained consent to contact the family. Of the participants who provided consent to contact, 73% completed the baseline assessment. These individuals did not differ in demographic characteristics to those who did not participate [40]. Participants were eligible if they were aged 12–18 years. Exclusion criteria included psychosis, intellectual disability, and a history of serious neurological disturbance. For the current study, participants were required to have begun regular drinking (i.e. drinking at least once/month for at least 6 months) before age 18 and to have met criteria for at least one DSM-5 AUD symptom during the ages of 12–18. Participants identified as Caucasian (83.1%), African American (16.4%) and other (< 1%) racial/ethnicity. This sample is similar in demographic and clinical characteristics to adolescents in nationally representative addiction treatment samples (e.g. [41,42]). Additional details can be found in prior publications (e.g. [43–45]).

### Procedures

This study was approved by the University of Pittsburgh institutional review board (IRB). Participants were initially assessed between the ages of 12 and 18 (May 1991–October 2000), when they completed baseline assessments characterizing life-time alcohol and drug use, substance use disorders and other psychopathology, health status, and other related variables. Similar measures were collected at follow-up assessments at 1, 3 and 5 years post-baseline, with an additional young adult follow-up covering the period to age 25 years. Each follow-up covered the interval since the last completed assessment. To characterize binge drinking status during adolescence, we used all available assessments conducted through age 18 years. Additionally, we used all available follow-up assessments from ages 19–25 years to characterize binge drinking and alcohol problems during young adulthood. Of the baseline sample, 97.5% participated in one or more follow-up, 82.9% in two or more follow-ups and 62.8% in three or more follow-ups. Young adult data from one or both of the age ranges (i.e. 19–21 and 22–25 years) were available from 94.7% of the baseline sample (93.1% for ages 19–21 and 80.3% for ages 22–25). Males and lower socioeconomic status (SES) participants, as assessed by the

Hollingshead Two-Factor Index [46], were less likely to complete follow-ups (see Supporting information).

### Measures

#### *Demographics*

Age, gender, race/ethnicity and SES [46] were assessed. The following measures were collected at baseline and follow-up.

#### *Drinking motives*

Inventory of Drinking Situations (IDS) questionnaire (100 items) assessed the antecedents of drinking [47], which are conceptually similar to drinking motives [35,48,49]. Participants rated the extent to which they 'drank heavily' in a range of situations in the past year. The IDS is a reliable and valid measure among adolescents [50]. We analyzed the following three subscales: pleasant emotions (10 items;  $\alpha = 0.91$ ), pleasant times with others (10 items;  $\alpha = 0.90$ ), and unpleasant emotions (20 items;  $\alpha = 0.97$ ). These subscales assessed enhancement, social, and coping motives, respectively (see [35,48,49]). All participants completed the IDS at baseline, and 360 participants (83.3%) completed the IDS at least once in young adulthood (ages 19–25). Analyses focused on drinkers at baseline and young adult follow-up ( $n = 270$ ). When multiple IDS scores were available, we used the oldest age (mean age = 22.8, SD = 2.0).<sup>1</sup>

#### *Alcohol use*

Alcohol consumption was measured by the semi-structured Lifetime Drinking History (LDH) interview [51], adapted for adolescents [52], which demonstrated good reliability and validity [52,53]. Alcohol quantities were assessed using standard drink amounts (i.e. 12 oz beer, 5 oz wine, 1.5 oz spirits, and 8–9 oz malt liquor). At baseline, alcohol use was recalled for each year of age since the start of regular drinking (i.e. average days/month, average quantity consumed per occasion, maximum number of drinks in one occasion, frequency of drinking episodes resulting in intoxication) using the time-line follow-back method (TLFB [54]). These questions were repeated for each subsequent year until the interview, such that for some participants the reference period was more than 1 year.<sup>2</sup> For follow-up assessments, alcohol use was recalled for each year of age since the last completed assessment.

#### *Other drug use*

The LDH [51] was adapted to assess drug use history (see [55]) and was administered similarly to the LDH above.

<sup>1</sup>Results were unchanged, however, when using mean IDS scores across young adult assessment time-points.

<sup>2</sup>If a participant reported never consuming more than their average quantity of alcohol, their average quantity was also used as a maximum quantity variable.

Here, participants reported nicotine and cannabis use frequency (days/month) and the number of illicit drugs used (i.e. cocaine/crack, stimulants, sedatives/anxiolytics, opioids, hallucinogens and inhalants).

#### *Adolescent and young adult DSM-5 AUD symptoms*

Adolescent and young adult AUD symptoms were collected with a modified version of the Structured Clinical Interview for DSM-IV (SCID) [53,55,56], which has shown good reliability [56]. The SCID included exploratory diagnostic items of alcohol craving (added as a diagnostic criterion in DSM-5) and assessment of alcohol-related problems, including risky sex, a drop in school grades, blackouts, and passing out, which were averaged to create a composite score for analyses [53]. Ages of symptom onset and offset were coded to generate past-year symptom count data.

#### *Calculation of binge drinking levels*

Reports of alcohol use quantity/occasion and frequency from the LDH interview [51] were used to assign participants to binge drinking categories. To maximize clinical significance and undue influence of rare alcohol use patterns, participants had to report drinking a threshold quantity/occasion on an average of at least once/month during a given year for each age. If the 'maximum number of drinks in one occasion' did not meet this threshold, the 'average quantity consumed per occasion' was used to categorize binge drinking status. If both were less than once/month, adolescents were assigned to the non-binge drinking category. Binge level I thresholds for ages 12–17 were defined using Donovan's [26] guidelines (Table 1); the NIAAA adult binge drinking definitions [3] were used for participants aged 18 and older. Binge level II was defined as two or more times the level I threshold and level III was defined as three or more times the level I threshold.

#### **Statistical analysis**

Binge levels (categorical variables) were presented as percentages for each age during adolescence (i.e. ages 12–18). Multinomial logistic regression was used to assess sex differences in binge level membership at each age during adolescence. One-way ANOVAs (using listwise deletion) were conducted to test for (1) cross-sectional differences in key variables (e.g. AUD symptoms, drug use) across binge

levels at each age during adolescence (a Games–Howell *post-hoc* test was used to control for multiple comparisons with unequal sample sizes [57]), (2) longitudinal associations between binge levels at each adolescent age and AUD symptom counts in young adulthood, (3) cross-sectional associations during the adolescent baseline session between specific motives for drinking and binge levels and (4) longitudinal associations between changes in drinking motives from adolescence to young adulthood and changes in binge drinking status during this time (controlling for ages at baseline and follow-up). Changes in motives from adolescence to young adulthood were computed via change scores (young adult minus adolescent score) (see [39]). Changes in binge drinking levels were defined by coding participants into one of the following four categories: (1) adolescent non-binge and level I binge drinkers who became levels II–III binge drinkers (increase), (2) those who stayed at levels II–III from adolescence to young adulthood (high maintain), (3) those who reduced their drinking (i.e. from levels II–III to non-binge and level I; reduce) and (4) those who remained non-binge and level I from adolescence to young adulthood (low maintain). We then compared increase/high maintain adolescents to reduce/low maintain adolescents on drinking motives. Finally, we reran these analyses only for those individuals who increased or decreased in binge drinking levels (omitting the maintain groups). For all analyses, the threshold value (i.e. alpha level) used to judge whether test statistics were statistically significant was 0.05. The analysis was not pre-registered and the results should be considered exploratory.

## **RESULTS**

#### *Percentages of adolescents in each binge drinking level*

Figure 1 shows the number/percentage of drinkers in each binge level across ages 12–18. As shown, at all ages, the majority (73–90%) of adolescents reported some type of binge drinking at least monthly, with a substantial percentage (40–60%) reporting binge levels II–III. While the percentage of youth reporting binge level I remained stable across ages 12–18, the percentages of drinkers in binge levels II–III were more variable. There were no gender differences in binge category membership for ages 12, 13, 15, 16, and 17 ( $P_s > 0.22$ ). At age 14, there were fewer binge level I females [odds ratio (OR) = 0.41, 95% confidence interval (CI) = 0.21, 0.81]. At age 18, there were more female non-binge drinkers (OR = 2.6, 95% CI = 1.3, 5.1).

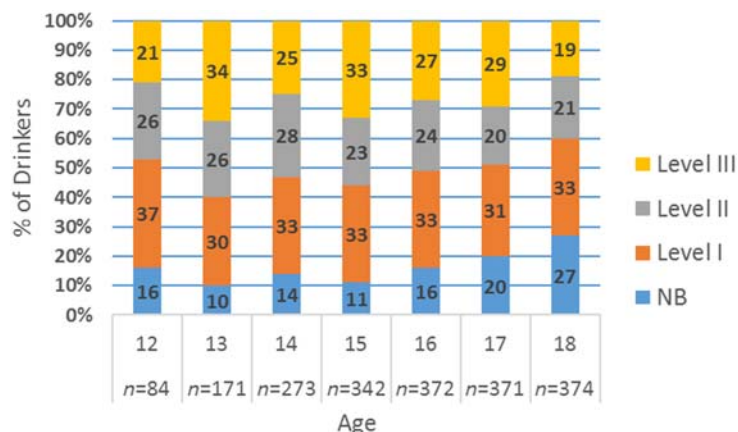
#### *Correlates of binge drinking levels in adolescence*

Table 2 depicts descriptive statistics for key variables across non-binge and binge levels for adolescents ages 12–18.<sup>3</sup> As

<sup>3</sup>Results were unchanged when controlling for gender in these analyses.

**Table 1** Level I binge drinking definitions in adolescents.

<i>Age (years)</i>	<i>Males</i>	<i>Females</i>
12–13	≥ 3 standard drinks	≥ 3 standard drinks
14–15	≥ 4 standard drinks	≥ 3 standard drinks
16–17	≥ 5 standard drinks	≥ 3 standard drinks
18	≥ 5 standard drinks	≥ 4 standard drinks



Note: NB=Non-binge drinker. Sample sizes vary across ages due to individual differences in the age of onset of drinking and the timing of assessments.

**Figure 1** Percentage of drinkers in each binge drinking level by age. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

shown, maximum quantities of alcohol consumed during one occasion significantly increased among successive binge levels (these quantities were used to assign adolescents to levels). Beginning at age 14, drinking days/month significantly increased throughout successive levels, with non-binge drinkers reporting the fewest drinking days and level III binge drinkers reporting the most. Binge drinkers (levels I–III) tended to report becoming intoxicated during more than 90% of drinking episodes, a substantially larger percentage compared to non-binge drinkers (~35%). Concurrent AUD symptoms significantly increased among successive binge levels beginning at age 14, although non-binge and level I binge drinkers met criteria for a similar number of symptoms at ages 14–15. Binge levels at ages 12–13 were not predictive of alcohol-related problems but became more predictive over time such that by age 17, non-binge drinkers reported significantly fewer problems than binge level I, who reported significantly fewer problems than binge levels II–III. A more complex pattern emerged for marijuana use but, generally, non-binge drinkers reported a similar number of marijuana use days as binge level I. Non-binge drinkers generally tended to report fewer marijuana use days than binge levels II–III. Nicotine use did not differ across binge levels, but this may be due to a ceiling effect (beginning at age 17, all individuals were smoking nearly every day of the month). Non-binge and level I binge drinkers generally reported using a similar number of illicit drugs, values that were significantly lower than binge levels II–III.

#### *Binge drinking levels as predictors of AUD symptoms in young adulthood*

At ages 19–21 and 22–25, 72.7% and 63.2% of this clinical sample had at least one AUD symptom, respectively. Binge drinking levels at earlier ages (i.e. aged 12–16 years) were not predictive of yearly maximum AUD symptoms

(AUD<sub>max</sub>) during the ages of 19–21 and 22–25 (all  $P$ s > 0.05), but closer to young adulthood, binge status became more predictive (see Fig. 2). At age 17, level I binge drinkers went on to have significantly fewer AUD<sub>max</sub> at ages 19–21 than level III ( $P = 0.010$ ); level II had fewer than level III ( $P = 0.007$ ). Non-binge drinkers at age 17 went on to have significantly fewer AUD<sub>max</sub> at ages 22–25 than level III binge drinkers ( $P < 0.001$ ). At age 18, non-binge drinkers went on to have significantly fewer AUD<sub>max</sub> at ages 19–21 than binge levels I ( $P = 0.043$ ), II ( $P < 0.001$ ) and III ( $P < 0.001$ ); level I binge drinkers had fewer symptoms than levels II ( $P = 0.028$ ) and III ( $P < 0.001$ ); and level II binge drinkers had fewer symptoms than level III ( $P = 0.022$ ). Non-binge drinkers at age 18 went on to have significantly fewer AUD<sub>max</sub> at ages 22–25 than level III binge drinkers ( $P = 0.001$ ); level I binge drinkers had fewer symptoms than level III binge drinkers ( $P = 0.011$ ). These associations, however, became non-significant after controlling for AUD symptom counts at ages 17–18 (all  $P$ s > 0.05).

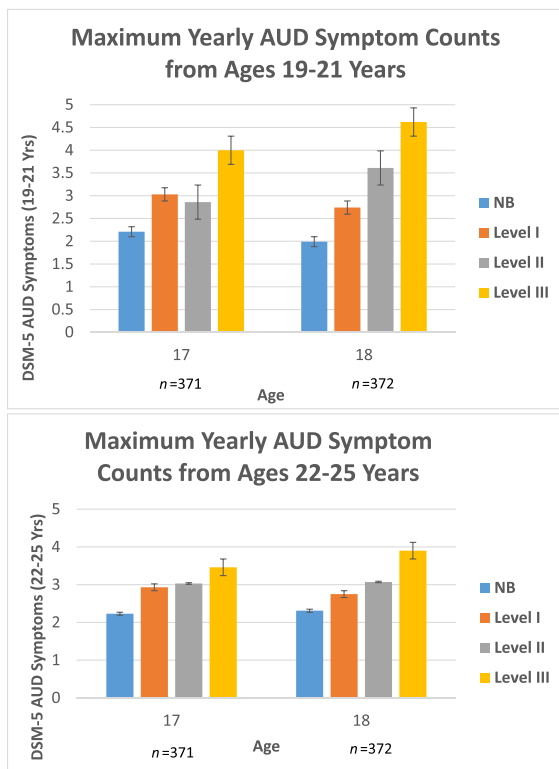
#### *Drinking motives and binge drinking levels*

Table 3 shows cross-sectional associations (during the adolescent baseline session) between specific motives for drinking (i.e. IDS scores) and binge drinking status. As shown, level III binge drinkers reported higher values than non-binge drinkers and level I binge drinkers for drinking during unpleasant and pleasant emotions; levels I–III binge drinkers reported higher values than non-binge drinkers for drinking during pleasant times with others. Table 4 indicates whether changes in drinking motives from adolescence to young adulthood were associated with changes in binge drinking status over this time. As depicted, results indicate that mean decreases in drinking during unpleasant emotions were significantly larger for reduce and low maintain drinkers compared to increase and high maintain

**Table 2** Descriptive statistics (mean, SE) of key variables across binge drinking levels.

Age (years)	Binge group category	Maximum drinks per occasion*	Drinking frequency (days/month)	Proportion drinking episodes intoxicated	AUD symptoms (concurrent)	Alcohol-related problems	Marijuana frequency (days/month)	Nicotine frequency (days/month)	Number of illicit drugs used
12 n = 84	NB	3.35 <sup>a</sup> (0.42)	2.36 <sup>a</sup> (0.61)	0.36 <sup>a</sup> (0.13)	0.69 <sup>ab</sup> (0.50)	0.31 <sup>ab</sup> (0.21)	2.72 <sup>a</sup> (1.54)	16.15 <sup>a</sup> (4.32)	0.54 <sup>a</sup> (0.14)
	LI	5.46 <sup>b</sup> (0.65)	4.33 <sup>a</sup> (0.64)	0.83 <sup>b</sup> (0.06)	0.52 <sup>a</sup> (0.19)	0.06 <sup>a</sup> (0.06)	5.78 <sup>ab</sup> (1.47)	17.55 <sup>a</sup> (2.68)	0.68 <sup>a</sup> (0.11)
	LII	8.20 <sup>c</sup> (0.62)	5.03 <sup>ab</sup> (0.94)	0.89 <sup>b</sup> (0.06)	1.45 <sup>ab</sup> (0.38)	0.36 <sup>ab</sup> (0.14)	8.78 <sup>ab</sup> (2.31)	16.23 <sup>a</sup> (3.04)	0.91 <sup>ab</sup> (0.19)
13 n = 171	LIII	13.33 <sup>d</sup> (0.80)	9.36 <sup>c</sup> (1.25)	0.94 <sup>b</sup> (0.05)	2.72 <sup>b</sup> (0.62)	0.78 <sup>b</sup> (0.21)	14.32 <sup>b</sup> (3.12)	18.00 <sup>a</sup> (3.36)	1.56 <sup>b</sup> (0.27)
	NB	4.93 <sup>a</sup> (0.99)	2.05 <sup>a</sup> (0.41)	0.55 <sup>a</sup> (0.12)	0.24 <sup>a</sup> (0.14)	0.12 <sup>a</sup> (0.12)	4.18 <sup>a</sup> (1.88)	20.60 <sup>a</sup> (3.37)	0.53 <sup>a</sup> (0.13)
	LI	7.21 <sup>ab</sup> (0.60)	5.19 <sup>b</sup> (0.67)	0.91 <sup>b</sup> (0.03)	1.15 <sup>b</sup> (0.20)	0.21 <sup>a</sup> (0.06)	8.56 <sup>ab</sup> (1.33)	23.31 <sup>a</sup> (1.68)	1.15 <sup>b</sup> (0.10)
14 n = 273	LII	9.62 <sup>c</sup> (0.59)	7.73 <sup>bc</sup> (0.96)	0.93 <sup>b</sup> (0.03)	1.95 <sup>bc</sup> (0.38)	0.52 <sup>a</sup> (0.13)	9.28 <sup>ab</sup> (1.71)	19.18 <sup>a</sup> (2.13)	1.09 <sup>b</sup> (0.12)
	LIII	13.90 <sup>d</sup> (0.41)	10.54 <sup>c</sup> (1.01)	0.89 <sup>b</sup> (0.03)	2.33 <sup>c</sup> (0.33)	0.52 <sup>a</sup> (0.11)	11.02 <sup>b</sup> (1.39)	22.47 <sup>a</sup> (1.67)	1.34 <sup>b</sup> (0.12)
	NB	5.10 <sup>a</sup> (0.73)	1.87 <sup>a</sup> (0.40)	0.41 <sup>a</sup> (0.08)	0.81 <sup>a</sup> (0.23)	0.24 <sup>a</sup> (0.09)	9.00 <sup>ab</sup> (1.92)	19.24 <sup>a</sup> (2.28)	0.89 <sup>a</sup> (0.12)
15 n = 342	LI	7.31 <sup>b</sup> (0.37)	4.92 <sup>b</sup> (0.48)	0.84 <sup>b</sup> (0.04)	1.42 <sup>ab</sup> (0.17)	0.35 <sup>a</sup> (0.07)	9.33 <sup>a</sup> (1.14)	21.23 <sup>a</sup> (1.39)	1.14 <sup>a</sup> (0.10)
	LII	11.84 <sup>c</sup> (0.49)	7.50 <sup>c</sup> (0.57)	0.89 <sup>b</sup> (0.03)	2.36 <sup>c</sup> (0.25)	0.73 <sup>b</sup> (0.11)	12.42 <sup>ab</sup> (1.21)	23.15 <sup>a</sup> (1.38)	1.68 <sup>b</sup> (0.14)
	LIII	15.16 <sup>d</sup> (0.38)	12.34 <sup>d</sup> (0.96)	0.93 <sup>b</sup> (0.02)	4.48 <sup>d</sup> (0.29)	1.04 <sup>b</sup> (0.13)	15.05 <sup>b</sup> (1.43)	23.76 <sup>a</sup> (1.45)	1.70 <sup>b</sup> (0.13)
16 n = 372	NB	5.95 <sup>a</sup> (0.78)	1.83 <sup>a</sup> (0.39)	0.33 <sup>a</sup> (0.08)	1.34 <sup>a</sup> (0.38)	0.32 <sup>a</sup> (0.13)	12.16 <sup>ab</sup> (2.09)	18.37 <sup>a</sup> (2.37)	1.03 <sup>a</sup> (0.13)
	LI	8.24 <sup>b</sup> (0.38)	4.44 <sup>b</sup> (0.29)	0.88 <sup>b</sup> (0.03)	1.87 <sup>ab</sup> (0.18)	0.51 <sup>ab</sup> (0.07)	10.86 <sup>c</sup> (1.01)	21.20 <sup>a</sup> (1.26)	1.28 <sup>a</sup> (0.08)
	LII	12.14 <sup>c</sup> (0.45)	7.88 <sup>c</sup> (0.70)	0.92 <sup>b</sup> (0.02)	3.38 <sup>c</sup> (0.30)	0.80 <sup>b</sup> (0.09)	15.93 <sup>b</sup> (1.21)	25.09 <sup>a</sup> (1.20)	1.74 <sup>b</sup> (0.15)
17 n = 371	LIII	15.53 <sup>d</sup> (0.28)	14.26 <sup>d</sup> (0.84)	0.94 <sup>b</sup> (0.02)	4.65 <sup>d</sup> (0.27)	1.19 <sup>c</sup> (0.11)	16.98 <sup>b</sup> (1.08)	24.35 <sup>a</sup> (1.08)	1.99 <sup>b</sup> (0.13)
	NB	7.06 <sup>a</sup> (0.68)	2.18 <sup>a</sup> (0.38)	0.24 <sup>a</sup> (0.05)	1.31 <sup>a</sup> (0.26)	0.27 <sup>a</sup> (0.08)	6.69 <sup>a</sup> (1.39)	20.79 <sup>a</sup> (1.77)	1.14 <sup>a</sup> (0.14)
	LI	9.84 <sup>b</sup> (0.40)	6.45 <sup>b</sup> (0.49)	0.88 <sup>b</sup> (0.03)	2.45 <sup>b</sup> (0.22)	0.46 <sup>a</sup> (0.07)	13.62 <sup>b</sup> (1.03)	23.99 <sup>a</sup> (1.07)	1.59 <sup>a</sup> (0.11)
18 n = 374	LII	12.00 <sup>c</sup> (0.38)	9.99 <sup>c</sup> (0.77)	0.92 <sup>bc</sup> (0.02)	4.13 <sup>c</sup> (0.27)	1.08 <sup>b</sup> (0.11)	15.74 <sup>bc</sup> (1.18)	25.15 <sup>a</sup> (1.16)	2.27 <sup>b</sup> (0.15)
	LIII	16.35 <sup>d</sup> (0.25)	14.88 <sup>d</sup> (0.90)	0.95 <sup>c</sup> (0.02)	5.18 <sup>d</sup> (0.28)	1.22 <sup>b</sup> (0.11)	17.72 <sup>c</sup> (1.15)	24.96 <sup>a</sup> (1.09)	2.24 <sup>b</sup> (0.14)
	NB	6.58 <sup>a</sup> (0.66)	1.79 <sup>a</sup> (0.33)	0.24 <sup>a</sup> (0.05)	1.17 <sup>a</sup> (0.19)	0.16 <sup>a</sup> (0.06)	9.22 <sup>a</sup> (1.39)	24.67 <sup>a</sup> (1.31)	1.36 <sup>a</sup> (0.16)
19 n = 371	LI	9.51 <sup>b</sup> (0.44)	6.39 <sup>b</sup> (0.54)	0.90 <sup>b</sup> (0.03)	2.21 <sup>b</sup> (0.20)	0.51 <sup>b</sup> (0.07)	12.52 <sup>ab</sup> (1.09)	24.04 <sup>a</sup> (1.11)	1.70 <sup>a</sup> (0.13)
	LII	12.72 <sup>c</sup> (0.45)	8.69 <sup>b</sup> (0.81)	0.92 <sup>b</sup> (0.03)	3.55 <sup>c</sup> (0.28)	0.82 <sup>bc</sup> (0.11)	14.72 <sup>b</sup> (1.41)	24.48 <sup>a</sup> (1.35)	2.07 <sup>b</sup> (0.17)
	LIII	16.01 <sup>d</sup> (0.26)	14.74 <sup>c</sup> (0.90)	0.92 <sup>b</sup> (0.02)	5.32 <sup>d</sup> (0.28)	1.17 <sup>c</sup> (0.11)	16.21 <sup>b</sup> (1.19)	25.67 <sup>a</sup> (0.98)	2.23 <sup>b</sup> (0.15)
20 n = 374	NB	5.27 <sup>a</sup> (0.43)	3.04 <sup>a</sup> (0.56)	0.32 <sup>a</sup> (0.05)	0.83 <sup>a</sup> (0.17)	0.12 <sup>a</sup> (0.04)	9.92 <sup>a</sup> (1.27)	24.71 <sup>a</sup> (1.12)	1.22 <sup>a</sup> (0.13)
	LI	9.97 <sup>b</sup> (0.41)	7.25 <sup>b</sup> (0.58)	0.98 <sup>b</sup> (0.01)	2.24 <sup>b</sup> (0.21)	0.33 <sup>b</sup> (0.06)	12.49 <sup>ab</sup> (1.13)	25.68 <sup>a</sup> (0.95)	1.64 <sup>a</sup> (0.11)
	LII	13.48 <sup>c</sup> (0.40)	11.78 <sup>c</sup> (0.94)	0.96 <sup>bc</sup> (0.02)	3.77 <sup>c</sup> (0.29)	0.79 <sup>c</sup> (0.11)	15.10 <sup>b</sup> (1.42)	27.12 <sup>a</sup> (0.96)	2.37 <sup>b</sup> (0.18)
21 n = 371	LIII	17.05 <sup>d</sup> (0.20)	17.55 <sup>d</sup> (1.10)	0.89 <sup>c</sup> (0.03)	5.10 <sup>d</sup> (0.27)	1.11 <sup>c</sup> (0.13)	16.21 <sup>b</sup> (1.43)	24.86 <sup>a</sup> (1.28)	2.17 <sup>b</sup> (0.17)

NB = non-binge drinker; LI = level I; LII = level II; LIII = level III; AUD = alcohol use disorder; SE = standard error. \*At least once per month in the past year. Alcohol-related problems = composite measure of risky sex, a drop in school grades, blackouts and passing out. Within each age (for each variable), groups with different superscripts differed significantly ( $P < 0.05$ ).



Note. Error bars represent standard errors. NB=Non-binge drinker.

**Figure 2** Binge drinking levels at ages 17 and 18 as predictors of alcohol use disorder (AUD) symptoms in young adulthood. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

drinkers—that is, greater reduction in risky drinking was associated with greater reduction in coping motives. Mean decreases in drinking during pleasant emotions and pleasant times with others were also significantly larger for reduce and low maintain drinkers compared to increase or high maintain drinkers, the latter of whom maintained their relatively high endorsement of drinking during pleasant emotions and pleasant times with others over time.<sup>4</sup>

## DISCUSSION

This paper is the first, to our knowledge, to detail predictors and consequences of binge levels I–III in a clinical sample of adolescents with alcohol problems followed into young adulthood. Adjusting binge drinking definitions to account for age-related differences in body size is a methodological advance that may reduce underestimation of heavy drinking in adolescents. A large majority of clinical youth (73–90%) reported engaging in some type of binge drinking in adolescence, with a substantial proportion (40–60%) engaging in binge levels II or III. These percentages are approximately 5–10 times larger than estimates of various binge drinking categories in US high school students

[1,20]. The percentages of non-binge drinkers increased somewhat with age, which could reflect prior treatment status or may be an artifact of using different binge drinking definitions (i.e. more drinks were required to attain binge drinking status as youth got older). Notably, 10–27% were non-binge drinkers, suggesting that negative alcohol-related consequences were occurring for those who failed to reach the standard binge drinking threshold. These results serve as a reminder that regular drinking during adolescence (regardless of whether the binge threshold is met) is unhealthy, and most likely warrants intervention.

Our analyses indicate that it is clinically useful to distinguish binge drinking (level I) from drinking at two or more times (level II) and three or more times (level III) the level I binge threshold, given greater negative consequences associated with binge levels II–III relative to level I. Specifically, concurrent AUD symptoms, marijuana and illicit drug use, and alcohol-related problems (i.e. risky sex, a drop in school grades, blackouts, and passing out) generally increased as severity in binge level increased, with non-binge and level I binge drinkers generally reporting fewer consequences/AUD symptoms than participants in binge levels II–III. While all levels of binge drinking warrant intervention, levels II–III appear to require more intensive intervention given the pronounced increase in negative alcohol-related consequences at these levels (see also [13,17,22,58] for similar findings in non-clinical samples). Results were generally consistent with Problem Behavior Theory [27], and suggest that clinical youth who engage in drinking beyond the binge threshold would probably benefit from interventions that target more than one problem behavior.

While prior studies have linked ‘standard binge drinking’ to increased rates of young adult AUD disorders (e.g. [29]), we believe this is the first study to test whether binge levels II–III in adolescents provide additional information (beyond binge level I) in the prediction of future AUD symptoms. As youth grew closer to young adulthood (i.e. at ages 17–18), binge status became predictive of maximum young adult AUD symptoms during ages of 19–21 and 22–25. Findings were also generally consistent with the notion that binge levels II–III provide additional predictive information, with levels I–II binge drinkers having significantly fewer maximum yearly AUD symptoms throughout young adulthood than level III binge drinkers. However, these associations became non-significant after controlling for AUD symptom counts at ages 17–18, suggesting that binge levels may not account for unique variance in the development of AUD symptoms after controlling for earlier AUD symptoms.

<sup>4</sup>This pattern of results remained the same when restricting analyses to only those individuals who increased or decreased in binge drinking levels, rather than also including those who maintained their binge drinking levels over time.

**Table 3** IDS scores (mean, SE) across binge drinking levels at baseline.

Binge group category	IDS unpleasant emotions	IDS positive emotions	IDS pleasant times with others
NB ( <i>n</i> = 54)	32.57 (3.70) <sup>a</sup>	41.13 (3.43) <sup>a</sup>	41.22 (3.34) <sup>a</sup>
LI ( <i>n</i> = 91)	33.14 (2.85) <sup>a</sup>	47.68 (2.64) <sup>a</sup>	50.10 (2.57) <sup>b</sup>
LII ( <i>n</i> = 79)	37.79 (3.06) <sup>a,b</sup>	49.14 (2.83) <sup>a,b</sup>	50.31 (2.76) <sup>b</sup>
LIII ( <i>n</i> = 120)	45.20 (2.49) <sup>b</sup>	54.94 (2.30) <sup>b</sup>	54.89 (2.24) <sup>b</sup>

IDS = Inventory of Drinking Situations; NB = non-binge drinker; LI = level I; LII = level II; LIII = level III; SE = standard error. Groups with different superscripts differed significantly ( $p < 0.05$ ).

**Table 4** Longitudinal associations between IDS change scores and binge drinking status changes from adolescence to young adulthood.

Binge group category	IDS unpleasant emotions change score	IDS positive emotions change score	IDS pleasant times with others change score
Reduce/low maintain ( <i>n</i> = 109; <i>n</i> = 49)	-20.26 (2.34)	-12.12 (2.16)	-13.01 (2.17)
Increase/high maintain ( <i>n</i> = 40; <i>n</i> = 72)	-7.87 (3.35)	0.84 (3.09)	-0.69 (3.11)
<i>F</i> -test results	$F_{(1, 258)} = 9.15, P = 0.003$	$F_{(1, 258)} = 11.74, P = 0.001$	$F_{(1, 258)} = 10.52, P = 0.001$

IDS = Inventory of Drinking Situations.

Finally, we extended prior findings showing that the maintenance of relatively high endorsement of social and enhancement motives over time was associated with binge levels II–III, whereas greater reduction in coping motives was associated with non-binge drinking and binge level I [38,39]. Results suggest that these motives may be fruitful targets for intervention to prevent levels II and III binge drinking in clinical youth. Importantly, drinking motives have been shown to be malleable over time (e.g. [59,60]), with motive-based intervention showing some effects in reducing alcohol use for some youth [61].

This study has limitations. The baseline associations are cross-sectional, thus the direction of relationships remains unclear. Reliance on self-report is also a limitation; adolescents may minimize or exaggerate drinking levels. The reference period for the TLFB was more than 1 year for some participants, thus recall for past drinking experiences may have been less reliable in these instances. Additionally, assignment to binge categories used a conservative approach of year-long monthly binge drinking behavior, which may have underestimated binge drinkers. Different approaches to assessing binge drinking might yield different results [58]. While categorical binge drinking levels aid in the identification and communication of a particular type of problem drinking, they also make arbitrary distinctions. There is little empirical basis for the designation of four or more/five or more drinks as the threshold for binge drinking [62,63], although one study showed that the standard five or more threshold was highly predictive of hangovers [22]. In general, future research is needed to determine the utility of using categorical binge drinking variables over continuous measures of alcohol consumption, and additional longitudinal studies are needed to help determine empirically based thresholds (should they exist).

In conclusion, results suggest that the 'standard' binge drinking definition could be augmented by considering adolescent binge drinking thresholds that are age- and gender-specific, particularly at earlier ages in adolescence [26], as well as thresholds that are two or more and three or more times the level I binge threshold. Levels II–III binge drinking showed statistically significant differences in adverse consequences relative to non-binge and level I binge categories in concurrent and predictive analyses, suggesting a qualitative difference in consuming alcohol at two or more times the standard binge threshold. Findings also suggest that the maintenance of relatively high endorsement of enhancement and social drinking motives over time is associated with binge levels II–III, whereas the reduction of coping motives over time is associated with a reduction in high-intensity drinking (i.e. moving from binge levels II–III to non-binge and level I binge drinking), pointing to promising avenues of drinking-motive based interventions for this particularly risky pattern of binge drinking (see also [64,65]).

#### Declaration of interests

None.

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### Supporting Information

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