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Sleep-Related Predictors of Risk for Alcohol Use and Related Problems in Adolescents and Young Adults

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PURPOSE: Growing evidence supports sleep and circadian rhythms as influencing alcohol use and the course of alcohol use disorder (AUD). Studying sleep/circadian–alcohol associations during adolescence and young adulthood may be valuable for identifying sleep/circadian-related approaches to preventing and/or treating AUD. This paper reviews current evidence for prospective associations between sleep/circadian factors and alcohol involvement during adolescence and young adulthood with an emphasis on the effects of sleep/circadian factors on alcohol use.
SEARCH METHODS: The authors conducted a literature search in PsycInfo, PubMed, and Web of Science using the search terms "sleep" and "alcohol" paired with "adolescent" or "adolescence" or "young adult" or "emerging adult," focusing on the title/abstract fields, and restricting to English-language articles. Next, the search was narrowed to articles with a prospective/longitudinal or experimental design, a sleep-related measure as a predictor, an alcohol-related measure as an outcome, and confirming a primarily adolescent and/or young adult sample. This step was completed by a joint review of candidate article abstracts by two of the authors.
SEARCH RESULTS: The initial search resulted in 720 articles. After review of the abstracts, the list was narrowed to 27 articles reporting on observational longitudinal studies and three articles reporting on intervention trials. Noted for potential inclusion were 35 additional articles that reported on studies with alcohol-related predictors and sleep-related outcomes, and/or reported on candidate moderators or mediators of sleep–alcohol associations. Additional articles were identified via review of relevant article reference lists and prior exposure based on the authors' previous work in this area.
DISCUSSION AND CONCLUSIONS: Overall, the review supports a range of sleep/circadian characteristics during adolescence and young adulthood predicting the development of alcohol use and/or alcohol-related problems. Although sleep treatment studies in adolescents and young adults engaging in regular and/or heavy drinking show that sleep can be improved in those individuals, as well as potentially reducing alcohol craving and alcohol-related consequences, no studies in any age group have yet demonstrated that improving sleep reduces drinking behavior. Notable limitations include relatively few longitudinal studies and only two experimental studies, insufficient consideration of different assessment timescales (e.g., day-to-day vs. years), insufficient consideration of the multidimensional nature of sleep, a paucity of objective measures of sleep and circadian rhythms, and insufficient consideration of how demographic variables may influence sleep/circadian–alcohol associations. Examining such moderators, particularly those related to minoritized identities, as well as further investigation of putative mechanistic pathways linking sleep/circadian characteristics to alcohol outcomes, are important next steps.

KEYWORDS: alcohol; adolescent; sleep; circadian rhythm; young adult; experimental model; longitudinal studies; research design

Abundant cross-sectional data indicate that alcohol use and related problems are accompanied by disruptions to sleep and circadian rhythms.[1] Alcohol's negative impacts on sleep are well established, especially in adults, and a smaller body of literature also reports alcohol's disruption of circadian rhythms.[2-4] Growing evidence supports sleep and circadian factors as influencing alcohol use and related problems, including as risk factors for the initial development of use and problems, as predictors for relapse in individuals with alcohol use disorder (AUD), and as targets for intervention.[2,5-7] Given the marked changes in sleep and circadian rhythms that occur throughout adolescence into young adulthood,[5] paralleling the time frame when initial alcohol use and development of alcohol-related problems are most likely to occur,[8] there may be particular value to studying the association between sleep/circadian rhythms and alcohol during this developmental stage.

Sleep and Circadian Changes in Adolescence and Beyond

As a result of living on a rotating planet with alternating light and dark periods, humans and most other living organisms have evolved to experience internal biological rhythms lasting approximately 24 hours.[9] These circadian rhythms modulate the timing of many, if not most, physiological, behavioral, and psychological processes, including the sleep-wake cycle, with the goal of optimizing temporal relationships with the environment and with one another. Notably, the timing of circadian rhythms is not static but shows developmental changes. Starting with the onset of puberty, the timing of sleep and circadian rhythms shifts later throughout adolescence, peaking around age 20 before reversing course and slowly shifting earlier over the rest of the life span.[10,11] The changes in sleep timing are driven by both biological and sociocultural factors and thus can vary based cross-nationally[12] and on sociodemographic characteristics.[11,13] Biological factors include the changes in circadian rhythms as well as changes in homeostatic sleep propensity, which accumulates more slowly during adolescence.[14] Exposure to blue light (e.g., via electronic devices) in the evening can exacerbate these tendencies toward later sleep and circadian timing.[15,16]

Although the need for sleep remains relatively stable during this period—with recommendations for 8 to 10 hours/night in youth ages 13 to 17 and for 7 to 9 hours/night in people age 18 and older—actual sleep duration tends to decrease, especially on school/work nights.[14,17] This reduction in sleep duration is driven in part by a mismatch between the tendency for later sleep/circadian timing and relatively early school schedules, particularly during middle school and high school. This mismatch, termed circadian misalignment or social jet lag, not only results in insufficient sleep duration, but also can contribute to difficulty falling asleep on school nights, daytime sleepiness on school days, and large swings in sleep timing and duration on weekdays versus weekends.[14] Such swings tend to manifest as later sleep timing and shorter sleep duration, especially for those with later circadian timing.[18] Although the effects of early school start times are most systematic during secondary education, circadian misalignment and the associated constellation of sleep problems can persist well after high school. Regardless of etiology, insomnia, insufficient sleep, and social jet lag remain prevalent in the years after high school graduation into people's twenties,[18-20] although prevalence varies based on sociodemographic characteristics.[21]

Sleep is multifactorial, and as illustrated above, different facets of sleep are interrelated in complex ways.[22,23] Circadian misalignment and social jet lag are often accompanied by a constellation of sleep-related problems and thus cannot be adequately captured by only assessing sleep quality, sleep duration, or sleep timing, especially if not distinguishing between school days or workdays and free days.

Alcohol Trajectories in Adolescence and Beyond

The developmental span from adolescence to young adulthood is a time of increasing alcohol use and related problems.[8] Alcohol use then tends to decline in early adulthood as individuals begin to "mature out" due to increases in adult responsibilities.[24] Further, both earlier initiation of alcohol use and more rapid progression from initiation to intoxication have been found to predict problematic alcohol use later on.[25-27] Multiple explanatory mechanisms are thought to underlie the onset and progression of risky alcohol use in adolescence through early adulthood. In particular, heightened sensation seeking and impulsivity have been consistently identified as potential risk factors for problematic alcohol use[28-33] and are related to sleep and circadian factors.[34,35]

Overview of Alcohol's Effects on Sleep

The effects of alcohol on sleep and, to a lesser extent, circadian rhythms in adult samples have been thoroughly and recently reviewed,[2-4] so are only briefly discussed here. Given the bidirectional relationships between sleep and alcohol use, a brief summary of the evidence for alcohol's effects on sleep and circadian rhythms is warranted as it provides important context in interpreting observational data where it is impossible to fully parse these bidirectional effects.

Alcohol administration studies in adults have assessed alcohol's acute effects on sleep via polysomnography, which measures brain activity (electroencephalography [EEG]), eye movements, muscle activity, and cardiac activity. These studies found that during the first half of the night, alcohol tends to shorten the time it takes to fall asleep (sleep onset latency [SOL]), reduce nighttime wakefulness (i.e., decrease wake after sleep onset [WASO]), decrease rapid eye movement (REM) sleep, and increase the deepest of the non-REM sleep stages (i.e., slow-wave sleep).[2] (See **Box: Glossary of Sleep-related Terms** for more detailed definitions.) However, during the second half of the night, alcohol tends to acutely increase WASO and reduce sleep efficiency (the percentage of time spent asleep relative to the time spent attempting to sleep), while leading to a rebound in REM sleep.[2] Overall, polysomnography studies suggest that adults spend more time awake on nights after consuming alcohol.[2] Some sex differences in the acute effects of alcohol have been noted, as described below.

Acute alcohol effects in adolescents have been much less studied, but findings suggest some distinctions from the effects observed in adults. In a study with 24 participants ages 18 to 21 (12 women) with a mean breath alcohol content of 0.084% at lights out, alcohol's effects were broadly similar but with less evidence of benefits for sleep. Specifically, adolescents did not exhibit the decrease in SOL or the REM rebound,[36] and although alcohol appeared to increase delta power (EEG activity in the 1–4 Hz range; typically highest during slow-wave sleep) during the first few sleep cycles, it simultaneously increased alpha power (EEG activity in the 8–13 Hz range; associated with quiet wakefulness) in frontal regions.[37] This alpha-delta pattern in response to alcohol has been observed in some but not all prior studies[38,39] and is thought to reflect disrupted sleep. No sex differences were reported.

As reviewed by Koob and Colrain,[2] alcohol's effects on sleep—when alcohol use is more chronic and/or when people who chronically use alcohol (i.e., patients with AUD) abstain from drinking—can diverge from the acute effects of alcohol in complex ways too nuanced to adequately review here. Generally, chronic alcohol use is associated with worse sleep (e.g., more insomnia, longer SOL and WASO), although sleep may intermittently improve on drinking nights; similarly, abstinence is typically associated with initial worsening of sleep with some incremental improvement over time.[2] Various sleep abnormalities persist in individuals with AUD, even with long-term abstinence (> 30 days). A recent meta-analysis of cohort studies in broader samples underscores the general conclusion that chronic alcohol use does not improve sleep overall, and likely increases the likelihood of developing sleep disorders over time.[40]

Although intensive longitudinal studies cannot confirm causality or directionality, analyses of day-to-day alcohol–sleep associations in young adults suggested that drinking on a given day was associated with later sleep timing that night.[41,42] Interestingly, such analyses offered mixed evidence for whether drinking worsened[43] or improved[42] sleep. Additionally, some studies in young adults have shown that cannabis use may mitigate alcohol's

Glossary of Sleep-related Terms

Actigraphy: Noninvasive and objective method of measuring rest-activity patterns, and thereby estimating sleep-wake characteristics, via a wearable device containing an accelerometer. Most typically worn on the wrist.

Chronotype: Tendency toward relatively earlier or relatively later timing of the circadian clock, often as indexed by timing of the sleep-wake schedule. Conceptually overlaps with circadian preference and/or morningness-eveningness—the self-reported preference for relatively earlier (morningness) or later (eveningness) patterns of activity and sleep.

Circadian misalignment: Mismatch between the timing of the behavioral sleep-wake schedule and that of the circadian clock, most obviously observed in the context of shiftwork and jet lag.

Eveningness: Self-reported preference for relatively later timing of sleep and activity. In contrast to morningness, a self-reported preference for relatively earlier timing of sleep and activity. See chronotype.

Polysomnography: A multiparameter assessment of sleep that includes electroencephalography (EEG) to assess brain activity, electrooculography (EOG) to assess eye movements, electromyography (EMG) to assess muscle activity, and electrocardiography (ECG) to assess cardiac activity. Often respiratory airflow, respiratory effort, and pulse oximetry are also measured. Typically applied in laboratory-based settings, although streamlined polysomnography-type devices are increasingly used in home settings.

Sleep efficiency: The percentage of time spent asleep relative to the time spent attempting to sleep.

Sleep onset latency (SOL): The amount of time it takes to fall asleep.

Slow-wave sleep: The deepest of three stages of non-rapid eye movement (non-REM) sleep.

Social jet lag: A specific type of circadian misalignment in which school and/or work obligations cause a mismatch between the imposed sleep-wake schedule on school days or workdays, whereas individuals return to their desired sleep-wake schedules (relatively more aligned with their circadian clocks) on free days. More common are individuals with a late chronotype (tendency toward evening circadian preference).

Wake after sleep onset (WASO): The amount of time spent awake during nighttime awakenings that occur after initially falling asleep.

effects on sleep,[43,44] although these studies require replication, and the relevant mechanisms remain unknown.

Alcohol's effects on sleep also depend on the timing of alcohol consumption; for example, a study in middle-aged men administered alcohol 6 hours before bedtime found no benefit for SOL.[45] This likely was due to a combination of the temporal dynamics of the biphasic response to alcohol and circadian variation in the response to alcohol. While the literature on alcohol effects on circadian rhythms is more limited, particularly in humans,[3,4] studies have suggested disruption of melatonin and core body temperature rhythms. Multiple animal studies have indicated that acute and chronic alcohol use disrupted the circadian system's response to light, which is the most important cue (zeitgeber, or time giver) for entraining to the 24-hour day.[46,47]

Although parallel effects in humans were not supported by one study in healthy adults reporting light or regular but not heavy alcohol use,[48] more recent work suggested reduced retinal responsivity to light in a group of adults who drank heavily.[49] Light or regular drinking has previously been defined as "consumption of one to five standard alcoholic drinks/week" and no more than three episodes of binge drinking in the past year.[49] Heavy drinking has been defined by the National Institute on Alcohol Abuse and Alcoholism as five or more drinks on any day or 15 or more drinks per week for men, or four or more drinks on any day or eight or more drinks per week for women (see https://go.nih.gov/TiogZz9). However, there is no standardized definition of either "light/regular drinking" or "heavy drinking" across the studies described in this article.

The present paper reviews current evidence for prospective associations between sleep/circadian factors and alcohol involvement during adolescence and young adulthood, with an emphasis on the effects of sleep/circadian factors on alcohol use and related outcomes. This focus was selected in part because identifying modifiable sleep–alcohol relationships during this developmental period offers the potential for shifting the trajectory for alcohol-related problems before they develop into chronic AUD. This article also describes and discusses potential mechanisms by which sleep may influence alcohol use and problems, as well as potential important differences in sleep–alcohol associations based on key moderators, such as assigned sex at birth; lesbian, gay bisexual, transgender, queer/questioning, intersex, and asexual (LGBTQIA+) identities; and racial and ethnic identities.

Methods

Search Methods

The initial search of the existing literature was conducted on July 18, 2022, in PsycInfo, PubMed, and Web of Science using the search terms "sleep" and "alcohol" paired with "adolescent" or "adolescence" or "young adult" or "emerging adult," in the title or abstract fields; results were restricted to English-language articles but had no restriction by date. Next, the search was narrowed by including only articles that had a prospective/longitudinal or experimental design, included a sleep-related measure as a predictor, assessed an alcohol-related measure as an outcome, and had a sample primarily composed of adolescents and/or young adults. Based on these search terms, the resulting ages of participants in the articles ranged from ages 12 to 30. Table 1 offers information on age ranges in specific studies. Two of the authors completed this step by conducting a joint review of candidate article abstracts.

Results of the Literature Search

The initial search resulted in 720 articles (174 in PsycInfo, 305 in PubMed, and 241 in Web of Science). After review of the abstracts to identify articles that met all the key search criteria, the list was narrowed to 27 articles reporting on observational longitudinal studies and three articles reporting on experimental studies (specifically, two intervention trials). Noted for potential inclusion were 35 additional articles that reported on studies with alcohol-related predictors and sleep-related outcomes, and/or reported on candidate moderators or mediators of sleep–alcohol associations. An additional 104 articles cited here were identified via a variety of methods, including review of relevant article reference lists and prior exposure based on the authors' previous work in this area. Finally, while this review focused on sleep/circadian–alcohol associations in human studies, a few select findings from three animal studies[46,47,50] were included when they appeared particularly complementary to the human findings and/or helped speak to a gap in the human literature.

Results of the Reviewed Studies

Longitudinal Sleep and Alcohol Studies

Overall, the existing literature—based on 27 articles, including three intensive longitudinal studies—provides consistent evidence that a range of sleep/circadian factors during adolescence predicts later alcohol involvement. These included difficulties with falling or staying asleep, lower overall sleep quality, shorter sleep duration, daytime sleepiness, later sleep timing and/or chronotype (i.e., tendency for relatively earlier or later sleep-wake timing), and variable sleep timing and/or social jet lag (see **Box: Glossary of Sleep-related Terms**). Alcohol-related outcomes assessed included metrics of both quantity and frequency of use, binge or heavy drinking episodes, alcohol intoxication, alcohol-related consequences/problems, AUD symptoms, and alcohol craving. Table 1 provides a summary of the longitudinal studies, including sample composition, study design, and timescale; which multidimensional sleep variables were predictive of alcohol outcomes; and whether differences across assigned sex, gender identity, and racial/ethnic identity were assessed.

Table 1. Summary of Longitudinal Studies Including Sleep-Related Predictors and Alcohol-Related Outcomes in Adolescent and/or Young Adult Samples

		Sample		Study Design		Multidimensional Sleep Variables—Related to Alcohol Outcome(s)?								
Author	Year	Sample Size & General Description	Sample Demographics*	Design	Time Frame	Regularity	Satisfaction†	Alertness	Timing	Efficiency	Duration	Composite	Alcohol Finding	Tested Sex/Gender and/or Race/Ethnicity
Fucito et al.[41]	2018	42 college students with concerns about their sleep, ≥ 1 occasion of heavy drinking in the past month	*M* age = 20.5 (*SD* = 1.31); 48% female; 4% Asian, 5% Black, 5% more than one race, 2% other, 69% White; 19% Hispanic/Latino	Intensive longitudinal; 7day protocol	Days	-	Y	Y	Y	-	-	-	Shorter sleep duration (actigraphy), earlier wake time (actigraphy), and better sleep quality all predicted more drinks the following day. In full model including all sleep variables, only wake time, sleep quality, and alertness upon waking predicted later alcohol use.	Tested differences across gender identity in sleep and alcohol variables (none significant)
Graupensperger et al.[51]	2022	409 young adults reporting past-month simultaneous use of alcohol and cannabis use and drinking alcohol ≥ 3 times in past month	*M* age = 21.6 (range = 18–25); 51% female; 16% Asian, 4% Black, 11% more than one race, 4% other, 48% White; 16% Hispanic/Latino	Intensive longitudinal; five 14-day bursts of twice-daily surveys separated by 4 months (i.e., 70 days total across 16 months)	Days, months, years	-	-	-	-	-	Y	-	At burst-level, shorter sleep duration was associated with greater alcohol use. At all three levels (person, burst, and daily), shorter sleep duration was associated with stronger morning alcohol craving. At burst and daily levels, shorter sleep duration was associated with stronger afternoon alcohol craving.	None tested
Hasler et al.[170]	2014	696 participants from study at the Pittsburgh Adolescent Alcohol Research Center. At baseline, 347 participants with current AUD (AUD+); 349 participants with no current or past AUD (AUD-)	AUD+: *M* age = 16.7 (range = 12–19); 37% female; < 1% Asian, 12% Black, 87% White AUD-: *M* age = 15.8 (range = 12–19); 57% female; < 1% Asian, 25% Black, < 1% Native American, 75% White	Longitudinal; data from baseline, 1-, 3-, and 5-year follow-up assessments	Years	Y	Y	-	-	-	N	-	In AUD- group, greater insomnia at baseline predicted increase in AUD symptoms at 1-year follow-up, while greater variability in weekday-weekend sleep duration predicted increases in AUD symptoms at 3- and 5-year follow-up.	AUD group differences reported across racial groups
Hasler et al.[54]	2016	707 children in Center for Education and Drug Abuse Research (CEDAR) study	*M* age = 11.4 (range = 9–13); 28.9% female; 21% Black, 79% White	Longitudinal; data from eight assessments spaced 2–3 years apart. Last assessment at approximately age 30	Years	Y	Y	-	-	-	-	-	More restless sleep predicted earlier onset of alcohol use. More variable sleep timing predicted earlier onset of AUD.	Sleep differences reported across racial groups; no significant differences across sex

Table 1. Summary of Longitudinal Studies Including Sleep-Related Predictors and Alcohol-Related Outcomes in Adolescent and/or Young Adult Samples (Continued)

		Sample		Study Design		Multidimensional Sleep Variables—Related to Alcohol Outcome(s)?								
Author	Year	Sample Size & General Description	Sample Demographics*	Design	Time Frame	Regularity	Satisfaction†	Alertness	Timing	Efficiency	Duration	Composite	Alcohol Finding	Tested Sex/Gender and/or Race/Ethnicity
Hasler et al.[53]	2017	729 adolescents in National Consortium on Alcohol and Neurodevelopment in Adolescence (NCANDA) study	*M* age = 15.9 (range = 12–21); 51% female; 7% Asian, 12% Black, 41% other, 75% White; 12% Hispanic/Latino	Accelerated longitudinal design; data from baseline and 1–year follow-up assessments	Months	N	N	N	Y	-	Y	-	Greater eveningness, later bedtime (weekday and weekend), and shorter weekday sleep duration all predicted higher severity of binge alcohol use.	Sleep differences reported across racial and ethnic groups
Hasler et al.[52]	2017	93 male participants from Pitt Mother & Child Project originally recruited in infancy	Assessments at age 20 and age 22; race/ethnicity not reported	Longitudinal; data from two time points (age 20 and age 22)	Years	-	-	-	Y	-	-	-	An indirect path was observed from circadian preference at age 20 to alcohol use and dependence at age 22 via the neural (medial prefrontal cortex) response on a monetary reward task. However, circadian preference at age 20 did not directly predict alcohol use or dependence at age 22.	None tested
Hasler et al.[5]	2022	831 adolescents in NCANDA study	*M* age = 16.2 (range = 12–21); 50.9% female; 7% Asian American, 12% Black, 41% other, 75% White; 12% Hispanic/Latino	Accelerated longitudinal design; data from baseline through 5-year follow-up (six annual assessments)	Years	N	N	Y	Y	-	Y	-	Greater eveningness, more daytime sleepiness, later weekend sleep timing, and shorter sleep duration (weekday/weekend) all predicted more severe alcohol binge drinking the following year. Sleep associations with binge severity differed between middle/high school versus post-high school adolescents.	Sleep differences reported based on sex; no differences across racial groups were assessed
Haynie et al.[67]	2018	2,785 high school students from the NEXT Generation Health Study	Age not reported; 55% female; 14% Black, 5% Other, 62% White; 19% Hispanic/Latino	Longitudinal; data from 10th, 11th, and 12th grades (Waves 1–3)	Years	Y	-	-	Y	-	N	-	Later chronotype and greater social jet lag both predicted greater likelihood of alcohol use and heavy episodic drinking (Wave 2 to Wave 3 only). Sleep duration did not predict subsequent alcohol involvement.	Sleep differences reported across gender identity and racial and ethnic groups in Supplement

Table 1. Summary of Longitudinal Studies Including Sleep-Related Predictors and Alcohol-Related Outcomes in Adolescent and/or Young Adult Samples (Continued)

		Sample		Study Design		Multidimensional Sleep Variables—Related to Alcohol Outcome(s)?								
Author	Year	Sample Size & General Description	Sample Demographics*	Design	Time Frame	Regularity	Satisfaction†	Alertness	Timing	Efficiency	Duration	Composite	Alcohol Finding	Tested Sex/Gender and/or Race/Ethnicity
Ho et al.[69]	2020	1,678 adolescents from Taiwan Youth Project; participants who had ever smoked cigarettes or consumed alcohol before Year 1 were excluded	*M* age = 13; 50% female; 8% Hakka, 12% Mainlanders, 1% Original Residents, 2% Other, 88% Weinan Islanders	Longitudinal; cohort starting in 7th grade (Year 1, 2000) and assessed until age 21 (Year 9, 2009); five waves of assessment	Years	Y	N	-	-	N	Y	-	Accumulating waves of sleep duration (< 6 hours) and social jet lag (≥ 0.5, 1, or 2 hours) increased the frequency of alcohol use at age 21. Sleep disturbance and sleep duration of at least 7 or 8 hours were not predictive of alcohol use.	None tested
McGlinchey & Harvey[55]	2015	4,882 adolescents from ADD Health	Wave 2: *M* age = 16; Wave 3: *M* age = 21.8; 52% female; 5% Asian, 24% Black, 4% Native American, 59% White; 8% Hispanic/Latino	Longitudinal; data from Wave 2 (1996) and Wave 3 (2001–2002)	Years	-	-	-	Y	-	-	-	Later bedtime at Wave 2 predicted increased odds of reporting alcohol "abuse" at Wave 3.	Alcohol use differences reported across sex and racial groups, although specific differences across racial groups were not specified
Mike et al.[56]	2016	186 boys from Pitt Mother and Child Project	*M* age = 11 (at baseline); follow-up between ages 20 to 22; 45% "non-White," 55% White	Longitudinal; data from baseline (age 11), with alcohol use history assessed at age 20 and age 22	Years	-	Y	-	-	-	Y	-	Shorter sleep duration and lower sleep quality both predicted earlier alcohol use, intoxication, and repeated use.	None reported
Miller et al.[171]	2016	568 college students who had violated campus alcohol policy and had been mandated to an alcohol prevention intervention	*M* age = 19.2 (*SD* = 1.2); 28% female; 84% White	Longitudinal; data from baseline, 1-, 3-, and 5-month follow-up assessments	Months	-	-	-	-	-	Y	-	Lower baseline sleep adequacy predicted alcohol-related consequences at 1-month follow-up. A stronger association was found between drinks per week and alcohol-related consequences in individuals with lower baseline sleep adequacy.	None tested

Table 1. Summary of Longitudinal Studies Including Sleep-Related Predictors and Alcohol-Related Outcomes in Adolescent and/or Young Adult Samples (Continued)

		Sample		Study Design		Multidimensional Sleep Variables—Related to Alcohol Outcome(s)?								
Author	Year	Sample Size & General Description	Sample Demographics*	Design	Time Frame	Regularity	Satisfaction†	Alertness	Timing	Efficiency	Duration	Composite	Alcohol Finding	Tested Sex/Gender and/or Race/Ethnicity
Miller et al.[57]	2017	829 middle school students from Rhode Island study examining risk factors for initiation/ progression of drinking	*M* age = 12.6 (*SD* = 1.02); 52% female; 15% "non-White;" 12% Hispanic/Latino	Longitudinal; ongoing prospective Web-based survey over 4-year period, with recruitment beginning in 2009; data from 6-month assessments over 2 years (Times 2–5), 3-year follow-up (Time 6), and 4-year follow-up (Time 7); two sleep assessments within first 2 years of study	Years	N	-	Y	-	-	Y	-	Both shorter sleep and greater daytime sleepiness predicted onset of full drinking, heavy episodic drinking, and alcohol-related consequences. Weekend bedtime delay predicted alcohol outcomes.	Racial identity dropped from model due to nonsignificant relation to alcohol outcomes.
Miller et al.[42]	2021	56 young adults; reporting ≥ 1 binge episode in past 30 days; also meeting diagnostic criteria for insomnia	*M* age = 22.4 (*SD* = 2.7); 75% female; 5% Black, 11% multiracial, 2% Native American/ Native Alaskan, 82% White; 4% Hispanic/Latino	Intensive longitudinal design; online survey and actigraphy for at least 7 days (average 8.52 diaries; range = 1–15 days)	Days	-	Y	-	N	Y	N	-	Better self-reported sleep efficiency predicted greater drinking the next day.	Differences based on sex were not reported; differences across racial/ethnic groups were not tested.

Table 1. Summary of Longitudinal Studies Including Sleep-Related Predictors and Alcohol-Related Outcomes in Adolescent and/or Young Adult Samples (Continued)

		Sample		Study Design		Multidimensional Sleep Variables—Related to Alcohol Outcome(s)?								
Author	Year	Sample Size & General Description	Sample Demographics*	Design	Time Frame	Regularity	Satisfaction†	Alertness	Timing	Efficiency	Duration	Composite	Alcohol Finding	Tested Sex/Gender and/or Race/Ethnicity
Nguyen-Louie et al.[58]	2018	95 adolescents from neuroimaging study on adolescent substance use in San Diego	Time 1: *M* age = 13.4 (*SD* = 0.7); Time 2: *M* age = 15.1 (*SD* = 0.9); Time 3: *M* age = 19.8 (*SD* = 0.9); 47% female; 6% Asian, 3% Black, 17% multiracial, 5.3% other, 68% White; 20% Hispanic/Latino	Longitudinal; data from Time 1 (ages 12–14), Time 2 (~ 1.5 years after Time 1), and Time 3 (~ 2.6 years after Time 2)	Years	-	-	Y	Y	-	-	Y	More frequent erratic sleep/wake behaviors (composite variable of delayed/variable bedtime and daytime dysfunction), greater sleepiness, and greater eveningness at Time 2 generally predicted more lifetime alcohol use by Time 3. However, erratic sleep/wake behaviors predicted lower alcohol use after controlling for daytime sleepiness and chronotype. Sleep variables were also tested as mediators between Time 1 risk factors (family history of SUD, inhibitory control, and internalizing/externalizing) and Time 3 lifetime alcohol use. Only erratic sleep/wake behaviors mediated Time 1 inhibitory control on Time 3 alcohol use.	None tested
Pasch et al.[59]	2012	723 adolescents from Identifying the Determinants of Eating and Activity (IDEA) or Etiology of Childhood Obesity (ECHO) cohort studies	*M* age = 14.7 (range = 10–17); 51% female; 1% Asian, < 1% American Indian, 5% Black, < 1% Native American/Pacific Islander, 6% other, 86% White; 5% Hispanic/Latino	Longitudinal; both 2-year studies; baseline data collected in 2006–2007 (IDEA) and 2007–2008 (ECHO); follow-up data collected in 2008–2009 (IDEA) and 2009–2010 (ECHO)	Years	Y	-	-	-	-	N	-	Larger weekend bedtime delay at baseline predicted higher likelihood of alcohol use at follow-up.	Sleep differences were reported across sex and racial groups.
Pieters et al.[60]	2015	555 adolescents from the Netherlands	*M* age = 13.96 (range = 11–16); 52% female; 86% had two White parents, 10% had a mix of White and "non-White" parents, 4% had two White parents	Longitudinal; two waves: Wave 1 (early 2008) and Wave 2 (late 2008)	Months	-	-	-	-	-	-	Y	Sleep problems at Wave 1 positively predicted alcohol use at Wave 2.	None tested

Table 1. Summary of Longitudinal Studies Including Sleep-Related Predictors and Alcohol-Related Outcomes in Adolescent and/or Young Adult Samples (Continued)

		Sample		Study Design		Multidimensional Sleep Variables—Related to Alcohol Outcome(s)?								
Author	Year	Sample Size & General Description	Sample Demographics*	Design	Time Frame	Regularity	Satisfaction†	Alertness	Timing	Efficiency	Duration	Composite	Alcohol Finding	Tested Sex/Gender and/or Race/Ethnicity
Stephenson et al.[72]	2020	3,402 participants (1,435 complete twin pairs; 36% monozygotic) from FinnTwin12, a population-based study of Finnish twins born between 1937 and 1987	Time 1: *M* age = 12; Time 2: *M* age = 14; Time 3: *M* age = 22 (range = 20–26); 57% female; no information on race/ethnicity	Longitudinal; analyses focus on predictors from waves at ages 12 and 14 predicting young adult outcomes (age 22)	Years	-	-	-	-	Y	-	-	At individual level, sleeping problems at ages 12 and 14 predicted alcohol misuse in young adulthood, but were no longer significant in co-twin comparisons.	None tested
Tavernier et al.[78]	2014	780 first-year Canadian university students identifying as being morning- or evening-type	*M* age = 19 (*SD* = .09); 72% female; 87% domestic-Canadian, remaining international students (37% Asia, 10% Caribbean, 15% European Union); race not reported	Longitudinal; 2-year study: Time 1 (baseline) and Time 2 (1-year follow-up)	Years	-	-	-	-	-	-	Y	Composite variable based on chronotype, insomnia symptoms, and sleep duration. Evening-type subgroups generally reported more alcohol use than morning-type subgroups, although evening-poor sleep and morning-poor sleep subgroups did not differ. The evening subgroups (good/moderate/poor sleep) did not differ in alcohol use.	Did not test differences across racial groups; similar distribution of morning-/evening-types based on sex
Troxel et al.[6]	2021	3,265 youth from southern California study by RAND Corporation	Wave 6: *M* age = 16.2 (*SD* = 0.7); Wave 11: *M* age = 21.6 (*SD* = 0.8); 53% female; 20% Asian; 2% Black (non-Hispanic); 12% other/multiracial; 20% White (non-Hispanic); 47% Hispanic/Latino	Longitudinal; data from six waves: Wave 6 (May 2013 to April 2014) to Wave 11 (July 2018 to June 2019)	Years	Y	Y	-	Y	-	N	-	Greater trouble sleeping, later weekday and weekend bedtimes, and smaller reductions in social jet lag were associated with higher likelihood of alcohol use over time.	Differences were reported in the associations between weekday/weekend bedtime and alcohol use based on sex.
Troxel et al.[68]	2022	2,995 youth from southern California study by RAND Corporation	Wave 8: *M* age = 18.3 (*SD* = 0.8); Wave 13: *M* age = 23.6 (*SD* = 0.8); 54% female; 20% Asian, 2% Black (non-Hispanic), 12% other/multiracial, 20% White (non-Hispanic); 46% Hispanic/Latino	Longitudinal; data from six waves: Wave 8 (June 2015 to May 2016) to Wave 13 (July 2020 to July 2021)	Years	-	-	-	-	-	-	Y	"Good sleepers" (composite variable based on sleep quality, duration, and social jet lag) reported lower levels of alcohol use and consequences. When compared to "suboptimal sleepers," "good sleepers" also reported less of an increase in alcohol consequences over time.	Differences were reported in composition of classes in terms of sex and ethnicity.

Table 1. Summary of Longitudinal Studies Including Sleep-Related Predictors and Alcohol-Related Outcomes in Adolescent and/or Young Adult Samples (Continued)

		Sample		Study Design		Multidimensional Sleep Variables—Related to Alcohol Outcome(s)?								
Author	Year	Sample Size & General Description	Sample Demographics*	Design	Time Frame	Regularity	Satisfaction†	Alertness	Timing	Efficiency	Duration	Composite	Alcohol Finding	Tested Sex/Gender and/or Race/Ethnicity
Waddell & Sasser[24]	2022	4,347 participants from ADD Health	Wave 2: *M* age = 16.0 (*SD* = 1.4); Wave 3: *M* age = 21.4 (*SD* = 1.4); Wave 4: *M* age = 28.5 (*SD* = 1.4); 52% female; 4% American Indian/Alaskan Native, 4% Asian, 24% Black, 6% other/multiracial, 68% White; 12% Hispanic/Latino	Longitudinal; data from three waves: Wave 2 (1996), Wave 3 (2001–2002), Wave 4 (2007–2008)	Years	-	-	-	-	-	Y	-	Longer sleep duration was associated with lighter drinking at the between-person level. Increases in sleep duration were associated with decreases in drinking at the within-person level. At the between-person level, higher levels of lack of premeditation were associated with greater drinking. At the within-person level, increases in sensation seeking were most strongly associated with increases in drinking for those reporting decreases in sleep duration.	None tested
Wong et al.[61]	2004	257 boys from Michigan Longitudinal Study (MLS); 60% of participants had parent with lifetime AUD	Wave 1: Age range = 3–5; Wave 2: Age range = 6–8; Wave 3: Age range = 9–11; Wave 4: Age range = 12–14; 100% White	Longitudinal; data from four regular waves at 3–year intervals	Years	-	Y	Y	-	-	-	Y	Composite index of sleep problems predicted higher likelihood of drinking at ages 12–14. Weaker associations were found for individual sleep items (trouble sleeping and overtiredness), although both predicted onset of drinking, but not drunkenness.	Not applicable
Wong et al.[63]	2009	386 children from MLS; 75% of participants with parent who met lifetime AUD	Wave 1: Age range = 3–5;* Wave 2: Age range = 6–8; Wave 3: Age range = 9–11; Wave 4: Age range = 12–14; Wave 5: Age range = 15–17; 24% female; 100% White **Note*: Girls joined study between the ages of 6 and 11.	Longitudinal; data from five regular waves and seven annual waves at 3-year intervals	Years	-	-	-	-	-	-	Y	Sleep problems during Waves 1 and 2 increased the probability of onset of alcohol use between the ages of 8 and 14 in boys but did not predict onset of alcohol use in girls before the age of 14. In contrast, sleep problems during Waves 1 and 2 increased the probability of onset of alcohol use between the ages of 15 and 17 in girls, but not boys.	Differences reported in sleep and alcohol outcomes based on sex; differences across racial groups could not be tested

Table 1. Summary of Longitudinal Studies Including Sleep-Related Predictors and Alcohol-Related Outcomes in Adolescent and/or Young Adult Samples (Continued)

		Sample		Study Design		Multidimensional Sleep Variables—Related to Alcohol Outcome(s)?								
Author	Year	Sample Size & General Description	Sample Demographics*	Design	Time Frame	Regularity	Satisfaction†	Alertness	Timing	Efficiency	Duration	Composite	Alcohol Finding	Tested Sex/Gender and/or Race/Ethnicity
Wong et al.[62]	2010	386 children from MLS; 75% of participants with parent who met lifetime AUD	Wave 1: Age range = 3–5;* Wave 2: Age range = 6–8; Wave 3: Age range = 9–11; Wave 4: Age range = 12–14; Wave 5: Age range = 15–17; 24% female; 100% White **Note*: Girls joined study between the ages of 6 and 11.	Longitudinal; data from five regular waves and seven annual waves at 3–year intervals	Years	-	N	Y	-	-	-	-	Overtiredness at ages 3–8 predicted all four alcohol variables (i.e., binge drinking, blackouts, driving under the influence, and alcohol problems) in emerging adulthood (ages 18–20). Sleep during adolescence (age 11–17) did not predict any alcohol outcomes during emerging adulthood.	Sleep differences tested by sex, though none were significant
Wong et al.[172]	2015	6,504 adolescents and young adults from ADD Health	Time 1: *M* age = 16.0 (*SD* = 1.8); Time 2: *M* age = 16.0 (*SD* = 1.6); Time 3: *M* age = 21.8 (*SD* = 1.8); Race/ethnicity/sex not reported	Longitudinal; data from three time points: Time 1 (1994–1995), Time 2 (1996), and Time 3 (2001–2002)	Years	-	Y	-	-	-	Y	-	Sleep duration at Time 1 was negatively associated with binge drinking at Time 2 (a 1-hour increase in sleep was associated with a 9% decrease in the odds of binge drinking). Sleep difficulties at Time 1 were associated with regretted sexual activities due to drinking at Time 2.	Differences reported in alcohol outcomes across sex and racial groups
Zhang et al.[65]	2011	1,611 children from Hong Kong study concerning childhood sleep problems	*M* age (baseline) = 9.0 (*SD* = 1.8); *M* age (follow-up) = 13.7 (*SD* = 1.8); 51% female; racial breakdown not specified	Longitudinal; 5-year study beginning in 2003–2004 (baseline), with follow-up assessment conducted between 2008 and 2010	Years	-	Y	-	-	-	-	-	New incidence of chronic insomnia was associated with increased risk of frequent alcohol use at 5-year follow-up, but baseline chronic insomnia and persistent chronic insomnia were not statistically significant.	Sleep differences reported by sex; differences across racial groups could not be tested.

*Age was rounded to 1 decimal place; demographic (sex/gender and race/ethnicity) percentages were rounded to whole numbers. No studies clarified whether assigned sex at birth or gender identity was assessed and reported. Therefore, the language (e.g., sex vs. gender) in the original article was retained. When possible, race/ethnicity terms were standardized to be consistent with National Institutes of Health categories. In some cases, the published papers did not specify the racial/ethnic identities beyond "White" and "non-White" (or "Caucasian" and "non-Caucasian," for which "White" and "non-White" were substituted).

†Sleep variables based on insomnia symptoms without numerical data to calculate efficiency were categorized under "Satisfaction."

Note: ADD Health, National Longitudinal Study of Adolescent to Adult Health; AUD, alcohol use disorder; ECHO, Etiology of Childhood Obesity studies; IDEA, Identifying the Determinants of Eating and Activity; *M*, mean; MLS, Michigan Longitudinal Study; NCANDA, National Consortium on Alcohol and Neurodevelopment in Adolescence; *SD*, standard deviation; SUD, substance use disorder.

A majority of the articles[5,6,51-63] also reported on other substance outcomes, particularly use of nicotine/tobacco and cannabis/marijuana, with findings suggesting that sleep-related risk for substance use may not be specific to alcohol. Indeed, the overall literature suggests a transdiagnostic scenario where multiple aspects of sleep/circadian disturbance (e.g., insomnia, sleep loss, delayed phase) increase the risk for alcohol and other substance use disorders as well as for other psychiatric disorders.[64]

Although this review focuses primarily on the period of adolescence through young adulthood, two papers based on the Michigan Longitudinal Study[61,62] and one paper based on a study in Hong Kong[65] reported that childhood sleep problems predicted later substance use, indicating that relationships between sleep and substance use are not specific to adolescents. Notably, childhood sleep tends to predict adolescent sleep,[62,65] which could partially explain the association with adolescent substance use, but also suggests the potential value of starting early with sleep-focused prevention and/or intervention efforts. Indeed, one study reported prospective sleep–substance use associations entirely within the fourth through sixth grades, and implicated inhibitory control as a potential mediator.[66] Although that study's findings contrasted with one of the papers from the Michigan Longitudinal Study (which did not support inhibitory control as a mediator in the sleep–alcohol associations),[62] changes in mood regulation, impulsivity, and/or poor decision-making remain plausible mechanisms in the longitudinal associations between childhood sleep problems and later substance use.

Several caveats are important to consider when interpreting the existing literature. First, multiple articles relied on the same longitudinal datasets; thus, 14 out of 27 longitudinal papers were based on six studies. Second, earlier studies tended to focus on only one or two sleep characteristics and were thus unable to treat sleep as a multidimensional construct. Third, papers based on more recent studies, seemingly designed to specifically consider sleep, were more likely to employ a multidimensional sleep framework.[5,6,41,53,67-69] Fourth, except for two intensive longitudinal studies[41,42] that used actigraphy—a wearable device containing an accelerometer to measure rest-activity patterns—most studies relied on self-reported sleep and are subject to the relevant biases. For example, beyond typical retrospective biases associated with self-report, there are also longstanding observations of subjective-objective discrepancies in sleep, particularly in individuals with insomnia disorder.[70] Also, none of the studies included objective circadian predictors (e.g., dim light melatonin onset) despite cross-sectional evidence that circadian timing is related to alcohol outcomes.[49,71] Fifth, observational designs cannot assess causation and directionality and therefore must be interpreted with caution. Relatedly, one recent co-twin study indicated that sleep-related risk for alcohol misuse exists over and above genetic and environmental factors.[72] However, other emerging research using genetic methods has yielded more mixed results whether the relationships between sleep/circadian characteristics and substance use should be attributed to shared genetic variance or pleiotropy[73-75] or suggests a causal relationship from sleep to substance misuse.[76]

Some of the included studies tested putative mediators of the sleep–alcohol relationship, such as behavioral inhibition, attention problems, and internalizing/externalizing symptoms; however, the results have been inconsistent (see below for further discussion). Furthermore, given that a tendency toward relatively late timing of the sleep-wake schedule (i.e., a later chronotype) is often associated with worse sleep among adolescents and young adults,[77] sleep characteristics are a putative mediator of the association between chronotype and alcohol-related risk. However, existing studies often have not supported this for alcohol[78] or other outcomes such as depression.[79,80] One study in late adolescents and young adult veterans reported that insomnia severity statistically mediated the association between depression or symptoms of post-traumatic stress disorder and alcohol use and related consequences.[81]

The time frame of assessment varied substantively across the studies, with intensive longitudinal designs narrowing the focus to day-to-day relationships whereas the more traditional longitudinal studies ranged from months to multiple years between assessments. These varying time frames are important when considering that distinct mechanistic pathways may be operating within different timescales. For example, studies with annual or multiannual time points may be speaking more to the cumulative effects of sleep/circadian characteristics, although few studies have directly tested this.[65] Interestingly, the intensive longitudinal designs (e.g., ecological momentary assessment [EMA]) appear more likely to find more nuanced associations between sleep and alcohol. For example, some EMA evidence from young adult samples suggests that better sleep efficiency[42] or quality[41] on a given night predicts more alcohol use the following day, although those findings emerged from samples with participants with sleep problems who consume alcohol. EMA findings from a much wider age range (ages 20 to 73) suggest that age may moderate sleep–alcohol associations; the younger group (age < 49) showed associations between worse sleep quality and more subsequent alcohol use whereas the older group (age > 50) drank more following nights of better sleep quality.[82]

The complex findings in EMA studies speak to the relevance of considering the multidimensional nature of sleep. In one study of undergraduate students who consumed alcohol (mean age = 20.5 years), shorter sleep and earlier wake times (based on actigraphy) and better sleep quality (based on self-report) all predicted more alcohol use the next day.[41] In the combined model that included all the sleep predictors simultaneously, only waking earlier and better perceived sleep quality upon waking predicted more alcohol use. One interpretation of

this is that shortened sleep led to deeper, more consolidated sleep, perceived in turn as higher quality, although it remains possible that shorter sleep may have impacted other intervening mechanisms (e.g., impaired cognitive control). Alternatively, as the authors suggested, late adolescents and young adults may be more likely to socialize and drink when feeling refreshed, especially given that drinking among adolescents and young adults primarily occurs in social contexts.[83] Collectively, these findings suggest the value of considering multidimensional sleep relationships with alcohol using designs that allow consideration of both short-term (i.e., day-to-day) and longer-term (i.e., months-to-years) timescales, such as embedding an EMA burst design within a longitudinal study, as done by Graupensperger and colleagues.[51] Relatedly, such designs allow parsing of between-person and within-person effects, which may well reveal distinct sleep–alcohol associations at the between-person and within-person levels.

In summary, the published longitudinal data indicate that multiple sleep and/or circadian characteristics prospectively predict alcohol-related outcomes during adolescence through young adulthood. However, the current literature is limited by overreliance on a relatively small number of longitudinal studies, largely relying on self-report measures, and insufficient consideration of the multidimensional nature of sleep. Important next steps include, but are not limited to, consideration of different timescales, including within the same study design, and examination of key mediators and moderators of sleep–alcohol associations.

Experimental Sleep and Alcohol Studies

At present, experimental evidence of causal effects of sleep on alcohol-related outcomes is based solely on insomnia treatment studies in individuals with heavy alcohol use and/or AUD, most of which are from samples older than adolescents or young adults. A systematic review and meta-analysis of nine studies of primarily middle-aged adults[7] concluded that insomnia treatment, particularly behavioral treatment, improved sleep quality and reduced depression in individuals with AUD. The authors found no definitive benefit of insomnia treatment for reducing alcohol use, although the relapse rates in two trials of cognitive-behavioral therapy for insomnia (CBT-I) were considerably lower (11% and 15%) than might be expected for adults in AUD treatment.[84] Caution is warranted in drawing strong conclusions about the potential impact on alcohol-related outcomes based on these studies, however, as the review also noted limitations related to small samples, relatively short follow-up periods, and not focusing on participants who were concurrently engaged in AUD treatment. These limitations reflect the fact that the studies generally were designed to focus on sleep outcomes rather than alcohol outcomes. Moreover, these studies varied in whether the patients were seeking or engaged in AUD treatment, and whether they were required to be abstinent at study start.

The limited published data from two sleep treatment studies in late adolescents and emerging adults are broadly consistent with the prior literature in adults, suggesting that sleep disturbance in the context of heavy alcohol use is amenable to nonpharmacological interventions; however, it remains unclear whether improving sleep measurably reduces alcohol involvement. A novel web-based intervention including both sleep and alcohol content improved sleep quality and sleep-related impairment in heavy-drinking college students,[85] although it did not outperform a control condition (psychoeducation about sleep hygiene) and did not significantly improve actigraphy-based sleep outcomes. Interestingly, although alcohol use through a 3-month follow-up declined in both conditions, reductions were larger in the control condition. The results suggested that greater reductions in sleep-related impairment may predict greater reductions in drinking (medium-to-large effect size), but those findings were not statistically significant.

Related work by Fucito and colleagues suggested that heavy-drinking college students were more receptive to sleep-focused interventions (even if they included content related to drinking) than to purely alcohol-focused interventions.[86] This may be due to less stigma associated with sleep treatment. Aside from direct effects of sleep treatment on alcohol outcomes, this could mean that sleep treatment may provide a "foot in the door" for individuals with sleep and alcohol problems. Accordingly, Fucito and colleagues are currently conducting a sleep intervention trial that focuses on sleep hygiene in young adults ages 18 to 25 who drink heavily.[87]

A more recent study tested the efficacy of CBT-I in 56 young adults ages 18 to 30 who reported monthly binge drinking and met criteria for insomnia disorder.[88,89] The study differed from prior CBT-I and alcohol studies in the sample age and that participants were still actively drinking at the start of CBT-I. The only alcohol-related treatment component was the standard sleep hygiene recommendation to reduce alcohol use before bedtime. With regard to sleep outcomes, CBT-I reduced self-reported insomnia severity relatively better than the sleep hygiene control condition, although neither treatment significantly improved actigraphy-based sleep efficiency.[88,89] Although drinking quantity and drinking-related consequences both decreased over time, these outcomes were not differentially better during CBT-I.[88] However, although insomnia improvements were not related to changes in drinking, they did mediate the reduction in alcohol-related consequences in the CBT-I group. A secondary analysis reported greater (albeit modest) reductions in alcohol craving for the CBT-I group than for the control group that, again, were statistically mediated by improvements in insomnia.[89] However, those

reductions in alcohol craving were not sustained at the 1-month follow-up assessment.

In summary, the existing experimental literature on sleep predictors of alcohol outcomes during adolescence and young adulthood is confined to a handful of trials testing nonpharmacological sleep interventions in individuals reporting heavy drinking and/or AUD. Consistent with the parallel literature in adult samples, such interventions appear beneficial for sleep-related outcomes but with no clear impact on alcohol-related outcomes. However, a preliminary finding of CBT-I reducing alcohol craving is worth further investigation, as is the further development of sleep-focused treatments, perhaps including more consideration of circadian factors.

Potential Mediators and Moderators

Prior reviews have examined plausible mechanisms linking sleep/circadian disturbances to alcohol use and alcohol-related problems, with a particular emphasis on reward function.[90-92] A recent review by the authors[91] proposed a broader conceptual model that considered both positive and negative reinforcement pathways, and noted that elevated impulsivity may exacerbate either pathway. While this model may have heuristic value, it is not without limitations. These include not explicitly addressing bidirectional effects (i.e., alcohol effects on sleep/circadian function) or incorporating plausible factors that influence which pathway is most salient for a particular individual or at a given time. Further, research on sleep–alcohol associations has largely been conducted with samples of predominantly White-identifying individuals and has largely not explored possible differences in associations between sleep and alcohol across assigned sex, racial and ethnic identities, and for LGBTQIA+ individuals. The following sections offer some preliminary evidence of the importance of including diverse samples in future investigations and of examining differences in associations to ensure generalizability of future treatments and to inform culturally responsive interventions for both sleep/circadian disturbances and AUD.

Mechanisms related to positive reinforcement

Extensive cross-sectional, longitudinal, and experimental evidence from both human and preclinical studies has supported the influence of sleep/circadian factors on reward-related processes and underlying physiology[92] and, in turn, the relevance of reward-related processes to risk for alcohol use and related problems.[28,93,94]

Although relevant human experimental studies probing sleep/circadian effects on reward-related processes have been more scarce than animal models, experimental sleep deprivation protocols have demonstrated causal effects on reward-related brain function in healthy adolescent and young adult samples.[95-97] For example, experimentally imposed circadian misalignment reduced the neural response to monetary reward and during response inhibition in healthy adolescents without regular substance use.[98] The analyses included objective measures of sleep duration and alertness, thus suggesting circadian effects on reward function beyond those of insufficient sleep. However, these studies have focused on non-alcohol rewards. In contrast to emerging animal research suggesting circadian misalignment during adolescence alters reward circuitry function and increases alcohol use during adulthood,[50] almost no published human studies have examined sleep/circadian effects on alcohol cue reactivity and/or its neural correlates. Furthermore, few existing studies have combined sleep/circadian effects, reward, and alcohol outcomes, although one cross-sectional analysis found that "eveningness"—the self-reported preference for relatively later timing of sleep and activity—was associated with altered neural processing of reward, which in turn is associated with greater alcohol use and AUD symptoms.[99] A longitudinal analysis in the same study found that the prospective association between eveningness and AUD symptoms was statistically mediated by the medial prefrontal cortex response to monetary reward.[52] Most recently, a study reported that an objective measure of circadian misalignment (measured on a Thursday) prospectively predicted a lower neural response to monetary reward (measured on a Friday) in late adolescents with regular alcohol use.[100] However, the reduced neural response to reward did not prospectively predict alcohol use that weekend, but rather was associated with more binge drinking episodes at baseline. Finally, in the aforementioned CBT-I trial in adolescents and young adults reporting heavy alcohol use and insomnia, the investigators found evidence of relatively larger reductions in delay discounting (large rewards only) in the CBT-I group, although this was not mediated by insomnia severity. However, there was no apparent effect on negative affect, suggesting that improved sleep may have relatively greater effects on reward-related processes.[89]

Some evidence suggests sleep/circadian modulation of the stimulating effects of alcohol (e.g., increases in energy and excitement). This may be particularly relevant during adolescence, when alcohol may be relatively more stimulating and less sedating than in adulthood.[101-103] Notably, a relatively more stimulating response to alcohol is a risk factor for AUD. Thus, adolescents at high risk for AUD endorsed greater alcohol-induced stimulation and stronger wanting for alcohol compared to adolescents at low risk for AUD.[104] Moreover, young adults reporting greater stimulation after alcohol administration were more likely to have developed AUD by 10-year follow-up.[105] In laboratory-based sleep studies in late adolescents and emerging adults, acute alcohol administration did not reduce SOL,[36] especially when consumed in the evening,[106] suggesting the stimulating rather than sedating effects also may be influenced by time of administration. Furthermore, later sleep timing was associated with greater self-reported stimulation response

following alcohol administration in the laboratory (at least in White male participants).[107]

Lastly, sleep/circadian factors may be relevant to positive reinforcement-related alcohol cognitions. Adolescents and young adults tend to report more motives attributed to improving their social experiences and enhancing enjoyment versus motives related to attenuating negative affect (i.e., coping).[108] Given that eveningness is associated with increased alcohol motives across the board,[109] including enhancement and social motives, it is possible that the tendency toward later sleep/circadian timing in this age group contributes to reasons for using alcohol.

Mechanisms related to negative reinforcement

Adverse life events and stress levels disrupt sleep and prospectively predict AUD outcomes, both on a longitudinal basis during adolescence into adulthood,[110,111] and more proximally (day to day).[112,113] Furthermore, demonstrating sleep- or drinking-related reactivity to stress heralds the risk for sleep-[114] or alcohol-related problems[115] in the future.

Several lines of evidence indicate that sleep problems, perhaps driven by stress and/or anxiety, may lead to using alcohol as a coping method, thus implicating negative reinforcement pathways. Studies suggest that about 10% (range 6% to 16%) of adolescents and young adults report using alcohol as a sleep aid, with higher rates in individuals with heavier alcohol use and/or worse sleep.[116-118] Interestingly, one longitudinal study of adolescents with and without AUD found that their use of alcohol as a sleep aid declined over time, dropping by half from baseline to 5-year follow-up; this may reflect adolescents' learning that alcohol's effectiveness at promoting sleep declines with regular use.[119]

Compared to "good sleepers," adults with insomnia may experience relatively greater tension reduction and deeper sleep (based on slow-wave sleep) in response to alcohol, underscoring why they might initially turn to alcohol as a sleep aid. Although experimental evidence suggests they rapidly develop tolerance to these effects, these individuals often persist in choosing alcohol as a sleep aid.[120,121] Similarly, young adults with insomnia who regularly use alcohol reported better sleep efficiency on drinking days, seemingly due to shorter SOL, in a recent EMA study,[42] and reported sleeping worse on nights when they avoided alcohol in the 2 hours before bed.[122] In contrast with the experimental study,[120] the association with better sleep efficiency remained even after accounting for number of consecutive drinking days.[42] Notably, these associations were not observed for actigraphy-based sleep efficiency.

Sleep also may modulate effects of stress on alcohol use. Along with associations with drinking motives in general (see above), eveningness in college students was associated with worse coping with stress, which in turn may predict drinking to cope.[109] Another study found that late chronotypes had both more adverse childhood experiences and greater alcohol use during young adulthood.[123]

Craving-related mechanisms

Craving—a criterion for diagnosis of AUD and widely studied as a proximal predictor of alcohol use—is a complex construct, with apparent contributions of both positive- and negative-reinforcement processes.[124] Recent studies have offered preliminary evidence that alcohol craving is influenced by sleep/circadian factors. Two studies reported the presence of a 24-hour rhythm in alcohol craving,[125,126] suggesting modulation by circadian rhythms, although the studies were mixed in whether sleep characteristics predicted the timing or amplitude of the craving rhythm. Lower sleep quality was associated with elevated tonic (i.e., long-term) craving as determined using the Obsessive-Compulsive Drinking Scale, but not with cue-induced craving (as measured using the Alcohol Urge Questionnaire) during a cue reactivity paradigm in patients with AUD.[127] Finally, less sleep predicted more alcohol craving the next day in an EMA study,[51] and reductions in insomnia severity mediated reductions in alcohol craving in a CBT-I trial.[89]

Relatedly, growing evidence implicates a role for the orexin/hypocretin system in sleep-alcohol associations via both negative reinforcement and reward-related processes. Orexin/hypocretin regulates wakefulness, reward seeking, and other motivated behavior, including alcohol craving and alcohol seeking; in turn, the orexin/hypocretin system is modulated by acute and chronic stress.[128,129] Ongoing trials are testing whether suvorexant, a dual orexin receptor antagonist, can reduce both alcohol craving and insomnia symptoms.[130,131]

Impulsivity-related mechanisms

Similar to craving, the multifaceted construct of "impulsivity" may be relevant to both positive and negative reinforcement pathways in understanding sleep/circadian-related risk for alcohol involvement. In general, facets of impulsivity are considered a key risk factor for the development of heavy alcohol use and related problems.[29,32] Importantly, impulsivity facets may differentially relate to alcohol use through both positive and negative reinforcement pathways. For example, negative urgency, or acting rashly in response to strong negative mood, may reflect drinking to cope with negative mood/stress whereas positive urgency may reflect expecting alcohol to increase arousal.[132]

Multiple sleep/circadian characteristics have been linked to impulsivity domains (e.g., Kang et al.[34,35]). For example, recent prospective evidence in adolescents suggested that both sleep duration and insomnia were bidirectionally associated with impulse control.[133] Recent studies found that later chronotype was associated with greater impulsivity overall (e.g., Kang et al.[34]), including greater self-reported trait- and state-level impulsivity across multiple subdimensions in White male

drinkers.[134] Also, as noted above, experimentally imposed circadian misalignment reduced neural activation in the right inferior frontal gyrus during response inhibition in healthy and non–substance-using adolescents.[98]

Moderation by assigned sex and gender identity

Studies found that both sleep/circadian characteristics and risk for problematic alcohol use vary by assigned sex at birth (sex); however, there has been insufficient attention to the role of sex in sleep/circadian–alcohol associations. This is important as rates of AUD among female individuals have risen 84% in the past decade, compared to a 34% increase among male individuals.[135,136] Consistent with this trend, alcohol use has risen for women but not men.[137] Prior research found that female individuals reported higher levels of disturbed sleep (e.g., insomnia),[138] while male individuals tended to report later sleeping times.[139] Recent findings suggest that sleep/circadian characteristics differentially contribute to alcohol risk for male and female individuals. Indeed, recent longitudinal studies found that male individuals in particular may be at heightened alcohol-related risk attributed to sleeplessness[138,140] and later weekday/weekend bedtime.[6] However, other studies observed stronger associations between multiple sleep characteristics (e.g., total sleep time, sleep efficiency, nighttime awakenings) and alcohol-related risks among female individuals.[5,141] Factors that may contribute to increases in alcohol use and sleep disturbance among female individuals may include heightened drinking to cope with negative affect and stress.[142-144] However, these studies did not clarify whether they were measuring assigned sex or gender identity (the term "identity" is used to reflect that race and gender are social constructs[145] and that the vast majority of research on humans asks participants to self-identify their race and gender).

Inequities in sleep[146,147] and alcohol use[148] exist for individuals with minoritized gender identities (e.g., transgender, nonbinary, gender-fluid). Importantly, a recent study examining factors that influenced sleep among individuals who identified as transgender found that one-third of the sample endorsed feelings of internalized shame (i.e., distress, anxiety, and dysphoria attributed to their identity) as reason for sleep disturbance.[149]

Inequities in sleep duration[150] and alcohol use[151] also exist among individuals with minoritized sexual orientations (e.g., lesbian, gay, queer, bisexual). However, only one cross-sectional study has examined whether sleep/circadian characteristics contribute to inequities in alcohol problems and whether these associations present differently among subgroups of people with minoritized sexual orientations (e.g., bisexual women, gay men).[152] The study found that compared to heterosexual men, gay men were less likely to experience short sleep duration and reported consuming fewer alcohol drinks per day. Lesbian and bisexual women, when compared to heterosexual women, reported a greater number of alcoholic drinks per day and were more likely to use sleep medication. Further, bisexual women were more likely to experience short sleep duration and to be diagnosed with a sleep disorder compared to heterosexual women.

It is important to place these findings within a minority stress model framework, where individuals with minoritized identities are exposed to identity-based stressors[153] that occur at both interpersonal and systemic levels.[154] Identity-based stressors—defined as chronic modes of stress attributed to discrimination and internalized stigma directed at one's minoritized identity (e.g., sexual, gender, or racial identities)—are prominent predictors of health inequities, including alcohol behaviors and sleep disturbances, among individuals with minoritized sexual and gender identities.[146,155,156] However, further examination of possible differential associations between sleep indices and alcohol behaviors is needed.

Moderation by racial and ethnic identities

As a function of sociohistorical context and multiple levels of discrimination, inequities in sleep health and alcohol problems have been shown for individuals with minoritized racial and ethnic identities.[157-162] Significantly less research has examined if sleep disturbances related to discrimination contribute to the inequities in alcohol problems and whether the associations between sleep and alcohol differ among individuals with different racial or ethnic identities. Structural racism affects neighborhood-level factors that impact sleep (e.g., noise pollution) and alcohol use (e.g., alcohol outlet density), and neighborhood socioeconomic indicators (i.e., income, crime rates, discrimination) have been implicated in inequities in sleep, which may contribute to downstream poor health outcomes.[163] Specifically, studies have identified that individuals with low socioeconomic status tend to inhabit urban areas, which may be more hazardous and noisier and may have higher levels of crime. Such neighborhood characteristics have been found to be associated with greater rates of chronic sleep disturbance,[164] which in turn have been linked to heightened alcohol consumption among adolescents as reviewed above (also see Edwards, Reeves, and Fishbein[165]). As individuals with minoritized racial and ethnic identities may be more socioeconomically disadvantaged as a result of sociohistorical structural and interpersonal discrimination, these youth may be at greater risk for poor sleep quality in addition to elevated risk for alcohol use. These environmental factors may also affect associations between sleep and alcohol differently for individuals with minoritized racial or ethnic identities. All of these potential associations have direct implications for prevention and treatment.

Cross-sectional evidence suggests that alcohol use may be more disruptive to sleep for Black individuals relative to White individuals. Among men with AUD, Black men had more severe

sleep disturbances compared to White men.[166] Based on National Health Interview survey data collected between 2004 and 2015, sleep duration and sleep quality were highest in Black individuals who never consumed alcohol (i.e., lifetime abstention) and worsened as alcohol use involvement increased.[167] For White individuals, this pattern was more variable. Importantly, the racial differences in this study were more pronounced for women than men, demonstrating the importance of examining intersectionality.

Research examining associations between sleep and alcohol use in minoritized racial or ethnic groups beyond Black or African American individuals is nascent. However, consistent with research with predominantly White samples, binge drinking in adolescence has been shown to relate to poorer sleep quality in young adulthood for Mexican American and American Indian (as defined in the article) individuals.[168]

Studies examining how sleep may differentially affect alcohol use and experiences while drinking across racial and ethnic groups are even more sparse. Preliminary research found that later sleep timing was related to increased sensitivity to the stimulating effects of alcohol for White men but not Black men;[107] however, no differences existed in associations with 24-hour rhythms in alcohol craving for Black and White young adults.[125]

Other possible moderators

Multiple other moderators of the relationship between sleep/circadian factors and alcohol use are plausible but have received little attention to date, including the role of age and/or developmental stage. An exploratory analysis of the longitudinal data from the National Consortium on Alcohol and Neurodevelopment in Adolescence study[5] found a different pattern of sleep/circadian predictors of binge alcohol severity at middle- and high-school age time points versus post–high-school age time points. This difference could reflect context, given systematic early school start times versus more flexibility in schedules after high school (i.e., college and/or employment), but more research is needed to replicate and further clarify this finding.

Sleep/circadian-related risk for alcohol outcomes also may be moderated by the stage of alcohol use and related problems, potentially varying as individuals progress through the three-stage cycle framework of AUD—binge/intoxication, negative affect/withdrawal, and preoccupation/anticipation as described by Koob and Colrain.[2] The shift from enhancement motives/positive reinforcement in the binge/intoxication phase to coping motives/negative reinforcement in the withdrawal/negative affect stage could be paralleled by a shift in relevant sleep/circadian pathways. That is, accumulating alcohol use/problems may contribute to more chronic and/or more distinct sleep/circadian disturbances, which in turn may maintain or exacerbate alcohol involvement. Additionally, sleep problems have been identified as a risk factor for relapse during early abstinence in individuals with AUD.[2]

Conclusions and Future Directions

Based on the above discussion, future research on the intersection between sleep and alcohol should address existing gaps related to both research methodology and specific questions addressed. For example, future studies should employ assessment batteries able to assess multidimensional sleep/circadian characteristics and should include both self-report and objective measures, particularly objective assessments not yet sufficiently leveraged in this literature, such as the Multiple Sleep Latency Test to assess daytime sleepiness. Research also can benefit from the use of combined longitudinal and intensive longitudinal designs, such as EMA bursts within a larger longitudinal study framework, which will allow consideration of both different timescales and parsing of between-person (trait) and within-person (state) effects.

Such studies should further explore the role of relevant moderators, with particular attention to sleep–alcohol associations for individuals with minoritized identities. Equally important is consideration of the association between sleep and cannabis use, including simultaneous use with alcohol, given the high prevalence of this practice in late adolescents and young adults and evidence suggesting somewhat opposing effects of both substances on sleep. Examination of potential differences in sleep–alcohol associations across international samples could help determine how varying cultural contexts may differentially influence sleep, alcohol use, and their association.

Furthermore, experimental research is needed to demonstrate causal effects of sleep/circadian manipulations on alcohol-related risk. Additionally, experimental studies using approaches such as forced desynchrony or ultradian sleep-wake protocols could help parse the role of circadian versus sleep homeostatic contributions in modulating alcohol-related processes (e.g., alcohol craving).

Other research gaps to be addressed include the clarification of potential shared genetic variance and/or pleiotropic contributions to sleep–alcohol associations, which should further clarify trait- versus state-level effects, as well as investigation of different mechanistic pathways linking sleep to alcohol outcomes. These ideally should allow for comparison of distinct pathways within the same dataset and include not only the putative mechanisms described above (e.g., reward function, negative reinforcement, impulsivity) but also others that may well be worth consideration, such as hypothalamic-pituitary-adrenal axis function.

Finally, research gaps exist with respect to treatment of adolescents and young adults with both alcohol problems and

sleep problems. Rigorous treatment studies in this population are needed that go beyond CBT-I to include attention to circadian factors, and with sufficient follow-up periods to better elucidate differential effects on alcohol.

Overall, the existing longitudinal and experimental evidence indicates that a range of sleep/circadian characteristics during adolescence and young adulthood influence risk for the development of alcohol use and/or related problems. Although studies in late adolescents and young adults engaging in regular and/or heavy drinking show that sleep treatment can improve sleep in those individuals, as well as potentially reduce alcohol craving and alcohol-related consequences, no studies in any age group have yet demonstrated that improving sleep reduces drinking behavior. Future research embedding intensive longitudinal studies within prospective research studies is needed to understand the underlying mechanistic pathways from sleep and circadian rhythm to differential alcohol use behaviors and problems as there is evidence that specific sleep indices may relate to certain AUD criteria.[169] Such studies could hold promise for informing treatment for both sleep problems and AUD.

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SCOPING REVIEW

Simultaneous Alcohol and Marijuana Use Among Young Adults: A Scoping Review of Prevalence, Patterns, Psychosocial Correlates, and Consequences

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BACKGROUND: Alcohol and marijuana are commonly used by young adults, and use of both substances, particularly at the same time, is prevalent among this population. Understanding the prevalence, patterns, correlates, and consequences of simultaneous alcohol and marijuana (SAM) use is important to inform interventions. However, this literature is complicated by myriad terms used to describe SAM use, including use with overlapping effects and same-day co-use.
OBJECTIVES: This scoping review identifies and describes the peer-reviewed literature focused on SAM use by young adults and distinguishes simultaneous use from same-day co-use of alcohol and marijuana. This review also provides a narrative summary of the prevalence of SAM use, patterns of SAM and other substance use, psychosocial correlates, and consequences of SAM use.
ELIGIBILITY CRITERIA: This review is limited to papers written in English and published in peer-reviewed journals between January 2000 and August 2021. It includes papers assessing simultaneous use or same-day co-use of alcohol and marijuana among young adults ages 18 to 30. Review papers, qualitative interviews, experimental lab studies, policy work, toxicology or medical reports, and papers focused on neurological outcomes are excluded.
SOURCES OF EVIDENCE: PubMed, PsycINFO, and Web of Science databases were searched. Databases were selected and the search strategy developed in consultation with an information specialist.
CHARTING METHODS: A data charting form was utilized to specify which information would be extracted from included papers. Eight categories of data were extracted: (1) research questions and hypotheses; (2) sample characteristics; (3) study procedures; (4) definition of SAM use; (5) prevalence of SAM use; (6) patterns of SAM and other substance use; (7) psychosocial correlates of SAM use; and (8) consequences of SAM use.
RESULTS: A total of 1,282 papers were identified through initial search terms. Through double-blind title/abstract screening and full-text review, the review was narrowed to 74 papers that met review inclusion criteria. Review of these papers demonstrated that SAM use was prevalent among young adults, particularly among those who reported heavier quantities and more frequent use of alcohol and marijuana. Enhancement-related motives for use were consistently positively associated with SAM use. SAM use was associated with greater perceived positive and negative consequences of alcohol and/or marijuana use. Inconsistencies in prevalence, patterns, correlates, and consequences were found between studies, which may be due to large variations in measurement of SAM use, populations studied, methodological design (e.g., cross-sectional vs. intensive longitudinal), and the covariates included in models.
CONCLUSIONS: The literature on simultaneous use and same-day co-use of alcohol and marijuana has expanded rapidly. Of the 74 included papers (61 on SAM use; 13 on same-day co-use), 60 papers (47 on SAM use; 13 on same-day co-use) were published within the last 5 years. Future research focusing on the ways in which SAM use confers acute risk, above and beyond the risks associated with separate consumption of alcohol and marijuana, is needed for understanding potential targets for intervention.

KEYWORDS: alcohol; marijuana; cannabis; co-use; simultaneous; review; young adult

Alcohol and marijuana are two of the most commonly used substances among young adults in the United States. In the past year, approximately 82% of young adults ages 19 to 30 reported alcohol use and 42% reported marijuana use.[1] Independently, these two substances are associated with numerous short- and long-term risks and harms.[2-5] Those who use both alcohol and marijuana, and in particular those who use both at the same time so that the effects overlap, experience more negative consequences (e.g., getting hurt, heated arguments, trouble with the law) than do individuals who use the substances separately (e.g., alcohol-only or marijuana-only use) or use on the same day but their effects do not overlap.[6,7] Furthermore, cannabis use disorder and alcohol use disorder often overlap, with more than 86% of individuals with a history of cannabis use disorder also meeting current criteria for alcohol use disorder.[8,9] Thus, understanding alcohol and marijuana use—and more specifically simultaneous use of these substances—is critical for the development of prevention and intervention efforts aimed at reducing consequences during the high-risk developmental period of young adulthood.

Simultaneous alcohol and marijuana (SAM) use is generally defined as using both substances at the same time so that their effects overlap. However, this terminology is not always consistent, and SAM use is sometimes also referred to as same-day use, co-use, or cross-fading, among other terms. In contrast, use of both alcohol and marijuana in general, but not necessarily at the same time or on the same day, is considered concurrent use; this is also sometimes referred to as co-use, polysubstance use, or co-occurring use, among other labels.[7,10] A recent focus in the literature has been on trends in concurrent use, such as how changes in marijuana use are associated with changes in alcohol use, and whether use of the two substances is based on complementary (i.e., rising and falling together) or substitution (i.e., one replaces use of the other) effects. (For reviews, see Guttmannova et al.,[11] Subbaraman,[12] and Risso et al.[13]) Given the variation in the operationalization of SAM use, and the application of often similar or the same terms to SAM use as concurrent use, it can be difficult to synthesize the literature specific to SAM use. Not only is it important to understand associations between alcohol and marijuana use in general, or among people who use both, but there is a need to better understand the prevalence, patterns, correlates, and consequences associated with simultaneous use. This is particularly important among young adults, as SAM use prevalence among this age group has been increasing historically.[14] Recent data suggest that many who use both alcohol and marijuana sometimes use both simultaneously[6,15] and are at the highest risk for engaging in SAM use.[14,16]

Recent acknowledgment of the need to identify situational risk factors has led to the examination of proximal predictors of SAM use, including social contexts. The use of timeline follow-back (an assessment method using a calendar and anchoring dates to obtain substance use estimates with retrospective reports on each day of a given period),[17] and daily and ecological momentary assessments (i.e., repeated assessments of substance use behaviors in real time and natural environments)[18] have provided a finer-grained understanding of patterns, correlates, and consequences at the event level. These repeated-measures methods allow for examination of associations between people (e.g., what distinguishes individuals who engage in SAM use from those who do not) and within people (e.g., what distinguishes situations when SAM use occurs compared to when it does not).

The Current Study

The purpose of the present scoping review was to do a comprehensive search for papers referencing SAM use by young adults and to organize the authors' current understanding around this literature to inform future research and intervention work. To the authors' knowledge, this is the first scoping review of this kind. Given the variability in definitions of SAM use in the extant literature, this review was inclusive of studies that examined use of both alcohol and marijuana on the same day without specifying use at the same time or within a specified time period (i.e., same-day co-use), to allow for greater synthesis of findings across study populations and research designs as well as for comparison of SAM use and same-day co-use. The objective of this review was to summarize research on the prevalence of SAM use, patterns of SAM and other substance use, psychosocial correlates (i.e., motives, norms, situational contexts), and consequences of SAM use. Where appropriate, results from studies utilizing repeated-measures designs to summarize the field's current understanding of situation-level risk are highlighted.

Methods

Protocol and Registration

The protocol was based on the 22-item Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR).[19] The protocol was not preregistered, but it can be obtained upon request from the corresponding author.

Eligibility Criteria

Sources of evidence (i.e., papers) were eligible for inclusion if they (1) were published in peer-reviewed journals between January 2000 and August 2021, (2) were written in English, (3) used human participants in the young adult age range (e.g., ages 18 to 30), and (4) included a focus on or measurement of simultaneous use or same-day co-use of alcohol and marijuana. Papers were excluded if they were review papers,

experimental laboratory research, qualitative research, or if they exclusively evaluated policy. In addition, the criteria were refined to exclude neuroscience studies (however, one was included that discussed patterns of SAM and other substance use) and those in which SAM use was based on toxicology or medical reports. The young adult age-related inclusion criterion was meeting one or more of the following: (1) the majority (51% or more) of the sample was between the ages of 18 and 30; (2) the mean or median age of the sample was between the ages of 18 and 30; (3) participants were in 12th grade or college (even if the age was not provided); or (4) an age range that included ages outside of 18 to 30, but with separate findings provided for young adults ages 18 to 30.

Information Sources and Search Strategy

Electronic databases searched included PubMed, PsycINFO, and Web of Science. The electronic search strategy was developed by the team's information specialist and refined through team discussion (see Table 1). The initial search was performed on February 24, 2021. After removing duplicates, papers identified by the search were entered into a Covidence database, which facilitates the use of PRISMA methodology (see Figure 1). An additional PubMed search without the MEDLINE-limiter "humans" was performed on May 20, 2021, to screen papers included in PubMed but not indexed by MEDLINE (e.g., smaller journals, manuscripts deposited into PubMed Central); a final search was conducted on August 25, 2021, to update search results prior to publication. These additional searches used the same strategy as the initial search and were performed by the team's information specialist.

Table 1. Search Criteria for Each Database

Database	Search Strategy	No. of Results Retrieved
PubMed	Original search: February 2021 ((adolesc* OR teen* OR youth* OR "young adult*" OR "young people*" OR "young person*" OR college* OR "high school*" OR "secondary school*" OR "emerging adult*") AND (alcohol OR drink* OR ethanol) AND (marijuana OR cannabi* OR THC) AND ((cross-fad* OR crossfad*) OR (simultaneous* OR concurr* OR cooccur* OR co-occur* OR co-use*))) AND ((humans[Filter]) AND (English[Filter])) May 2021 search (without the "humans" limit) August 2021 search (without the "humans" limit)	705 4 53
PsycINFO	Original search: February 2021 1. (cross-fad* OR crossfad* OR simultaneous OR concurr* OR cooccur* OR co-occur* OR co-use*) 2. (alcohol OR drinking OR ethanol) AND (marijuana OR cannabi* OR THC) 3. (adolesc* OR teen* OR youth* OR young adult* OR young people* OR college* OR high school* OR secondary school* OR emerging adult*) Limits: Human, English, all journals August 2021 search	700 49
Web of Science	Original search: February 2021 1. TS = (cross-fad* OR crossfad* OR simultaneous OR concurr* OR cooccur* OR co-occur* OR co-use) 2. TS = (alcohol OR drinking OR ethanol) AND ALL = (marijuana OR cannabi* OR THC) 3. TS = (adolesc* OR teen* OR youth* OR young adult* OR young people* OR young person* OR college* OR high school* OR secondary school* OR emerging adult*) Limits: English August 2021 search	706 54

Note: THC, delta-9-tetrahydrocannabinol; TS, topic search.

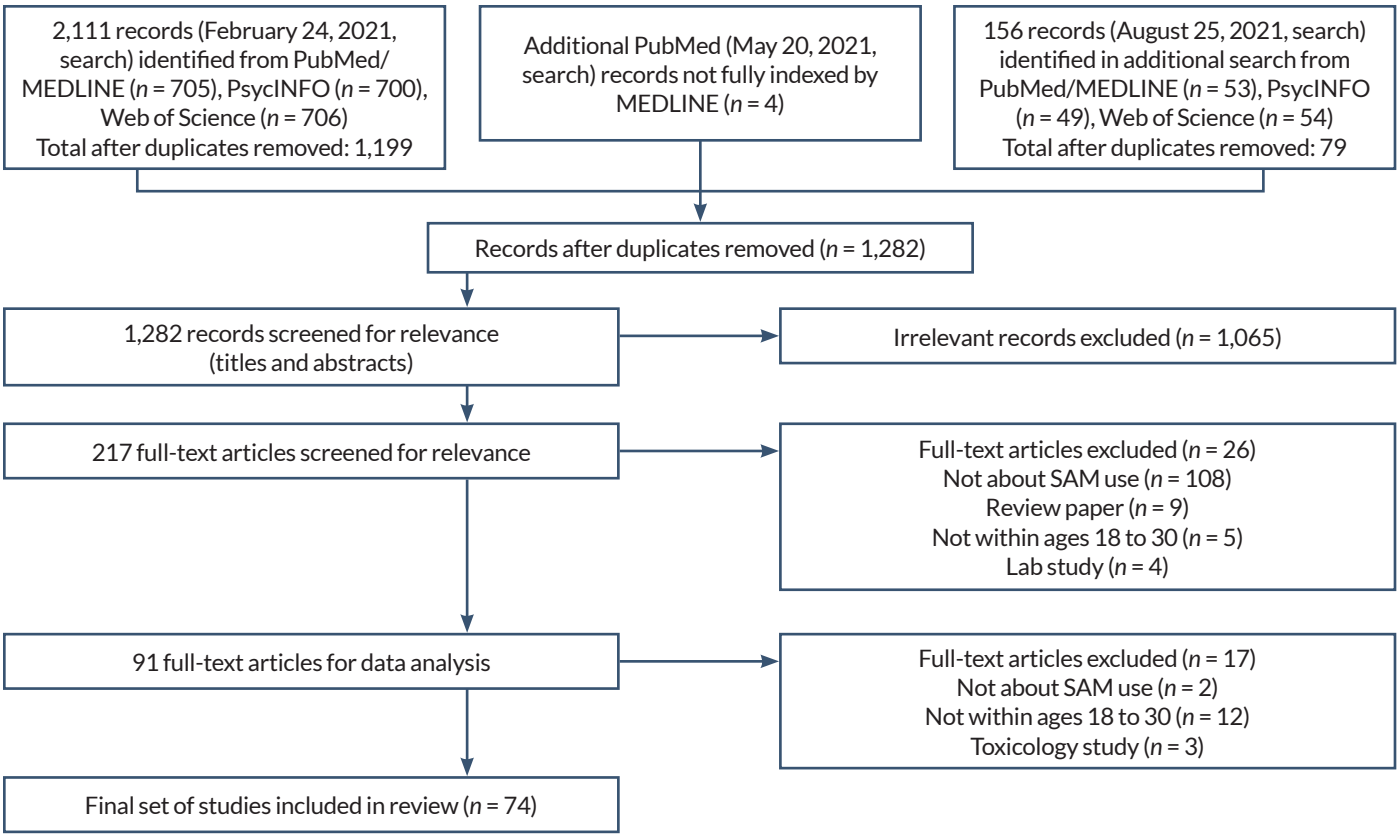

Figure 1. Flow diagram showing literature search and selection of articles. *Note:* SAM, simultaneous alcohol and marijuana.

Selection of Sources of Evidence

Sources of evidence were selected through double-blinded title and abstract screening and full-text review performed in Covidence by four of the authors. The titles and abstracts of all papers identified by the electronic database search were screened by two of the four authors involved at this stage to assess eligibility for inclusion. The full texts of papers not excluded during title and abstract screening were also reviewed by two of the four authors to definitively determine whether papers met all eligibility criteria. Reasons for exclusion decisions were catalogued by Covidence, and disagreements were resolved through discussion.

Data Charting Process and Data Items

Prior to data extraction/charting, the research team developed a data charting form specifying which information would be extracted from included papers. Eight categories of data were extracted: (1) research questions and hypotheses; (2) sample characteristics (i.e., eligibility criteria, age, gender, race/ethnicity) and recruitment procedures; (3) study procedures (i.e., study design, analytic method); (4) SAM use definition; (5) prevalence of SAM use; (6) patterns of SAM and other substance use; (7) psychosocial correlates of SAM use; and (8) consequences of SAM use. Findings generally were extracted only from the text of the results sections to limit assumptions in interpretations of these findings. Information included in tables but not described in the text of the results sections was generally not extracted. The authors met several times to discuss what types of information were to be collected in each category. Papers were divided among the authors, who then extracted the relevant data into the data charting form for each paper. Data items and categories were then divided among authors, and a second author reviewed and revised the extracted data in the data charting form for each data item/category.

Synthesis of Results

Evidence from included papers was grouped into the four areas identified in the review's objectives: (1) prevalence of SAM use, (2) patterns of SAM and other substance use, (3) psychosocial correlates, and (4) consequences of SAM use. Results are presented in narrative format. Some papers provided evidence in more than one area of focus and are included in more than one subsection of the results. Other papers that did not clearly specify SAM use (e.g., those that assessed a broader range of polysubstance use that included illicit drugs such as cocaine, 3,4-methylenedioxymethamphetamine (MDMA or Ecstasy), or psilocybin mushrooms in addition to alcohol and marijuana) or did not directly test associations within the review's objectives (e.g., papers in which SAM use was tested as a moderator) are retained in Appendix 1 but are not described in the Results section.

Results

Selection of Sources of Evidence

As shown in the PRISMA diagram in Figure 1, the initial electronic database searches conducted in February 2021 identified 2,111 records (1,199 nonduplicate papers) related to SAM use or same-day co-use that were written in English and published in peer-reviewed journals between January 2000 and February 2021. After abstract and title screening, 179 papers were deemed eligible for full-text review. After full-text review, 55 papers met all inclusion criteria and were included in the scoping review. A second PubMed search was conducted in May 2021 yielding four additional records (no duplicated papers), all of which were deemed eligible for full-text review and three of which are included in the scoping review. A third search of all three databases in August 2021 identified 156 records (79 nonduplicate papers) published since the date of the initial search (February 2021), of which 34 were deemed eligible for full-text review and 16 met all inclusion criteria and are included in the scoping review. In summary, 1,282 nonduplicate papers related to SAM use or same-day co-use were identified, 217 papers underwent full-text review, and a total of 74 papers are included in this scoping review.

Characteristics of Sources of Evidence

Appendix 1 provides a list of all 74 papers identified in the final search for relevance for this scoping review. The appendix includes each paper's methodological design, population, age range, sample size, SAM definition, and whether it is included in the Results section of this review in reference to prevalence, patterns, correlates, and/or consequences of SAM use.

To capture all relevant papers, the authors started the search with inclusive terms for young adult and concurrent or simultaneous alcohol and marijuana use and then systematically reviewed these papers for relevance to SAM use or same-day co-use. This process resulted in a set of papers that was more focused, but continued to vary widely in sample, methods, and measures. The time frames (e.g., yesterday, past month, past 3 months, past year) and response options (e.g., dichotomous, ordinal) of SAM use measures differed between papers. Of the papers included in this review, use was operationalized into four categories based on whether alcohol and marijuana use were specified as occurring simultaneously or overlapping or within different dimensions of same-day use. The categories include using alcohol and marijuana:

- At the same time or together so that their effects overlapped (n = 27 papers)
- On the same day within a specified time period (e.g., within 3 hours of each other; n = 9 papers)
- At the same time or together without specifying that their effects overlapped or at the same event or occasion without specifying overlapping effects of use within a specified time period (e.g., at the last party attended, during the current night out; n = 25 papers)
- On the same day without specifying that they were used together or within a specified time period (n = 13 papers)

After careful discussion, the authors categorized SAM use as being inclusive of the first three categories. The fourth category was considered "same-day co-use"—rather than SAM use—because it could not be determined whether alcohol and marijuana use were overlapping or used in relatively close timing with each other. The same-day co-use category was included in this review given varying definitions of SAM use to sometimes include these types of definitions. By inclusion, it may help specify differences in findings. Therefore, of the 74 included papers, 61 were categorized as SAM use and 13 as same-day co-use.

Of the 74 papers, 36 analyzed cross-sectional data and 38 analyzed longitudinal data. Of the papers reporting longitudinal data, nine used data from panel studies with various follow-up intervals, and 22 used data from daily or ecological momentary assessment studies that allowed for testing between- and within-person associations. The remaining seven papers used data collected via the timeline follow-back method, in which participants reported their substance use at a single time point, but the assessment referenced a past series of days (e.g., past month), resulting in a series of day- or occasion-level substance use reports.

Of the 74 included papers, 45 (61%) focused exclusively on young adults ages 18 to 30; 18 (24%) used samples including individuals on the younger end of the age range (e.g., 12th-grade students) or included both late adolescents and young adults; and 11 (15%) included a larger age range of adults, with either a majority of the sample in the young adult age group or estimates stratified by age ranges.

Prevalence of SAM Use

There were eight papers from nationally representative U.S. samples. Six were from the Monitoring the Future (MTF) study, and two were from the National Alcohol Survey. Estimates based on MTF data indicated that 20% to 25% of 12th-grade students (modal age 18) reported past-year SAM use, both when averaging across longer time periods (e.g., 1976–2011) and shorter, more recent periods (e.g., 2007–2016).[15,20-22] An estimated 6% to 7% of 12th-grade students engaged in SAM use most or all of the time.[20,21] Similar findings were noted at later ages (e.g., modal ages 19 or 20 through 29 or 30) in papers following MTF participants longitudinally.[14,16] Estimates based on National Alcohol Survey data found that approximately 15% of young adults ages 18 to 29 who reported drinking in the past year also reported past-year SAM use in data from 2000, 2005, and 2010.[6,23]

Historical trends

Three papers, all from MTF, reported on historical trends in SAM use over sufficiently long periods of time with nationally representative U.S. samples.[14,20,21] Overall trends in SAM use were closely tied to trends in marijuana use and alcohol use.[14,20,21] Among 12th-grade students who reported marijuana use, SAM use trends were highly correlated with alcohol use.[21] Correspondingly, among young adults who reported alcohol use, SAM use trends were highly correlated with trends in marijuana use prevalence.[14] Generally, the prevalence of past-year SAM use among 12th-grade students was highest in the late 1970s, decreased throughout the 1980s and early 1990s, increased during the mid- and late 1990s, and was relatively stable from the late 1990s until 2007, when a slight increase was observed through 2011.[20] Among young adults who used alcohol, SAM use trends varied by age.[14] For those ages 19 to 28, SAM use prevalence generally decreased from the mid-1970s through the early to mid-1990s, but prevalence was stable for those ages 29 or 30.[14] From the early to mid-1990s through 2011, trends continued to vary by age, ranging from an increase through the mid-2000s followed by no significant change for those ages 19 or 20, to generally consistent increases in use for those ages 21 to 26, to stable use prevalence for those ages 27 or 28.[14]

Demographic characteristics

Most papers examining gender and/or sex differences in SAM use, including those using nonrepresentative samples, found that a greater proportion of males than females engaged in SAM use.[15,23-28] One paper also found that males consumed greater amounts of alcohol and were high for greater lengths of time on SAM use days than females.[29] Fewer papers examined race/ethnicity differences. Those that did generally found that White young adults, in comparison to young adults of other racial/ethnic groups, were more likely to engage in SAM use, did so more frequently, and tended to consume greater quantities of alcohol and marijuana when engaging in SAM use.[15,16,21] However, these findings were not consistent, and some depended on whether analyses were bivariate or multivariate. Only one paper examined age differences in SAM use during young adulthood with rigor.[14] This paper used MTF data to estimate SAM use prevalence among young adults who drank alcohol at six modal ages and found SAM use prevalence was highest between ages 19 and 22 at approximately 30%, decreased throughout the twenties, and reached 19% at modal age 29 or 30. A few papers examined differences in SAM use between full-time 4-year college students and non–college students.[16,30] One paper found the likelihood of SAM use was higher for college students not living with their parents relative to those living with their parents.[16] Another paper found that the within-person association between alcohol and marijuana use was weaker for college students compared to young adults not in college.[30]

Patterns of SAM and Other Substance Use

SAM use appears to be most common among individuals who use alcohol, marijuana, or illicit drugs more frequently and in greater amounts. Many papers found SAM use was greater among those who engage in heavier drinking and marijuana use.[16,20-24,28,31-38] For instance, one paper found that SAM use was most prevalent among those using four or more modes of cannabis administration (e.g., joint, bong, vape, edibles).[39] Another found that individuals who engaged in more frequent SAM use had a greater likelihood of any illicit drug use (not including marijuana).[21]

Six papers using mixture models (e.g., latent class/profile analysis) to examine patterns of SAM use with other substance use found similar results. Generally, latent classes with high probabilities of SAM use also had high probabilities of other risky substance use behaviors (e.g., using alcohol and marijuana with greater frequency or in greater quantities, experimentation with illicit drugs).[15,40-42] In three of these papers, SAM use distinguished one or more latent classes of individuals who use substances from others.[15,40,41] The probability of using tobacco and other drugs (i.e., other than alcohol, marijuana, tobacco) was 50% or greater in each profile associated with SAM use.[43] One paper using mixture models was an exception in that it found that the latent class with the lowest probabilities of substance use reported the highest past-year frequencies of SAM use.[44] However, this paper's findings may be biased due to its eligibility criteria (e.g., past-year alcohol, marijuana, and tobacco use), sampling method (i.e., convenience sampling from Craigslist), and sample characteristics (i.e., 89% male; 86% White).

Papers examining daily associations of SAM use or same-day co-use with alcohol and marijuana in terms of consumption and intoxication have produced inconclusive findings. Regarding daily associations between SAM use and alcohol intake, one paper found that young adults consumed more alcohol on SAM use days relative to alcohol-only use days,[32] whereas another paper found no differences in alcohol (number of drinks) or marijuana (number of hits) consumption on SAM use days relative to alcohol- and marijuana-only use days, respectively.[45] For same-day co-use, several papers found that more alcohol was consumed on days marijuana was also used relative to days that only alcohol was used.[46-48] Between-person findings in these papers provided some evidence that greater average alcohol intake was associated with more frequent SAM use[32] and less frequent same-day co-use.[46,47]

Regarding daily associations between SAM use and intoxication, one paper found that young adults reported greater subjective intoxication on SAM use days as compared to both alcohol-only and marijuana-only use days,[49] whereas another found no differences in level of subjective intoxication on SAM use days as compared to both alcohol-only and marijuana-only use days.[45] Some evidence suggests that SAM use may moderate associations between alcohol and marijuana intake and subjective intoxication such that these associations are weaker

on SAM use days relative to alcohol-only and marijuana-only use days, respectively.[49] For same-day co-use, one paper found that estimated blood alcohol concentrations were higher on days when both alcohol and marijuana were used relative to days when only alcohol was used.[46] Another paper examining same-day co-use found that young adults tended to drink less alcohol on days when marijuana was used before alcohol.[50]

Psychosocial Correlates of SAM Use

Situational and peer context

Eight papers examined contexts associated with SAM use.[21,25,31,38,51-54] Overall, context was an important correlate associated with SAM use across samples (community, treatment seeking) and designs (cross-sectional, event-level). However, findings on specific settings were mixed. Among papers using cross-sectional data, SAM use was significantly less likely to occur in bars and restaurants compared to outdoor and public locations (e.g., park, beach).[52] However, the likelihood of SAM use was higher in settings in which more people were perceived to be intoxicated,[52] and individuals had increased odds of SAM use if they engaged in more alcohol and/or marijuana use in certain settings (e.g., park).[21] In contrast, among a sample of treatment-seeking adults in Canada, SAM use was more likely than marijuana use alone to occur across settings and social compositions, including at home (alone or with friends), at work/school (alone or with friends), with strangers, at bars or taverns, and when driving a car.[25]

Findings from papers using daily or ecological momentary assessment data were also mixed. Associations between contexts and SAM use seemed to differ based on participants' ages as well as whether the comparison day was alcohol-only or marijuana-only use.[51,54] One paper found that college students were more likely to engage in SAM use—compared to alcohol-only and marijuana-only use—at a friend's place.[54] These students were also more likely to engage in SAM use at parties and less likely to engage in SAM use at a bar or restaurant relative to alcohol use only.[54] This paper also found that college students were more likely to engage in SAM use relative to marijuana use only in contexts with greater numbers of people.[54] Another paper found that associations between SAM use and contexts differed between young adults under age 21 and those age 21 and older.[51] For those under age 21, SAM use was more likely to occur at home than alcohol-only use, but odds of SAM use across other physical contexts did not differ from alcohol-only use. For those age 21 and older, SAM use, compared to alcohol-only use, was more likely to occur at a friend's house or outdoors and less likely to occur in a bar or restaurant. For those age 21 and older but not those under age 21, SAM use was less likely than alcohol-only use to occur when young adults were alone.[51]

Two papers using longitudinal data examined the relationship between social networks and SAM use. In a paper on the role of friends among college students, data collected over two semesters showed that having a greater proportion of friends who used alcohol or marijuana was related to greater likelihood of simultaneous use compared to concurrent use.[31] In an investigation of how changes from early to late adolescence were associated with SAM use in young adulthood, time with peers using alcohol and marijuana in sixth or seventh grade was predictive of greater likelihood of SAM use in young adulthood (mean age = 20.7).[53] Similarly, greater alcohol and marijuana use by a sibling or an important adult during adolescence was associated with SAM use in young adulthood, although family effects were no longer significant when all domains (individual, peer, family, neighborhood) were included.

Motives for use

A total of seven papers included measures of motives in relation to SAM use or same-day co-use.[21,25,55-59] Across samples, designs, and measures, motives (particularly SAM-specific motives) were found to be an important correlate of SAM use. Two papers (one using cross-sectional data and one using longitudinal data) described the factor structure and validity of four-factor SAM-specific motives measures, including motives for conformity, positive effects, calm/coping, and social.[55,56] The subscales from these SAM-specific motives measures were associated with the frequency of SAM use in the past month[55] and the past 3 months[56] after controlling for alcohol- and marijuana-specific motives.

Three papers utilized daily methods to assess the associations between motives and SAM use or same-day co-use among community samples.[57-59] In a paper assessing both cross-fading motives (i.e., use of alcohol and marijuana at the same time to enhance the positive effects of alcohol or marijuana) and general substance use motives across SAM use occasions, greater cross-fading motives were associated with alcohol use outcomes at the between- and within-person level.[58] Further, enhancement, social, and coping motives were positively associated with alcohol and marijuana use at the within-person level, and general enhancement and coping motives were associated with greater alcohol and marijuana use at the between-person level. When examining general or substance-specific motives, elevated enhancement and coping motives on alcohol use occasions and social motives on marijuana use occasions were associated with a greater likelihood of SAM use at the between-person level.[59] Within-person, elevated conformity, enhancement, and coping motives on alcohol use occasions, as well as social, conformity, and coping motives on marijuana use occasions, were associated with a greater likelihood of SAM use. Finally, compared to days when only marijuana was used, same-day co-use of alcohol and marijuana was associated with elevated marijuana-related enhancement and social motives.[57] Together, these findings show that enhancement motives emerge as an important correlate of SAM use, but other motives (coping, social, conformity) have mixed findings.

Finally, two papers using cross-sectional data examined the "reasons"[21] for and "functions"[25] of SAM use. Similar to the paper

on cross-fading motives,[58] among a national sample of 12th-grade students, using alcohol to increase the effects of another drug had a stronger association with frequency of SAM use than other alcohol-related motives for use.[21] Finally, compared to marijuana use only, SAM use was more likely to occur across all functions assessed, with the greatest odds occurring for self-medication reasons (e.g., "to calm myself down") among treatment-seeking individuals in Canada.[25]

Social norms

Two papers using cross-sectional data found perceived descriptive norms (e.g., perceptions of prevalence and/or quantity of peer substance use) and SAM use frequency were positively associated in samples of college students[60] and community young adults.[35] Further, both papers found that individuals who engaged in SAM use, compared to individuals who used only alcohol[35] and individuals who used alcohol or marijuana but did not engage in SAM use,[60] endorsed greater descriptive norms of their friends' and/or peers' substance use, as measured by the perceived number of drinks in a typical week[35] or the percentage of friends and peers who engaged in SAM use at least monthly.[60]

Expectancies and perceived risk

Two papers included information related to outcome expectancies for alcohol use[52] and SAM use.[53] In one paper, cross-sectional research found that negative expectancies for alcohol-related outcomes were associated with decreased odds of SAM use, but positive expectancies were not associated with odds of SAM use.[52] SAM-specific expectancies were not assessed. In contrast, a longitudinal study examining changes from early to late adolescence found that increases in positive expectancies of SAM use during late adolescence were predictive of SAM use in young adulthood.[53]

Two papers included perceived risk of SAM use. One paper using daily assessment data from a community sample of young adults found that SAM use was especially likely to occur among those with a lower perceived risk of SAM use.[30] Another study using cross-sectional data found that individuals who engaged in heavier alcohol and marijuana use were more likely to have experienced cross-fading (i.e., intoxication from alcohol and marijuana at the same time) and perceived cross-fading as more desirable and less risky.[61]

Other psychosocial or cognitive factors

A cross-sectional study examining behavioral economic demand indices found that individuals who engaged in SAM use exhibited greater overall expenditures on alcohol compared to individuals who used alcohol and marijuana concurrently; moreover, individuals who engaged in SAM use were less sensitive to alcohol price increases than were individuals who used both substances concurrently.[62] In additional papers, SAM use was positively associated with sensation seeking among a community sample who engaged in past-year SAM use,[35] was not associated with working memory in a community sample,[63] and was less likely to occur on days on which college students used certain adaptive emotion regulation strategies (i.e., reappraisal, problem-solving).[64] In addition, SAM use was positively associated with depressive symptoms cross-sectionally in a community sample[52] and in a national sample of young adults.[23] Compared to alcohol-only use, SAM use and SAM use frequency were associated with higher levels of psychosis, oppositional defiant disorder, and conduct disorder in a community sample of young adults.[28] Another paper found that young adults who reported more depressive symptoms across 2 years also reported more frequent SAM use; furthermore, during months with more depressive symptoms, young adults engaged in more SAM use compared to months when they used alcohol only (levels of depressive symptoms did not differ across months with SAM use compared to neither alcohol nor marijuana or concurrent use).[65] Further, SAM use was positively associated with likelihood of alcohol dependence.[23] Among a Swiss population that engaged in same-day co-use of alcohol and marijuana, symptoms of alcohol use disorder and cannabis use disorder appeared to be associated with distinct clusters of symptoms rather than overlapping disorders.[66]

Consequences Associated With SAM Use

Negative consequences of SAM use

Thirty-three papers (14 cross-sectional, five longitudinal, and 14 event-level) examined associations between SAM use or same-day co-use and the negative consequences of use. The measurement of negative consequences in these papers largely centered around alcohol, and papers varied widely in their definition and measurement of consequences. This assessment typically involved pooling items from existing alcohol and/or marijuana consequence measures and modifying the instructions (e.g., "Below is a list of things that sometimes happen to people either during or after they have been drinking alcohol or using marijuana."[24]). Among most cross-sectional and longitudinal papers,[6,23,24,28,35,36,38,55,56,60,65,67,68] evidence consistently suggested a positive association between SAM use or same-day co-use and number of negative consequences experienced, even after controlling for demographics, impulsivity, delinquency, motives, alcohol use, and/or marijuana use. Of these papers, half focused on comparing individuals who engage in SAM use to individuals who use both substances concurrently or individuals who use alcohol only,[6,24,35,36,38,68] whereas the remaining focused on SAM use frequency as a predictor of consequences.[23,28,55,56,60,67] In both college and community samples, individuals who engaged in SAM use reported a greater number of negative consequences relative to those who used alcohol only,[24,35,36] though findings were mixed when comparing individuals who engaged in SAM use with those who used concurrently.[24,36,38] Papers on SAM use frequency showed a similar pattern, with more frequent SAM use associated with greater negative consequences.[55,56,60]

Others have found that using only specific marijuana–alcohol combinations, such as combining only leaf or concentrate marijuana products with beer, during the same occasion may actually decrease the odds of negative SAM-related consequences relative to using multiple marijuana products (e.g., leaf, concentrate, edible) and/or multiple alcohol products (e.g., beer, wine, liquor).[33] Interestingly, ordering effects (i.e., using alcohol before marijuana vs. using marijuana before alcohol) on same-day co-use occasions were not associated with the number of negative consequences.[49,50] Days with heavy episodic drinking (HED; i.e., 4+/5+ drinks for women/men) and marijuana use were associated with increased risk for consequences relative to days in which young adults engaged in non-HED drinking, non-HED drinking and marijuana use, and/or marijuana-only use.[49,69] Notably, non-HED drinking occasions may not differ from non-HED and marijuana use occasions or marijuana-only occasions with regard to alcohol consequences.[69]

Although most papers examined consequences broadly, a subset of papers investigated specific consequence types, including academic, cognitive, social, sexual, aggression, and sleep-related.[6,23,24,36,65,67,68,70-72] Compared to those who used alcohol only, individuals who engaged in SAM use were at higher risk across consequence types,[6,23,24,36] including alcohol-related harms (e.g., problems with relationships, finances, work, or health).[6] Fewer papers included individuals who used alcohol and marijuana concurrently but did not engage in SAM use, as a comparison.[6,24,36] Among those papers, individuals who engaged in SAM use reported more blackouts, risky driving, and negative academic consequences,[24,36] but differences in social consequences were mixed.[6,36] This elevated risk—both broadly and for specific types of consequences—appeared to be a function of high-intensity drinking (i.e., drinking more than twice the binge drinking threshold)[68] and more frequent simultaneous use.[24] Other factors, such as SAM-specific norms and motives, also were found to increase negative consequences,[55,56,60,73] including those specific to marijuana use[55] and SAM use.[56] Interestingly, young adults tended to attribute the consequences they experience more to alcohol use than to SAM use.[24]

Among the papers using daily assessments, both between- and within-person effects of SAM use on negative consequences have emerged.[32,33,45,49,58,74,75] Although most of the papers in this area assessed consequences specific to substance use type (i.e., alcohol, marijuana, SAM), some combined consequences across substances (e.g., total substance-related consequences).[45,49] At the between-person level, young adults with stronger cross-fading motives on average reported more negative alcohol consequences, but not more negative marijuana consequences.[58] At the within-person level, the effect of SAM use on negative consequences was more pronounced. Among a sample of youth and young adults, SAM use (relative to alcohol-only use) at the last party attended was associated with greater odds of negative consequences (e.g., getting in a fight, having unprotected sex, experiencing forced sex, getting into a car crash, getting in trouble with parents, having a hangover).[74] Other papers linked SAM use to greater consequences relative to alcohol-only or marijuana-only use occasions.[45] Still, not all papers found a link between same-day co-use and consequences after controlling for alcohol and/or marijuana use.[29,32,67,75] For example, among college men, there was no evidence of same-day co-use increasing the likelihood of interpersonal conflict above and beyond alcohol or marijuana use.[67]

SAM use and risky driving

Eleven papers (seven cross-sectional, one longitudinal, and three daily assessment) examined SAM use and risky driving. In these papers, risky driving was typically assessed as a single item (e.g., substance-involved driving, being stopped by the police, tickets/warnings/accidents), with the exception of one community study that incorporated a multiple-item measure of driving risk.[76] Among college and community samples, individuals who engaged in SAM use were more likely to report risky driving compared to those who used alcohol only,[6,20,24,76] those who used marijuana only,[76] or those who co-used alcohol and marijuana.[36] Relative to individuals who only used marijuana or only drank alcohol, individuals who engaged in SAM use endorsed lower risk perceptions for substance-involved driving.[76] In a paper on young adults sampled when leaving a college district bar, 45% of participants who engaged in SAM use that night reported intending to drive after leaving the bar relative to 29% of those who used alcohol only.[77] Findings linking SAM use with a greater likelihood of riding with an intoxicated driver have been mixed, as one paper found evidence supporting this association[78] and another did not.[34] A third paper found evidence indicating that same-day co-use was associated with greater odds of riding with an intoxicated driver in comparison to alcohol-only days.[79]

Perceived or subjective positive effects or consequences

Four papers using daily assessments explored associations between SAM use and its perceived or subjective positive effects or consequences (e.g., feeling relaxed, social, or buzzed).[29,32,45,58] Across these papers, the measurement of positive consequences centered around alcohol,[29,32,58] marijuana,[29,58] or substance use more broadly.[45] Findings revealed a positive association between SAM use days and perceived positive consequences of alcohol[32] and/or substance use,[45] such that more positive consequences tended to be reported on SAM use days relative to alcohol-only[32] and marijuana-only days.[45] Notably, these effects persisted even after controlling for other relevant factors such as demographics, motives, weekend day, alcohol use, and/or marijuana use. A recent paper found no significant differences in average daily counts of perceived positive consequences between planned and unplanned SAM use days.[29] When considering motives, one paper found that higher cross-fading motives in general were associated with greater perceived positive consequences from alcohol and marijuana; in addition, SAM use days with higher cross-fading motives were associated with greater perceived positive consequences of alcohol.[58]

Discussion

The search identified 74 papers eligible for inclusion in this scoping review on four broad topics relevant to SAM use and same-day co-use by young adults. The four areas reviewed (i.e., prevalence of SAM use, patterns of SAM and other substance use, psychosocial correlates, and consequences of SAM use) elucidate information relevant for the field.

The literature on young adult SAM use is quickly growing. Of the 74 papers (61 on SAM use, 13 on same-day co-use) included in this review, 60 papers (47 on SAM use; 13 on same-day co-use) were published within the last 5 years (since 2017). However, the number of papers within each topic area was fairly limited, with the exception of consequences. Findings suggest that SAM use is prevalent and associated with negative consequences and perceived positive consequences. Review of the papers using nationally representative samples suggests that up to approximately one-quarter of young adults reported SAM use in the prior year,[15,20-22] with a higher prevalence during the transition to young adulthood (i.e., ages 19 to 22).[14] Two papers indicated 15% of young adults (ages 18 to 29) who drink engage in SAM use;[6,23] however, these two studies were conducted prior to the legalization of nonmedical use of marijuana, which started in 2012 in Washington and Colorado and extended to at least 18 states and the District of Columbia by 2021. More recent findings from nationally representative samples suggest that marijuana use and concurrent use of alcohol and marijuana have been increasing steadily.[10] Continued investigation of SAM prevalence in representative samples with data post-2012 is needed, including examination of longitudinal time trends. Although this review focuses on trends from representative samples, individual papers often report higher rates of SAM use when the samples are more specific to those who use alcohol and/or marijuana; one paper found that almost 75% of college students who reported past-year use of alcohol and marijuana engaged in SAM use in the past year,[60] further demonstrating SAM use as a high-risk and prevalent behavior.

There is strong evidence across numerous papers to suggest that engaging in SAM use is common among individuals who engage in heavier and more frequent alcohol and marijuana use, including those who also use illicit substances.[16,20-24,28,31-38] Findings from papers with different designs and analytic techniques consistently show that patterns of alcohol, marijuana, and other substance use distinguish those who engage in SAM use from other patterns of use. However, the evidence is less conclusive regarding the predictors and implications of SAM use for alcohol and marijuana use from event-level studies. The lack of consistent findings at the situation level is likely due, at least in part, to great variation in the eligibility criteria of samples (i.e., based on any use of alcohol, marijuana, or both, or use of either or both at particular levels), differences in the measurement and modeling of SAM use (e.g., comparing SAM days to alcohol-only days, marijuana-only days, or co-use days), and the presence or absence of covariates. Additional research is needed on the types of people and the types of situations that are associated with SAM use and consequences, with particular attention paid to the extent to which findings may or may not be generalizable.

Consistent, strong evidence was found across papers demonstrating associations between SAM use or same-day co-use with negative consequences (typically focused on consequences from alcohol use, but also marijuana or combined substance use),[6,23,24,35,36,55,56,60,67] as well as several other papers documenting associations between SAM use or same-day co-use with mental health and driving risks.[6,20,24,36,76] These effects were often present even after controlling for relevant demographics, alcohol use, and/or marijuana use. Most of the papers assessed the number of consequences reported, with little consistency in the measurement of consequences; fewer papers focused on specific harms. To inform interventions, further understanding of the impacts of SAM use on various aspects of functioning is needed as well as how young adults evaluate these consequences.

Only four papers examined perceived positive consequences associated with SAM use, and participants generally reported more positive consequences on SAM use occasions than alcohol-only or marijuana-only occasions.[29,32,45,58] The theoretical and clinical importance of understanding the perceived positive effects of SAM use may be critical to informing interventions aimed at motivations and expectations related to SAM use. For example, research on alcohol expectancies and consequences has found that young adults perceive some expectancies and consequences as positive or neutral, despite these traditionally being included on measures of negative outcomes (e.g., hangovers).[80,81] There is also emerging evidence that individuals have specific motives for SAM use and that these motives are associated with increased risk of SAM use[58,59,82] and negative consequences in daily assessment studies.[58] Across these papers, enhancement-related motives, including to get cross-faded,[58] were consistently associated with SAM-related behaviors. Surprisingly, only two papers examined social norms related to SAM use,[35,60] despite the large focus on young adult social norms in the alcohol literature.[83]

The authors identified several considerations in interpreting the findings from this review. First, many of the papers reviewed included nonrepresentative samples; thus, it is important to consider inclusion criteria and sample characteristics across papers (see Appendix 1). Sample selection is important for considering the findings, particularly for daily assessment studies, which often use higher-risk samples currently engaging in SAM use. Second, it is important to consider study design and whether or what comparisons are being made to SAM use (e.g., SAM use vs. alcohol-only, marijuana-only, co-use, or non–substance use occasions), particularly when examining effects or negative consequences resulting from SAM use. The question at hand in these studies is determining whether SAM use effects

are "worse" than effects on other use days. Often these studies control for the amount of alcohol and/or marijuana and assume the effect of SAM use is multiplicative. That is, controlling for the amount of use is implicitly testing whether, for example, having seven standard drinks and spending 4 hours high from marijuana leads to greater consequences when this substance use overlaps than if it occurs separately. This analytic design leads to a strict test of the impacts or effects of SAM use, and implicit assumptions of these models often are not discussed. Specifically, although research designs that answer questions about between-person effects are important for determining who may be at risk, the focus on between-person differences does not consider why or when risk for or consequences of SAM use might be greater in an individual's typical day-to-day experience. Conversely, comparisons from daily assessment studies are less universal because the samples are often highly selective. Together, these findings highlight the need for clarity in the descriptions of measures and methods used and the relative benefits and limitations of study designs.

The authors identified some measurement considerations. First, the majority of papers used a dichotomous indicator of any versus no SAM use, which fails to capture the intensity of use of alcohol and/or marijuana. Future studies should include more nuanced measures of SAM use to model this heterogeneity. It is particularly important to specify how SAM use is operationalized in each study to compare results. For example, SAM use that is defined as alcohol and marijuana use that is overlapping or within the same time frame is different than same-day co-use of alcohol and marijuana; different effects may be observed, and there would be different hypothesized mechanisms for risks. As mentioned in the introduction, the terminology for these behaviors varies across studies, which makes synthesizing results challenging. The authors of this review recommend that all authors clearly define the constructs used in their research, while reserving the use of the "simultaneous alcohol and marijuana (SAM) use" terminology for behavior strictly defined as the use of alcohol and marijuana at the same time so that their effects overlap.

Second, consistent with literature related to marijuana use, most studies in this review did not include measurement of marijuana potency or quantity consumed. Unlike alcohol, there is no standard unit measure of marijuana, which is further complicated by differing delta-9-tetrahydrocannabinol (THC) potency and modes of use. Future research should try to include more consistent and nuanced measurement of marijuana use; in fact, the National Institute on Drug Abuse is recommending that researchers utilize a standard THC unit in human subjects research when applicable.[84,85] Further, papers should be reviewed in light of the context in which the data were collected; for example, increases in THC content over time, particularly in states where nonmedical use of marijuana is legal, may confound issues related to SAM use and effects of use. Future research needs more nuanced models and measurements to assess main and synergistic effects of the two substances, including how variations in SAM use may lead to increasing consequences and ultimately to cannabis use disorder and/or alcohol use disorder. Although other polysubstance use is not reviewed here, some studies did include this and suggest that SAM use is an early indicator of simultaneous use with illicit substances.[42]

Prevention/Clinical Implications

Given that individuals who engage in SAM use tend to use alcohol and marijuana more heavily and more frequently, prevention efforts aimed at identifying these individuals are greatly needed, particularly during young adulthood. Notably, once individuals who engage in SAM use are identified, it will be important to determine whether current empirically supported strategies for reducing alcohol use (e.g., brief motivational interventions, personalized feedback interventions)[86] also reduce SAM use. However, there is little evidence that these interventions have a secondary impact on marijuana use,[7,87] although research in this area is limited. Further, it is unclear if stand-alone marijuana interventions (though there are fewer empirically supported stand-alone interventions for young adults compared to alcohol interventions)[88,89] have a secondary effect on alcohol or SAM use. Few interventions for SAM use, particularly for young adults, have been conducted and have yielded limited success.[90] For example, a motivational intervention focused on emerging adult themes (e.g., identity exploration, instability, self-focus, feeling in-between, a sense of possibilities) had no effect on SAM use days,[91] while a brief motivational intervention with adults visiting the emergency department showed reductions in SAM use days.[92] Given these mixed findings, the authors of this review encourage more research, first, to better understand the mechanisms by which SAM use may lead to risk, in order to identify the most appropriate intervention targets. Currently, motives for use (e.g., enhancement, cross-fading) as well as social norms may be good candidates for inclusion in interventions. Young adults may self-select into social groups (e.g., higher proportion of individuals who engage in SAM use) or contexts (e.g., private spaces, outdoor locations) that increase the odds of SAM use. At the situation level, use of protective strategies (e.g., limiting alcohol use before marijuana use, having a designated driver) may help reduce consequences on SAM use occasions, including substance-involved driving.

Limitations of Review

This review should be read within the context of certain caveats, including search terms, databases used, and the inclusion/exclusion process. There may have been relevant papers that were not initially included, based on the selection of search terms and databases (e.g., reports, unpublished papers), or studies that remain unpublished because of null findings. This review focuses on SAM use during young adulthood due to the high-risk nature

of this population. Thus, papers focused solely on adolescents younger than age 18 or adults older than age 30 were excluded. There is a growing body of work focused on unique circumstances of SAM use among adolescents,[93] and future work should continue to explore SAM use among other populations at risk. Additionally, the initial search may have missed papers that referenced general samples of adults more broadly if their abstracts did not mention the inclusion of young adults. Although all papers were independently reviewed by two authors to reduce bias, there may be instances when conceptualizations or terms identified as not fitting the current definition of SAM use were misinterpreted by both reviewers and thus excluded. Finally, this review focused on papers that included self-reported SAM use, survey research, and psychosocial-related variables, and did not review or report outcomes that were based on toxicology or medical reports; neurological, policy, or economic outcomes; or qualitative results. Such research may provide additional context for understanding SAM use, as well as its predictors and consequences, among young adults.

Conclusions

There continues to be an increasing research focus on SAM use, with new findings emerging quickly. To date, it is clear that SAM use is prevalent among young adults and is associated with perceived positive and negative consequences. However, much remains to be learned. In particular, the ways in which SAM use confers acute risk—above and beyond the risks associated with separate consumption of alcohol and marijuana—need to be identified. Psychosocial correlates identified so far include motives for SAM use and norms about use. Whether these additional constructs could be added to supplement existing alcohol- or marijuana-focused interventions, or whether new stand-alone SAM interventions are needed, remains to be seen. Increased understanding of the mechanisms by which SAM use leads to negative consequences is needed to design and test the most effective intervention strategies.

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Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Subbaraman & Kerr, 2015	6	Cross-sectional	National sample from National Alcohol Survey (2005 and 2010)	Age group 18–29	8,626	SAM use: Unspecified overlap	✓			✓
Terry-McElrath & Patrick, 2018	14	Longitudinal; Panel	Nationally representative sample of 12th-grade students from Monitoring the Future	NR	11,789	SAM use: Overlapping effects	✓			
Patrick et al., 2018	15	Cross-sectional	Nationally representative sample of 12th-grade students from Monitoring the Future survey; sample limited to cases from 1976 to 2016 that reported past-year alcohol and marijuana use	NR	84,805	SAM use: Overlapping effects	✓	✓		
Patrick et al., 2019	16	Longitudinal; Panel	Nationally representative sample of 12th-grade students from Monitoring the Future who participated in longitudinal follow-up at modal ages 19 or 20 from 2007 to 2016	NR	1,719	SAM use: Overlapping effects	✓	✓		
Terry-McElrath, O'Malley, & Johnston, 2014	20	Cross-sectional	Nationally representative sample of 12th-grade students from Monitoring the Future	NR	72,053	SAM use: Overlapping effects	✓	✓		✓

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Terry-McElrath et al., 2013	21	Cross-sectional	Nationally representative sample of 12th-grade students from Monitoring the Future	NR	34,850	SAM use: Overlapping effects	✓	✓	✓	
Patrick et al., 2017	22	Cross-sectional	Nationally representative sample of 12th-grade students from Monitoring the Future	NR	24,203	SAM use: Overlapping effects	✓	✓		
Midanik et al., 2007	23	Cross-sectional	National sample from National Alcohol Survey (1999–2001)	Age group 18–29	4,630	SAM use: Unspecified overlap	✓	✓	✓	✓
Jackson et al., 2020	24	Cross-sectional	College students who reported past-year alcohol and marijuana use	Age group 18–24	1,390	SAM use: Overlapping effects	✓	✓		✓
Pakula, Macdonald, & Stockwell, 2009	25	Cross-sectional	Clients from treatment programs in Canada reporting past-year marijuana or cocaine use	Age group 18–29	499	SAM use: Unspecified overlap	✓		✓	
Subbaraman & Kerr, 2020	26	Cross-sectional	Sample includes six representative surveys of adults in Washington state between January 2014 and October 2016	Age group 18–29	5,492	SAM use: Unspecified overlap	✓			
de Oliveira et al., 2013	27	Cross-sectional	Nationwide sample of Brazilian college students	Age group 18–24	12,544	SAM use: Unspecified overlap	✓			

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Thompson et al., 2021	28	Longitudinal; Panel	Community sample of youth in 10-year longitudinal study with biennial surveys; data from time points 5 and 6	Time 5 Ages 20–26 Time 6 Ages 22–29	Time 5 464 Time 6 478	SAM use: Time frame specified	✓	✓	✓	✓
Fairlie et al., 2021	29	Longitudinal; Daily/EMA	Community sample who reported SAM use at least once in past 2 weeks and alcohol use at least three times in past month	Age group 18–25	Baseline 409 Daily SAM 322 Daily unplanned SAM 308	SAM use: Overlapping effects	✓			✓
Yeomans-Maldnado & Patrick, 2015	30	Longitudinal; Daily/EMA	12th-grade students in the Midwest who participated in a baseline survey and completed at least one follow-up wave and daily survey	Follow-up X_{age} = 18.3	89	SAM use: Overlapping effects	✓		✓	
Meisel et al., 2021	31	Longitudinal; Panel	Incoming first-year college students	Age group 17–23	1,294	SAM use: Time frame specified		✓	✓	
Lee et al., 2020	32	Longitudinal; Daily/EMA	Community sample who reported SAM use at least once in past 2 weeks and alcohol use at least three times in past month	Age group 18–25	391	SAM use: Overlapping effects		✓		✓
Stevens et al., 2021	33	Longitudinal; Daily/EMA	College students who reported past-year alcohol and marijuana use and past-month SAM use	Age group 18–24	274	SAM use: Overlapping effects		✓		✓

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Sukhawathanakul et al., 2019	34	Longitudinal; Panel	Youth who participated in the biennial Victoria Healthy Youth Survey from 2003 to 2013	Age group 22–28	640	SAM use: Time frame specified		✓		✓
Linden-Carmichael, Stamates, & Lau-Barraco, 2019	35	Cross-sectional	National sample who reported alcohol use in the past month	Age group 18–25	1,017	SAM use: Time frame specified		✓	✓	✓
Cummings et al., 2019	36	Cross-sectional	First-year college students who reported any past 3-month substance use	X_{age} = 18.1	610	SAM use: Unspecified overlap		✓		✓
Collins, Bradizza, & Vincent, 2007	37	Cross-sectional	Community and college sample who reported drinking at least one 40 oz container of malt liquor a week	Age group 18–35	639	SAM use: Unspecified overlap		✓		
Looby et al., 2021	38	Cross-sectional	College students from seven universities across six states	X_{age} = 19.9	4,764	SAM use: Unspecified overlap		✓	✓	✓
Swan, Ferro, & Thompson, 2021	39	Cross-sectional	College students from a university in Canada, restricted to those who used cannabis in the last 6 months	Age group 17–26	368	SAM use: Time frame specified		✓		
Arterberry, Treloar, & McCarthy, 2017	40	Cross-sectional	College students in an introductory psychology class at a large, public university	X_{age} = 19.0	897	SAM use: Unspecified overlap		✓		

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Cadigan et al., 2019	41	Cross-sectional	Community sample who drank at least once in the past year and are currently enrolled in a 2- or 4-year institution	Age group 18–23	526	SAM use: Unspecified overlap		✓		
Bailey, Farmer, & Finn, 2019	42	Cross-sectional	Sample recruited for overrepresentation of externalizing problems	Age group 18–30	2,098	SAM use: Unspecified overlap		✓		
Linden-Carmichael & Allen, 2021	43	Cross-sectional	Young adults who reported past-month HED and SAM use	Age group 18–25	522	SAM use: Overlapping effects		✓		
Stamates, Roberts, & Lau-Barraco, 2021	44	Cross-sectional	Community sample who reported past-year alcohol, cannabis, and tobacco use	Age group 18–25	510	SAM use: Time frame specified	✓			
Linden-Carmichael et al., 2020	45	Longitudinal; Daily/EMA	Sample recruited near large, public university who reported past-month SAM use and HED in past 2 weeks	Age group 18–25	154	SAM use: Overlapping effects		✓		✓
Gunn et al., 2018	46	Longitudinal; TLFB	Incoming first-year college students in 2-year longitudinal study who reported at least one episode of alcohol and marijuana use during data collection	Baseline X_{age} = 18.4	488	Same-day co-use		✓		
Metrik et al., 2018	47	Longitudinal; TLFB	Veterans who used alcohol and marijuana on at least 1 day in the 180-day TLFB assessment period	X_{age} = 30.0	127	Same-day co-use		✓		

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Ito et al., 2021	48	Longitudinal; TLFB	College students in Colorado during the time period when recreational marijuana was decriminalized then legalized	X_{age} = 18.4	375	Same-day co-use		✓		
Sokolovsky et al., 2020	49	Longitudinal; Daily/EMA	College students who reported past-year alcohol and marijuana use and past-month SAM use	X_{age} = 19.8	341	SAM use: Time frame specified		✓		✓
Gunn et al., 2021	50	Longitudinal; Daily/EMA	College students who reported past-year alcohol and marijuana use and past-month SAM use	Age group 18–24	258	Same-day co-use		✓		✓
Linden-Carmichael, Allen, & Lanza, 2021	51	Longitudinal; Daily/EMA	Sample recruited near large, public university who reported past-month SAM use and HED in past 2 weeks	Age group 18–25	148	SAM use: Overlapping effects			✓	
Lipperman-Kreda et al., 2018	52	Cross-sectional	Youth who participated in a randomized community trial in California	Age group 18–30	1,538	SAM use: Unspecified overlap			✓	
D'Amico et al., 2020	53	Longitudinal; Panel	Youth who originally participated in a substance use prevention program in middle school	Follow-up X_{age} = 20.7	2,429	SAM use: Unspecified overlap			✓	
Gunn et al., 2021	54	Longitudinal; Daily/EMA	College students who reported past-year alcohol and marijuana use and past-month SAM use	Age group 18–24	313	SAM use: Time frame specified			✓	

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Patrick, Fairlie, & Lee, 2018	55	Cross-sectional	Community sample who, at recruitment, reported drinking at least once in the past year	X_{age} = 21.4	286	SAM use: Overlapping effects			✓	✓
Conway et al., 2020	56	Longitudinal; Panel	College students who reported past-year alcohol and marijuana use and SAM use	Age group 18–24	Baseline 1,014 Follow-up 904	SAM use: Overlapping effects			✓	✓
Arterberry et al., 2021	57	Longitudinal; Daily/EMA	Emergency department attendees who reported illicit drug use or prescription drug misuse in past 4 weeks	Age group 18–25	97	Same-day co-use			✓	
Patrick et al., 2020	58	Longitudinal; Daily/EMA	Community sample who reported SAM use at least once in past 2 weeks and alcohol use at least three times in past month	Age group 18–25	281	SAM use: Overlapping effects			✓	✓
Patrick et al., 2019	59	Longitudinal; Daily/EMA	Community sample who reported SAM use at least once in past 2 weeks and alcohol use at least three times in past month	Age group 18–25	399	SAM use: Overlapping effects			✓	
White et al., 2019	60	Cross-sectional	College students who reported past-year alcohol and marijuana use	Age group 18–24	1,389	SAM use: Overlapping effects			✓	✓

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Patrick & Lee, 2018	61	Cross-sectional	Community sample from Washington; screening survey for longitudinal study on social role transitions and alcohol use	Age group 18–23	807	SAM use: Unspecified overlap			✓	
Ramirez, Cadigan, & Lee, 2020	62	Cross-sectional	Community sample who, at recruitment, reported drinking at least once in past year	X_{age} = 21.9	480	SAM use: Overlapping effects			✓	
Schuster, Mermelstein, & Hedeker, 2016	63	Longitudinal; Daily/EMA	Youth who participated in study on smoking and reported at least one episode of marijuana, tobacco, or alcohol use during 5-year follow-up EMA	Follow-up X_{age} = 21.3	287	SAM use: Unspecified overlap			✓	
Weiss et al., 2017	64	Longitudinal; Daily/EMA	Undergraduate psychology students who reported alcohol use at least twice in the past month	X_{age} = 19.2	1,640	SAM use: Unspecified overlap			✓	
Fleming et al., 2021	65	Longitudinal; Panel	Community sample who, at recruitment, reported drinking at least once in the past year	Age group 18–23	773	SAM use: Overlapping effects			✓	✓
Baggio et al., 2018	66	Longitudinal; Panel	Swiss men recruited from national military recruitment centers who reported SAM use in the past year	Baseline X_{age} = 20.0 Follow-up X_{age} = 21.3	Baseline 1,559 Follow-up 991	Same-day co-use			✓	

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Brown, Testa, & Wang, 2018	67	Longitudinal; Daily/EMA	First-year college males from large public university	Age group 18–19	427	SAM use: Time frame specified				✓
Davis et al., 2021	68	Cross-sectional	College student sample; for interactive effects, subset of students who consumed alcohol in past year	X_{age} = 18.4	Prevalence 1,234 Interactive effects 997	SAM use: Unspecified overlap				✓
Mallett et al., 2019	69	Longitudinal; Daily/EMA	Third-year college students from a large, public university who were part of a longitudinal study and reported alcohol and other drug use in the past year	X_{age} = 20.1	451	Same-day co-use				✓
Norman et al., 2019	70	Cross-sectional	Individuals in Australia who went to bars or clubs	Age group 20–27	5,078	SAM use: Unspecified overlap				✓
Graupensperger et al., 2021	71	Longitudinal; Daily/EMA	Community sample who reported SAM use at least once in past 2 weeks and alcohol use at least three times in past month	Age group 18–25	409	SAM use: Overlapping effects				✓
Read et al., 2021	72	Longitudinal; Daily/EMA	Females who were part of a long-term longitudinal study on adolescent substance risk	Age group 21–24	174	Same-day co-use				✓
Stevens et al., 2021	73	Longitudinal; Daily/EMA	College students who reported past-year use of alcohol and marijuana	Age group 18–24	281	SAM use: Overlapping effects				✓

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Egan et al., 2019	74	Cross-sectional	Youth who participated in a randomized community trial	Age group 15–20	834	SAM use: Unspecified overlap				✓
Merrill et al., 2019	75	Longitudinal; Daily/EMA	College students who reported weekly HED or experiencing at least one negative alcohol-related consequence in past 2 weeks	Age group 18–20	96	SAM use: Unspecified overlap				✓
Duckworth & Lee, 2019	76	Cross-sectional	Community sample who, at recruitment, reported drinking at least once in the past year; data from Month 18	X_{age} = 22.2	511	SAM use: Overlapping effects				✓
Thombs et al., 2009	77	Cross-sectional	Patrons exiting bars in college bar district	Median age = 21	469	SAM use: Unspecified overlap				✓
Patrick et al., 2021	78	Longitudinal; Daily/EMA	Community sample who reported SAM use at least once in past 2 weeks and alcohol use at least three times in past month	Age group 18–25	408	SAM use: Overlapping effects				✓
Hultgren et al., 2021	79	Longitudinal; TLFB	College students who reported past-year use of alcohol and another substance (e.g., marijuana, nicotine)	X_{age} = 20.1	367	Same-day co-use				✓
Roche et al., 2019	94†	Longitudinal; TLFB	Non–treatment-seeking regular drinkers in Los Angeles area	X_{age} = 29.0	179	Same-day co-use				

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Barrett, Darredeau, & Pihl, 2006	95†	Cross-sectional	College students who reported use of at least two substances in their lifetime	X_{age} = 21.7	149	SAM use: Unspecified overlap				
Licht et al., 2012	96†	Cross-sectional	Danish adults who reported lifetime history of at least 15 illicit drug experiences (excluding marijuana) and use of MDMA or hallucinogens at least once in the past year	Age group 18–35	59	SAM use: Unspecified overlap				
Olthuis, Darredeau, & Barrett, 2013	97†	Cross-sectional	Community sample from Canada who reported lifetime cannabis use	X_{age} = 26.8	226	SAM use: Unspecified overlap				
Østergaard, Østergaard, & Fletcher, 2016	98†	Cross-sectional	Bar or club goers in Denmark and England	Age group 18–35	1,019	SAM use: Unspecified overlap				
Wade et al., 2020	99†	Cross-sectional	Community sample in Wisconsin	Age group 16–26	75	Same-day co-use				
Coughlin et al., 2021	100†	Longitudinal; TLFB	Community sample who reported risky alcohol use in past 3 months and at least 1 day of alcohol use and 1 day of cannabis use in past 30 days	Age group 16–24	468	Same-day co-use				
Linden-Carmichael et al., 2021	101†	Longitudinal; Daily/EMA	Community sample who reported past-month SAM use and past 2-week HED	Age group 18–25	154	SAM use: Overlapping effects				

Appendix 1. Sample Descriptions, Categorization of Simultaneous Alcohol and Marijuana (SAM) Use, and Areas of Focus Related to Narrative Review (Continued)

Citation Author & Year	Citation Number	Study Design	Population	Age (range or mean)	Sample Size	Categorization of SAM*	Inclusion in Narrative Results			
							Prevalence	Patterns	Correlates	Consequences
Daros et al., 2021	102†	Longitudinal; TLFB	Community sample of regular cannabis users (at least once per month for 6+ months) in Canada	Age group 19–26	153	Same-day co-use				
Lee, Cadigan, & Patrick, 2017	103†	Cross-sectional	Community sample who, at recruitment, reported drinking at least once in the past year	X_{age} = 21.4	315	SAM use: Overlapping effects				

***Categorization of SAM use.** SAM use: Overlapping effects = At the same time or together so that their effects overlapped; SAM use: Time frame specified = On the same day within a specified time period (e.g., within 3 hours of each other); SAM use: Unspecified overlap = At the same time or together without specifying that their effects overlapped or at the same event or occasion without specifying overlapping effects of use within a specified time period (e.g., at the last party attended, during the current night out); Same-day co-use = On the same day without specifying that they be used together or within a specified time period.

†Ten papers were identified in the search process and included through data extraction; however, the focus of each paper was outside the specific topics of the current review, or results related to SAM were mostly descriptive and thus not presented in the narrative synthesis.

Note. EMA, ecological momentary assessment; HED, heavy episodic drinking; MDMA ("ecstasy"), 3,4-methylenedioxy-N-methylamphetamine; NR, Not reported; SAM, simultaneous alcohol and marijuana; TLFB, timeline follow-back; X_{age}, mean age.

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NIAAA 50th ANNIVERSARY FESTSCHRIFT

Alcohol and the Adolescent Brain: What We've Learned and Where the Data Are Taking Us

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Publisher's Note
This article was based on a presentation at the NIAAA 50th Anniversary Science Symposium, "Alcohol Across the Lifespan: 50 Years of Evidence-Based Diagnosis, Prevention, and Treatment Research," held on November 30–December 1, 2020. Links to the videocast are available on the NIAAA 50th Anniversary Science Symposium agenda webpage. Opinions expressed in contributed articles do not necessarily reflect the views of the National Institute on Alcohol Abuse and Alcoholism, National Institutes of Health. The U.S. government does not endorse or favor any specific commercial product or commodity. Any trade or proprietary names appearing in *Alcohol Research: Current Reviews* are used only because they are considered essential in the context of the studies reported herein.

This article is part of a Festschrift commemorating the 50th anniversary of the National Institute on Alcohol Abuse and Alcoholism (NIAAA). Established in 1970, first as part of the National Institute of Mental Health and later as an independent institute of the National Institutes of Health, NIAAA today is the world's largest funding agency for alcohol research. In addition to its own intramural research program, NIAAA supports the entire spectrum of innovative basic, translational, and clinical research to advance the diagnosis, prevention, and treatment of alcohol use disorder and alcohol-related problems. To celebrate the anniversary, NIAAA hosted a 2-day symposium, "Alcohol Across the Lifespan: 50 Years of Evidence-Based Diagnosis, Prevention, and Treatment Research," devoted to key topics within the field of alcohol research. This article is based on Dr. Tapert's presentation at the event. NIAAA Director George F. Koob, Ph.D., serves as editor of the Festschrift.

KEYWORDS: alcohol; adolescence; binge drinking; neuroimaging; magnetic resonance imaging; neuropsychological tests; young adults; drinking behavior

The past 50 years of research supported by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) have resulted in an accumulation of invaluable data to address the multifaceted problems surrounding underage drinking. Youth use of alcohol remains a pervasive social and public health concern in the United States and a leading cause of disability and mortality during adolescence.[1,2] Alcohol use in adolescence has a distinct pattern from adult drinking, whereby adolescents may have fewer drinking occasions but consume relatively high levels per occasion, referred to as binge or heavy episodic drinking and defined as consuming four or more standard ethanol consumption units on an occasion for females and five or more for males.[3-5] Highly prevalent among youth in Western countries is an intermittent pattern of heavy alcohol consumption that typically is associated with social leisure occasions on weekend nights.[6] Moreover, adolescent alcohol use, along with smoking and illicit drug use, has undergone changes in prevalence and patterns in recent decades. For example, alcohol use peaked in the mid-1990s, with approximately 50% of 12th graders reporting past-month alcohol use, followed by a steady long-term decline to 30% in 2018. In 2020, the downward trend reversed course, with 34% of 12th graders reporting past-month alcohol use.[1] Recent reports indicate that prevalence estimates for 2021 will need to account for impacts of the COVID-19 global pandemic on underage substance use behavior and availability.[7]

High-risk alcohol consumption patterns and associated problems alone increase risk for adverse outcomes—such as motor vehicle accidents, high-risk sexual behaviors, other illicit substance use, and mental health challenges—for adolescents who drink. These risks are further compounded by the fact that adolescence is a period of crucial brain development and maturation.[8,9] Neuroimaging studies have provided clear evidence that the brain (a) continues to develop throughout adolescence and into adulthood, and (b) undergoes important structural and functional changes in synaptic plasticity and neural connectivity during adolescence.[10,11] These changes and the enormous plasticity of the teen brain make adolescence a time of both great risk and great opportunity.[11]

This article begins with an overview of typical adolescent brain development, followed by a summary of four key themes in the current understanding of alcohol and the adolescent brain: (1) predictors of underage drinking; (2) consequences of alcohol on adolescent brain structure and function; (3) moderating and confounding factors, including age of onset, sex disparities, family history, co-use of other substances, and mental health comorbidities; and (4) reversibility of and recovery from alcohol misuse. The article concludes with a discussion of where the data lead us to reach the next milestones in NIAAA-supported research.

Typical Adolescent Brain Development

The brain of an adolescent, much like teenage behavior, undergoes significant developmental changes. This neurodevelopment continues after adolescence, typically until around age 25.[12-15] The maturational processes in the brain occur in stages, with more basic functions (e.g., motor and sensory functions) maturing first and areas such as the lateral temporal and frontal lobes, which are responsible for higher cognitive function (e.g., decision-making, attention), developing later in adolescence.[13] The prefrontal cortex is one of the last brain regions to complete its maturation. Its rate of change does not plateau until the third decade of life, in concert with typical developmental trajectories of cognitive abilities, such as decision-making, attention, and cognitive control.[16-18] The late maturation of the prefrontal cortex has been linked to risky behavior during adolescence, particularly if the limbic subcortical system develops earlier.[16]

Executive functioning typically matures during this developmental stage,[19] coincident with gray matter reductions and white matter growth.[20,21] Functional magnetic resonance imaging (fMRI) studies of executive behaviors have demonstrated increasing prefrontal activity and better inhibitory control with adolescent age.[22] Challenges in executive functioning have been observed in adolescents with a family history of alcohol use disorder (AUD),[23] repeated childhood trauma experiences,[24] and poor sleep,[25] all of which also have been identified as risk for adolescent binge drinking and AUD.[17,26,27] Deficits in control circuitry have been linked to impulsivity, sensation seeking, and alcohol use into early adulthood.[28]

One of the studies investigating adolescent alcohol use and its effects is coordinated by the National Consortium on Alcohol and Neurodevelopment in Adolescence (NCANDA), which is conducting a multisite longitudinal study supported by funding from NIAAA and other National Institutes of Health partner institutes. Launched in 2012, this five-site consortium recruited a community cohort of 831 diverse adolescents ages 12 to 21 from five U.S. regions (Durham, North Carolina; Palo Alto, California; Pittsburgh, Pennsylvania; Portland, Oregon; and San Diego, California). Half the sample was enriched for key characteristics conveying risk for heavy drinking among adolescents (i.e., family history of substance use disorder, youth externalizing or internalizing symptoms, and having tried alcohol by age 14). Most of the sample (85%) reported very limited alcohol use at project entry; the remaining 15% exceeded typical age thresholds for alcohol at project entry in this cohort-sequential design.[29] At project entry and annually thereafter, participants received neuroimaging (high-

resolution structural, diffusion, and resting-state fMRI scans), neurocognitive testing, detailed substance use and mental health interviews; provided urine samples for drug testing as well as saliva samples for genetics and pubertal hormone assays; and completed various self- and parent reports on personality, behaviors, and environment.[29] NCANDA will continue to examine the interactive effects of typical development as well as adolescent alcohol use and executive dysfunction into early adulthood.

Resting-state fMRI findings from NCANDA and other studies have shown that intrinsic functional networks subserving cognitive control and limbic circuitry develop across adolescence and may be influenced by adolescent heavy drinking.[24,30,31] Moreover, the adverse effects of alcohol may be more prominent in girls than in boys.[32]

Predictors of Underage Drinking

Being able to identify youth at higher risk for alcohol misuse could lead to early intervention and ultimately help reduce the significant personal and public health burden of AUD; however, relatively few studies have explored individual-level precursors of adolescent alcohol use. Prospective longitudinal studies of substance-naïve youth are uniquely positioned to identify factors predating the onset of alcohol use. Squeglia et al. identified several markers of alcohol initiation by age 18 in 137 adolescents.[27] These markers included demographic and behavioral factors (e.g., male sex, higher socioeconomic status, early dating, more externalizing behaviors, positive alcohol expectancies), lower executive functioning, thinner cortices, and less brain activation in diffusely distributed brain regions.

NCANDA seeks to expand on these findings using a greater number of measurements in a large sample to lead to more accurate individual-level forecasting. The consortium is employing machine learning models, which can avoid multiple-comparison correction and reduce measures to a single, individual-level prediction.[33,34] NCANDA developed a model that distinguished youth who drink heavily from those who drink little or no alcohol, based on patterns of macrostructural and microstructural imaging metrics in multiple brain regions.[35] The analyses suggested delayed development of white matter connectivity among the older youth in the sample who drank heavily, as well as increased risk of subsequent heavy drinking in youth with more externalizing symptoms. These findings fit closely with those from the IMAGEN Consortium, which found that variability in personality, cognition, life events, neural functioning, and drinking behavior features predicted Alcohol Use Disorders Identification Test scores at ages 14 and 16.[36]

Neural Consequences of Underage Heavy Drinking

Gray Matter Volume

Unlike white matter, gray matter volume peaks in the primary school-age years, around age 10.[11] Squeglia et al. reported that youth who drank heavily (n = 75) (defined using modified Cahalan quantity x frequency criteria[37,38]) showed accelerated reductions in gray matter volumes in cortical lateral frontal and temporal areas compared to those who drank no or little alcohol (n = 59).[39] These results were largely unchanged with co-use of marijuana and other drugs; also, similar patterns of developmental trajectory abnormalities existed in males and females. This finding was replicated in the NCANDA cohort, which examined the influence of alcohol use on gray matter structure in 483 adolescents ages 12 to 21 both before and 1 to 2 years after the onset of heavy drinking.[13] For youth with no or low alcohol consumption, gray matter volumes declined throughout adolescence, with rates slowing in many brain regions in later adolescence. However, youth who initiated heavy drinking exhibited a steeper decline in frontal gray matter volumes. For both youth with no or low alcohol consumption and those with heavy drinking, cannabis use did not influence gray matter volume trajectories.

These findings were confirmed in a recent analysis spanning five time points in the NCANDA study and using linear mixed-effects models.[40] A greater number of past-year binge drinking episodes was linked to greater decreases in gray matter volumes in 26 of 34 bilateral Desikan-Killiany cortical parcellations tested. The strongest effects were noted in frontal regions as well as among younger adolescents; moreover, the effects largely attenuated in later adolescence. The gray matter volumes decreased most for individuals with greater numbers of binge-drinking episodes and recent binge drinking. These findings provide yet more evidence that adolescent binge drinking is linked to a greater risk of more prominent gray matter reductions during adolescence.[40]

Functional MRI studies further suggested that adolescents with histories of heavy drinking showed aberrant patterns of activation in response to cognitively challenging tasks,[41,42] including tasks of working memory and inhibition. In adolescents with a history of 1 to 2 years of heavy drinking, the aberrant activation was not linked to detectable deficiencies in task performance. However, if heavy drinking persisted longer, reduced task performance was often evident in the adolescents.[43,44] This pattern of results suggested that the brain may be able to compensate for subtle neuronal insults for a period of time, but if drinking patterns persist and become heavier, the brain may no longer be able to compensate and may be vulnerable to the effects of repeated and sustained heavy doses of alcohol.

White Matter Volume and Integrity

Throughout adolescence, white matter volume increases and matures, resulting in myelination that increases speed of neuronal transmission and modulates the timing and synchrony of neuronal firing patterns that convey meaning in the brain.[11] Squeglia et al. reported that adolescents who drank heavily showed attenuated white matter growth of the corpus callosum and pons relative to adolescents who did not drink.[39] Pfefferbaum et al. indicated that among those in the NCANDA sample who consumed no or little alcohol, white matter regions grew at faster rates in younger age groups and slowed toward young adulthood.[13]

To examine the potential for a neurotoxic effect of alcohol use on adolescent development of white matter, Zhao et al. conducted a whole-brain analysis of fractional anisotropy of NCANDA participants ages 12 to 21 at baseline.[45] For 63 adolescents who initiated heavy drinking, the researchers examined white matter quality before and after drinking onset and compared it to the white matter maturation trajectory of 291 adolescents with no or low alcohol consumption. Results showed deterioration of white matter integrity in youth who drank heavily compared with age- and sex-matched controls. Moreover, the slope of this reduction over time corresponded with days of drinking since the study entry.[45] Within-subject analyses contrasted developmental trajectories of youth before and after they initiated heavy drinking. These analyses suggested that drinking onset was associated with, and appeared to precede, disrupted white matter integrity. This disruption was greater in younger adolescents than in older adolescents, and was most pronounced in the genu and body of the corpus callosum.[45] It is possible that these brain structure changes may occur concomitantly with modifications in certain neurotransmitter and hormone secretion systems, which markedly influence the refinement of certain brain areas and neural circuits.[46]

Neurocognition

Along with altered development and maturation of gray and white matter, studies have reported neurocognitive consequences of underage drinking, such as impairments in attention,[47] verbal learning,[48,49] visuospatial processing,[47,50] and memory.[49] Neurocognitive deficits linked to moderate to heavy drinking during this critical developmental period may lead to direct and indirect changes in neuromaturational course, with effects that may extend into adulthood. Squeglia et al. examined neurocognitive function in adolescents who drank heavily, moderately, or not at all, based on the Cahalan classification system.[51] Their findings suggested that initiation of moderate to heavy alcohol use and incurring hangovers during adolescence may adversely influence neurocognitive functioning. For females, more drinking days in the past year predicted a greater reduction in performance on visuospatial tasks, in particular visuospatial memory, from baseline to follow-up. For males, a tendency was seen for more hangover symptoms in the year before follow-up testing to predict a relative worsening of sustained attention.[51]

Alcohol Cue Reactivity

Another set of studies demonstrated that youths who drank heavily exhibited greater brain activation while viewing alcohol advertisements[25,52-54] than while viewing ads for nonalcoholic beverages.[52] Adolescents are exposed to alcohol advertising materials on a daily basis in many countries. As studies in adults with AUD have shown atypical responses to alcohol-related materials,[55] Tapert and colleagues used fMRI analyses to determine whether similar response patterns existed in adolescents who drink.[52] The study included 15 adolescents ages 14 to 17 with AUD and 15 demographically similar adolescents who drank infrequently. The participants were shown pictures of alcoholic and nonalcoholic beverage advertisements during neuroimaging. Adolescents with histories of heavy drinking showed greatly enhanced neural activation while viewing the pictures of alcoholic beverages compared with pictures of nonalcoholic beverages. The extent of alcohol-related activation was greatest for those with the highest levels of monthly alcohol intake (see Figure 1). In contrast, youth with limited drinking histories showed similar levels of activation while viewing the two beverage picture types. These results demonstrated pronounced alcohol cue reactivity in heavy drinking teens, particularly in reaction to alcohol advertising materials.

Factors Contributing to Adolescent Alcohol Use

Age of Onset

Studies examining longer-term impacts of adolescent alcohol misuse have yielded mixed results. Some studies reported a maturing-out without significant consequences in adulthood, while others found ongoing effects on mental health, physical health, and social functioning, as well as higher levels of alcohol use and AUD.[56] Analyses using data from the National Longitudinal Alcohol Epidemiologic Survey determined that 40% of those initiating alcohol use before age 15 were diagnosed with AUD at some point in their lives compared to only 10% of those who delayed the onset of drinking until age 21 or later.[57]

The first study of adolescents (ages 12 to 15 at baseline; $N = 215$) to assess the association between age of adolescent drinking onset and neurocognitive performance found that earlier age of drinking onset predicted poorer performance on tasks requiring psychomotor speed and visual attention. Similarly, an earlier age of onset of regular (weekly) drinking predicted poorer performances on tests of cognitive inhibition and working memory.[58] This study suggested that early onset

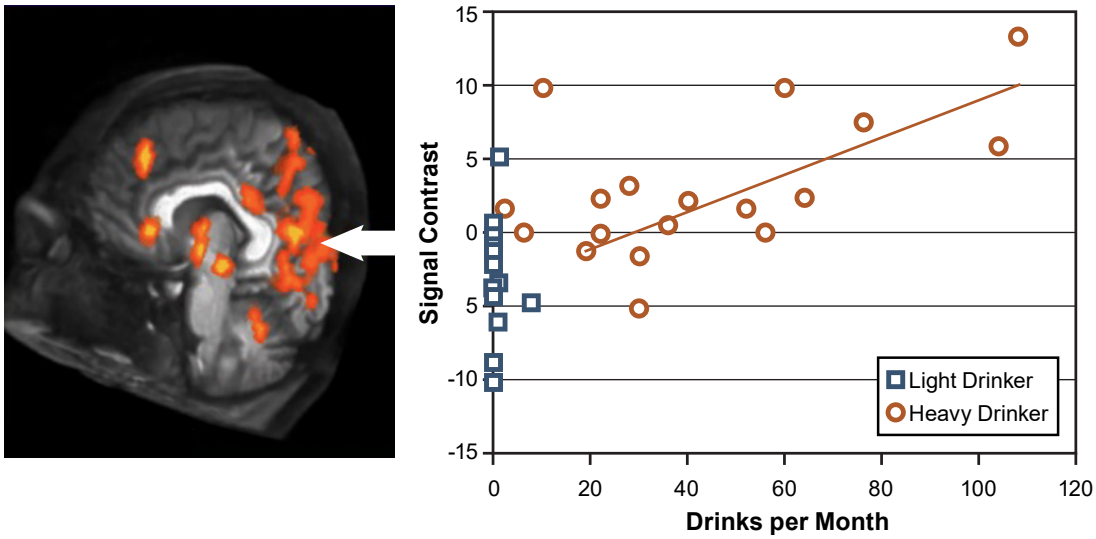

Figure 1. Response to alcohol pictures in youth with heavy versus light drinking. Brains of youths who drank heavily activated strongly in response to seeing alcohol advertisements but showed little brain response to nonalcoholic beverage ads; this difference (i.e., signal contrast) was smaller in youth who drank lightly. The difference in brain response was greatest in adolescents with the highest consumption levels and was especially strong in the left hemisphere (positive affect), limbic, and visual cortex areas. *Source:* Tapert et al., 2003.[52]

of drinking increased risk for subsequent neuropsychological dysfunction.

Sex Disparities

Several studies have reported that the associations between alcohol and brain structure and function differ by sex, especially in adolescents engaging in binge drinking. While not conclusive across the literature, female adolescents who engaged in binge drinking appeared to show effects such as blunted activation in frontal, temporal, and cerebellar cortices compared to females who did not drink, whereas male adolescents who engaged in binge drinking showed the opposite activation pattern.[59] Female adolescents ages 15 to 17 meeting criteria for AUD showed larger prefrontal cortex volumes than female controls, while male adolescents with AUD had smaller prefrontal cortex volumes than male controls.[60] A similar finding was observed for white matter.

Family History of AUD

Having a family member with AUD is associated with almost double the risk of initiating drinking in early adolescence.[57] Using fMRI, Spadoni et al. observed greater neural activity during rest and reduced activity during an active baseline condition were linked to denser family history of AUD.[61]

Mental Health Comorbidities

Adolescence is the peak time for both onset of substance misuse and emergence of mental illness, including anxiety disorders, bipolar disorder, major depression, eating disorders, and psychosis.[10] The National Survey on Drug Use and Health (NSDUH) estimated that 20% of adolescents had a mental illness that persisted into adulthood.[2] Moreover, adolescents with a past-year major depressive episode were more likely to be current binge alcohol users (6% vs. 4%).[2] However, it remains unclear how comorbid mental health problems contribute to and exacerbate the neurobiological effects of alcohol misuse.[4] Frontal and temporal cortical thinning may predict increased vulnerability to development of adolescent depression. In the NCANDA sample of 692 adolescents without a history of depression, the 101 youth who transitioned into depression were found at study baseline to have thinner cortices in the superior frontal cortex, precentral and postcentral regions, and superior temporal cortex, beyond effects attributable to age and sex.[62,63]

Adverse Childhood Events

Childhood trauma and post-traumatic stress symptoms have been shown to confer increased risk for adolescent and adulthood AUD, mental illness, and physical health problems.[64,65] Youth with trauma exposure showed thinner frontal cortices, and those with chronic post-traumatic stress disorder (PTSD) had smaller orbital frontal cortices[66] and less superior posterior cortical and cerebellar gray matter volume.[67] These observations indicate that trauma may be associated with structural brain aberrations.

NCANDA has also examined the relationship between childhood trauma and subsequent adolescent alcohol use.[68] In a sample of 392 NCANDA participants, adverse childhood event history was linked to greater self-reported executive dysfunction spanning four annual follow-ups. Greater childhood trauma also was linked to less connectivity in sensorimotor and cognitive control networks (i.e., the bilateral dorsal anterior cingulate cortex, right anterior insula, right intraparietal sulcus,

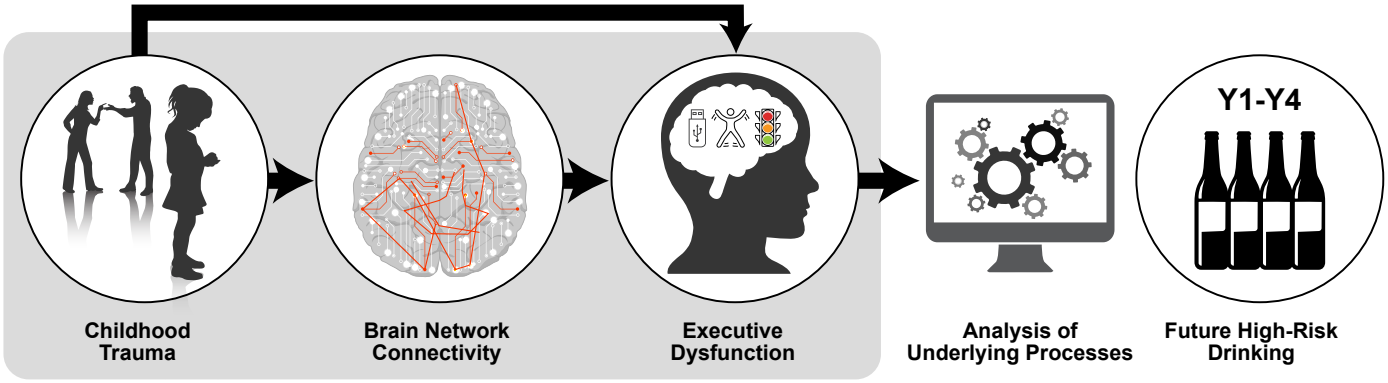

Figure 2. Model depicting how childhood trauma may lead to subsequent high-risk drinking. *Note:* Y1-Y4, Year 1 through Year 4. *Source:* Silveira et al., 2020.[24]

and bilateral pre- and postcentral gyri hub regions) at baseline. This reduced connectivity explained the relationship between executive dyscontrol and subsequent increased frequency of adolescent binge drinking (see Figure 2).[24]

Poor Sleep

Sleep patterns change substantially during adolescence and emerging adulthood.[69] Lack of sleep, going to sleep relatively late, and large weekend-weekday sleep differences all are risk factors for alcohol use in adolescents and young adults.[70] Similarly, in the NCANDA sample, sleep difficulties in adolescence predicted later substance use problems.[71] The reverse has also been seen, with acute and chronic alcohol intake altering sleep structure and electroencephalography patterns[72] in older adolescents[73] and adults.[69] NCANDA will continue to longitudinally examine whether these changes remain evident into adulthood and how alcohol use influences sleep neurobiology.

Use of Other Substances

Co-use of multiple substances may influence the relationship between alcohol use and neural integrity. For example, during a spatial working memory task, adolescents with co-occurring AUD and cannabis use disorder showed less inferior frontal and temporal neural activation but a greater medial frontal response compared to adolescents with AUD alone.[74] Co-use of alcohol with cannabis also may adversely influence executive functioning.[75] Given the high rates of co-occurring alcohol and other substance use during adolescence,[76] future well-powered studies will benefit from detailed analyses of various combinations of substances of abuse on neural and neurocognitive outcomes.

Recovery From Consequences of Adolescent Heavy Drinking

In adults with AUD, improvements in attention and concentration, reaction time, and memory are generally seen after 2 to 8 weeks of abstinence;[77] however, executive functioning, processing speed, visuospatial, and verbal skills appear more resistant to recovery,[78] and spatial processing deficits may persist for years.[79] Younger adults tend to recover more quickly and completely than older adults (i.e., over age 50).[80] As mentioned previously, preliminary evidence suggested that adolescent heavy drinkers showed greater response to alcohol cues,[54] more emotional reactivity and poorer distress tolerance,[81] and poorer visuospatial performance compared with adults.[82] These effects remitted after a month of abstinence, indicating that some deficits are linked to alcohol intake and may be transitory. However, executive dysfunction[81] and negative mood states[83] did not remit within 4 weeks of abstinence, suggesting that these differences may have predated the onset of heavy drinking or may take more time to recover. As reported by Infante et al., cortical gray matter volume decreases were greater in proximity to reported drinking episodes in a dose-response manner, suggesting a causal effect and raising the possibility that normal growth trajectories may recover with alcohol abstinence.[40] However, other studies have suggested that impaired visuospatial functioning following adolescent AUD persisted even after reduced levels of use.[84]

Where Do the Data Lead Next?

Longitudinal studies with large, diverse, representative samples of youth and a range of detailed measures are key to helping understand the behaviors that convey disadvantages to adolescent and young adult development and outcomes. To date, a handful of large-scale multisite studies are being conducted to

gain insight into the consequences of adolescents transitioning into and out of substance use. These include the largest long-term study of brain development in the United States, the Adolescent Brain Cognitive Development (ABCD) Study, which is currently underway; NCANDA; the IMAGEN study in Europe; the Pediatric Imaging, Neurocognition, and Genetics (PING) study; and the Lifespan Human Connectome Project (HCP) study. NCANDA has already been able to confirm impressions from prior smaller studies that adolescent heavy drinking appears linked to accelerated gray matter decline,[40] disrupted functional connectivity,[30] and reduced cognitive performance. Determining the degree to which these effects remit or persist with alcohol abstinence or reduced use will be a key next step in this line of work.

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Recovery and Youth: An Integrative Review

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Although rates of alcohol and other substance use disorders in adolescents have been estimated for decades, little is known about the prevalence, pathways, and predictors of remission and long-term recovery among adolescents. This article provides an integrative review of the literature on youth recovery. A final selection of 39 relevant articles was grouped into five sections: treatment outcomes, special emphasis populations, recovery-oriented systems of care, families, and non–abstinence-based approaches. The review recommends more adolescent research in three basic areas: more research about medication-assisted treatment and recovery as well as harm reduction approaches for adolescents; expansion of research on recovery practices for youth who do not receive treatment due to personal choice or societal disparities; and more life course research, which may begin with adolescent participants and extend across the life span. Additionally, the authors suggest the recovery capital model for adolescents and the neuroscience of addiction may provide additional precision and direction for the study of youth recovery.

KEY WORDS: recovery; substance-related disorders; alcohol-related disorders; adolescence; continuum of care; alcohol; youth; recovery capital

INTRODUCTION

Recovery from alcohol use disorder (AUD) or other substance use disorder (SUD) is an evolving concept. This article reviews youth recovery, as little is known about the prevalence, pathways, and predictors of remission and long-term recovery among adolescents and how these may contrast with recovery in emerging and older adults. Although much of the literature on alcohol or other substance use in youth has focused on prevention, adolescents can and do develop AUD or other SUD. Data reported by the annual National Survey on Drug Use and Health showed nearly 1 million youths (ages 12 to 17) needed treatment for AUD or SUD in 2018, although only 83,000 of them received services in a treatment center.[1]

Historian William White has suggested that the recovery movement began in the late 1990s with an extraordinary cultural and political mobilization supported by the Recovery Community Services Program of the Substance Abuse and Mental Health Services Administration's (SAMHSA) Center for Substance Abuse Treatment.[2] White

identified the 2001 Recovery Summit in St. Paul, Minnesota, which launched Faces and Voices of Recovery, as a milestone in the recovery advocacy movement. The recovery movement impacted research literature as well. Kaskutas, Witbrodt, and Grella conducted a Google Scholar search dating to 1959 and found a significant increase from 2001 to 2012 in the number of articles about alcohol or other substance use with "recovery" in the title.[3] The American Psychiatric Association then released the fifth edition of its *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) in 2013, which revised the diagnostics for SUD, creating a range of symptoms from mild to moderate to severe. This revision helped shift the perception of SUD as existing along a continuum of severity rather than as a distinct positive or negative diagnosis, which was intended to impact how practitioners treated SUD and how researchers studied it.

In the midst of the burgeoning recovery advocacy movement, SAMHSA's Center for Substance Abuse Treatment convened the first National Summit on Addiction Recovery in 2005 to create one of the first definitions of recovery: "Recovery from alcohol and drug problems is a process of change through which an individual achieves abstinence and improved health, wellness, and quality of life."[4] In 2011, SAMHSA broadened this definition even more by removing the mention of abstinence as a criterion for recovery: "a process of self-directed change through which individuals improve their health and wellness, live self-directed lives, and strive to reach their full potential." These were only two of nearly a dozen definitions to come. According to Ashford and colleagues, at least 10 relevant definitions of recovery emerged between 2005 and 2017, from which their own Recovery Science Research Collaborative (RSRC) highlighted three as the "leading definitions of recovery": SAMHSA in 2011, the American Society of Addiction Medicine in 2013, and the Betty Ford Institute Consensus Panel in 2007.[5(p180)] Guided by these statements, the RSRC crafted its own definition: "Recovery is an intentional, dynamic, and relational process that involves sustained efforts to improve multiple aspects of wellness, and which may vary by individual, social, and experiential contexts."[5(p183)] In an effort to be more holistic and inclusive, similar to SAMHSA's 2011 description, the RSRC made no mention of reducing or abstaining from alcohol or substance use.

Along the same lines, none of the major efforts to conceptualize recovery have specified age or developmental concerns, which creates the impression that either the definitions were intended for adults, or the drafters considered adolescent recovery to be indistinguishable from adult recovery. In most instances, youth recovery simply has not been addressed in the definitional literature. Over the last decade, however, addiction neuroscience has shown that alcohol or other substance use during adolescence has a substantial impact on brain development. According to the National Institute on Drug Abuse: "The fact that this critical part of a teen's brain [the prefrontal cortex] is still a work in progress puts them at increased risk for trying drugs or continuing to take them. Introducing drugs during this period of development may cause brain changes that have profound and long-lasting consequences."[6(p10)] In addition, youths under age 18 cannot legally drink alcohol without parental supervision or use cannabis in states where recreational use is allowed, must be enrolled in school, and are considered minors and thus legally dependent on parents or guardians. For youths in recovery, therefore, the developmental, legal, and familial context fundamentally differs in ways that render adult-based conceptualizations of recovery insufficient.

Adolescent treatment and recovery support programs expanded at the same time as definitions of recovery were being adopted, and the youth data from both the annual National Survey on Drug Use and Health and the Monitoring the Future studies have shown precipitous drops in virtually every indicator of alcohol or other substance-related disorder—including youth meeting the criteria for SUD, youth needing treatment, and youth receiving treatment. The number of youths ages 12 to 17 who needed treatment—a key

indicator of potential referrals—was nearly 2.3 million in 2002, but by 2018, the number had fallen to 946,000.[1]

The reason for the decline in adolescents with SUD is uncertain, but the recovery movement no doubt played a role by spurring programs that reduced recidivism and provided tertiary prevention. AUD and SUD, though, have persisted, as have the treatment and recovery support gaps. Despite the efforts to define and potentially quantify the recovery process, the specific phenomenology of youth recovery has remained diffuse. Although substantial literature on adolescent AUD and SUD and treatment outcomes has arisen over the last 20 years, this review of the youth recovery literature has been complicated by inconsistent conceptions of the ages bounding "youth"; the definition, genesis, and life course of adolescent recovery; and the outcomes that are deemed successful. There exists a tapestry from which to divine an understanding of adolescent recovery, but a coherent typology has been elusive. This article thus uses other topics in the Recovery From AUD featured topic series as an organizational guide. As most of the issue's subtopics are not exclusively youth-focused, this article brings adolescence to the forefront, discussing (1) treatment outcomes, (2) special emphasis populations, (3) recovery-oriented systems of care, (4) families, and (5) non–abstinence-based approaches. This article concludes with a call for a clearer and more focused definition of recovery from AUD and SUD for adolescents, as well as more prospective and longitudinal research on sustained recovery and its impact on individual young people and society.

METHODS

This article provides a thorough and current review of the literature supported by representative references, utilizing an integrative review approach.[7] The methodology reflects the topic series' guidelines to review AUD among youth with a focus on recovery and within a limit of 50 references. Having three authors minimized potential bias, and each person conducted an independent review of articles. Multiple meetings were held discussing search criteria, findings, and selection. The process was emergent, iterative, and reflexive, and it considered prior reviews looking at similar issues. The authors ultimately decided the best organizing frame was from the topic series itself. Other frames emerged and were considered, but the topics from the journal itself ultimately worked best for consistency and clarity.

Problem Identification

This review was initially conceived as an exploration of the prevalence, pathways, and predictors of remission and long-term recovery among not only adolescents, but also emerging adults, commonly understood as the population ages 18 to 25. It also was intended to address not only recovery support services but also early interventions. After multiple conceptual discussions and after receiving consent from the editors, the authors agreed to focus on youths ages 12 to 18, the life phase usually referred to as adolescence. The literature and prevalence data on emerging adults (ages 18 to 25) are robust and worthy of their own review, but including that age group in this review could have drowned out the focus on adolescents. Although the life phase of transitional-age youth (ages 16 to 24) includes minors and youths transitioning from state custody and foster care, including that entire group also necessarily adds emerging adults, thus creating similar issues. As the adolescent age group is fundamentally different from emerging adults in a number of ways, including legal status, brain development, recovery capital, and family involvement, the authors felt a study of the trends and gaps in the literature on adolescents was needed. The scope also was narrowed to focus on the recovery process rather than the early intervention and treatment outcome literature highlighting specific treatments (such as multidimensional family therapy or motivational interviewing). This allowed the review to approach recovery as part of the treatment process as well as distinct from it. As treatment was not the focus of this review, the only treatment articles considered

for this review incorporate investigations into specific factors that influence the recovery process. Treatment studies exploring treatment outcomes and/or effectiveness per se were considered beyond the scope of this review.

Literature Search

Articles were included if they explored problematic alcohol and drug use or AUD and recovery among adolescents. As the adolescent life phase is understood differently in the literature—sometimes containing 18-year-olds and sometimes not—this review included articles focused on people age 18 and younger. Articles were included if they explicitly mentioned recovery or expanded on facets of the recovery process, such as personal or environmental characteristics that support recovery, broadly defined. Such topics included abstinence, sobriety, mutual aid, relapse, and alternative peer groups. Studies were excluded that focused solely on treatment outcomes, screening, or prevention. The year of publication was not considered when determining eligibility.

A systematic search was conducted in November 2019 of published studies in PsycINFO and PubMed (see Figure 1). These databases represent curated repositories of health, social science, and medical/clinical literature. Databases were searched for major themes of alcohol and recovery among adolescents. Based upon journal guidelines, articles must have explicitly included alcohol use in order to be considered for the study. Due to the conceptual ambiguity of recovery, additional terms commonly used in the field over the past few decades were included: relapse, remission, self-help, sobriety, and abstinence. Targeted searches also incorporated the key words "alternative peer group" and "recovery high school." After the removal of duplicates, the search resulted in 2,490 unique articles (specific search strings available upon request).

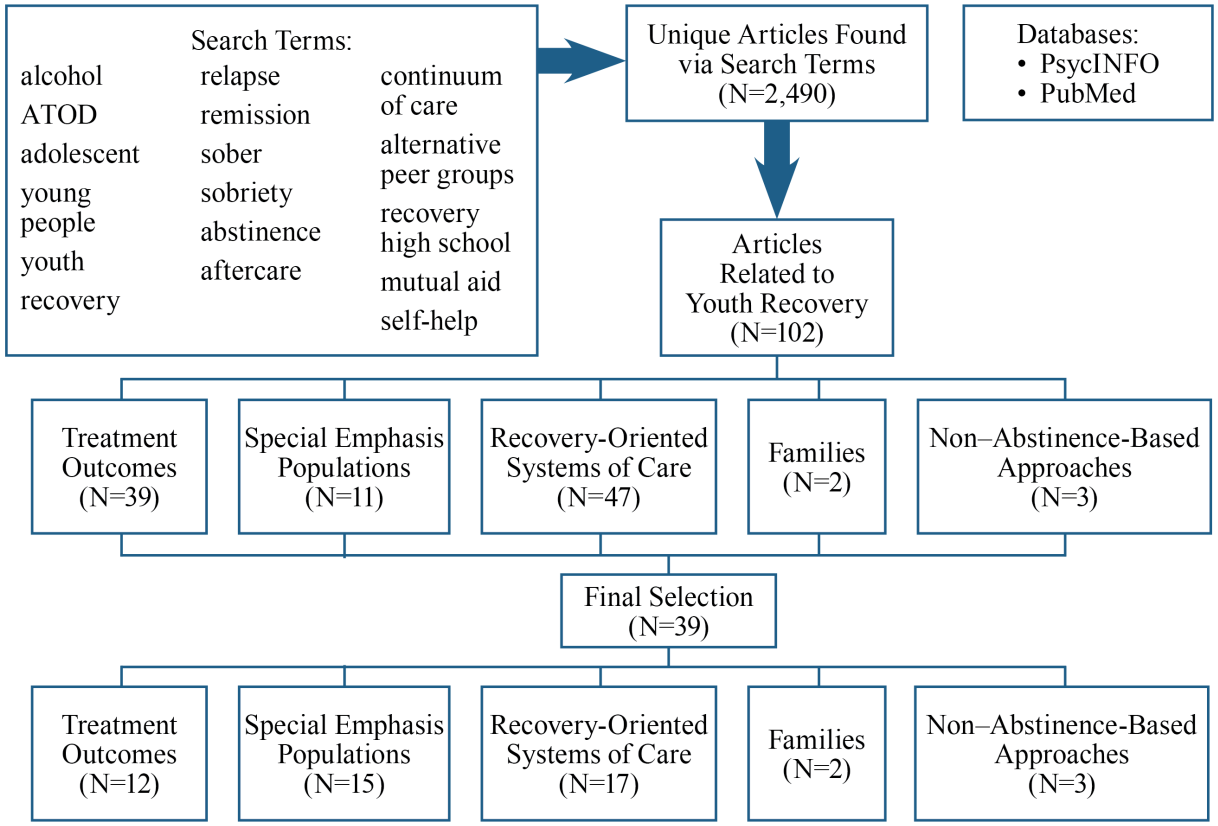

Figure 1 Literature search tree for an integrative review of recovery and young people. *Note:* ATOD, alcohol, tobacco, and other drugs.

Data Evaluation

Two authors independently reviewed half of the articles' titles and abstracts, and the lead author randomly reviewed articles for fidelity. In the initial screening, the full text of any ambiguous article was reviewed by multiple authors until a consensus was reached. After screening, 102 articles were identified as relating to youth recovery.

Data Analysis

Authors independently reviewed the 102 articles identified to create broad categories based on the variables and/or context studied (e.g., mutual aid, adolescent peer group, relapse). Due to the complexity and breadth of the literature, authors independently reviewed and coded articles for key themes and identified one to two main foci. The authors then met and refined the list of key themes. With a unified list of foci, authors again reviewed and coded articles. More than 20 major topics and 53 subtopics were identified. Because of the limited space and the range of topics, authors chose to organize the major topics to mirror those covered in the topic series. The 23 primary categories were thus grouped into five sections for review: treatment outcomes, special emphasis populations, recovery-oriented systems of care, families, and non–abstinence-based approaches. The description and rationale for each of those sections is discussed earlier.

After reaching an agreement on the conceptual framework, two authors independently identified which of the 102 articles to include in the literature review. This process included assessing articles on individual characteristics as well as considering the breadth of articles reviewed. Individual study characteristics included sample size for quantitative studies, credibility enhancements such as triangulation in qualitative work, publication year, recovery focus, and implications of findings. Macro-level considerations included representing a range of authors, study designs, distribution across topic areas, and conceptual frames. Upon completion, those two authors met to reach a consensus, and the lead author then independently assayed the articles to approve of the final selection of 39 for inclusion, a number within the journal's preferred limit of 50 total citations (Table 1).

RECOVERY AS A TREATMENT OUTCOME

Until relatively recently, adolescent recovery from AUD or other SUD has been researched mostly as part of a linear model of addiction treatment. Recovery was understood to be abstinence-based, and adolescent recovery usually was assumed to include some form of treatment. Indeed, most researchers have viewed adolescent recovery as the result of successful treatment rather than a distinct phenomenon. If recovery programs were studied at all, they were seen as aftercare, or continuing care, to sustain the gains of treatment. Articles examining treatment outcomes and relapse thus account for the majority of the articles about recovery and youth. Treatment outcomes (e.g., abstinence, symptom reduction) were identified traditionally as the dependent variable, as opposed to the growing body of research studying recovery itself as the dependent variable. Instead of viewing recovery as its own construct, the following articles represent those studies that evaluated treatment outcomes as a proxy for recovery.

Treatment outcome articles cover myriad modalities, including both specialty (i.e., treatment centers, hospitals) and non–specialty treatment (i.e., doctor's offices, emergency rooms, support groups). Within the context of recovery from a treatment lens, longitudinal treatment outcome studies provide insight into adolescents' behavior post-treatment and the variables that impact abstinence or relapse. For the purpose of this review, articles researching treatment modalities were included if they focused on treatment in a recovery context. This means the study emphasized how the recovery process supported treatment instead of whether a singular treatment modality was effective, with the locus being the aspects of recovery rather than the components of treatment.

Table 1 References Identified in Literature Search (N = 39)

Main Topic	Reference Number	Author	Year
Treatment Outcomes			
	8	Brown et al.	2001
	9	Myers, Brown, and Mott	1993
	10	Brown and Ramo	2006
	11	Latimer et al.	2000
	12	Tapert et al.	1999
	13	Chung et al.	2015
	14	Cornelius et al.	2003
	15	Kaminer and Godley	2010
	16	Cavaiola, Schiff, and Kane-Cavaiola	1990
	17	Maisto et al.	2003
	18	Chung et al.	2005
	19	Kaminer et al.	2018
Special Emphasis Populations			
	20	McCarthy et al.	2005
	21	Sterling et al.	2009
	22	Pagano et al.	2015
	23	Krentzman et al.	2012
	24	Winward et al.	2014
Recovery-Oriented Systems of Care			
	25	Winters et al.	2007
	26	Godley et al.	2019
	27	Kaminer, Burleson, and Burke	2008
	15	Kaminer and Godley	2010
	28	Chi et al.	2009
	29	Dennis et al.	2015
	30	Kelly and Urbanoski	2012
	31	Nash, Hennessy, and Collier	2019
	32	Nash and Collier	2016
	33	Nash	2020
	34	Johnson et al.	2016
	35	Johnson et al.	2018
	36	Pullen et al.	1999
	37	Cloud and Granfield	2008
	38	Hennessy, Cristello, and Kelly	2019
	39	Finch, Moberg, and Krupp	2014
	40	Hennessy et al.	2018
	41	Finch et al.	2018
Families			
	42	Stewart and Brown	1993
	43	Jaffe	2002
Non–Abstinence-Based Approaches			
	44	Marlatt and Witkiewitz	2002
	49	De Sousa	2014
	19	Kaminer et al.	2018

There is much research evaluating potential mediators and moderators of treatment outcomes, such as social skills and cognitive abilities. Brown and colleagues, for example, studied adolescents' behavior for 4 years post-treatment, and their findings elucidate variables impacted by the developmental transition from adolescence into young adulthood, which may uniquely impact treatment outcomes.[8] Other literature explored internal factors, such as coping skills, developmental and neurocognitive considerations, and psychosocial factors.[9-11]

Due to the social and environmental pressures faced by adolescents, the development of positive psychosocial skills can be an essential element in treatment, as such skills have been associated with avoiding relapse.[9,11] From a developmental perspective, coping skills and neurocognitive abilities were found to distinctively impact adolescents' relapse.[12] These factors were more salient for adolescents with lower intellectual abilities, whereas other factors may be more salient for those with average or above-average intellectual abilities.[12] According to Latimer and colleagues, an adolescent with at least one protective factor (e.g., social connectedness, goal directedness, peer abstinence), who completed long-term treatment followed by continuing care, was more likely to achieve successful outcomes compared to those with fewer protective factors.[11]

External factors, such as one's environment or social influences, can also impact treatment outcomes. Peer affiliation and influence have been shown to play critical developmental roles in adolescents' post-treatment behaviors. When adolescents return to their previously held social groups and support systems following treatment, they can be faced with contradicting desires to abstain from alcohol and other substance use while simultaneously maintaining their relationships with substance-using peers.[13] Among adolescents who relapsed post-treatment, Cornelius and colleagues found social pressure, withdrawal, and negative affect to be the most common factors.[14]

Continuing care has been highlighted in the literature as supporting treatment gains and preventing relapse. Kaminer and Godley suggested that, because adolescents were less likely than adults to remain abstinent after one treatment episode, evaluating continuing care was essential.[15] Cavaiola and colleagues highlighted the importance of continuing care as part of the recovery process in an early article published 30 years ago.[16] While still emphasizing abstinence and relapse prevention, Cavaiola et al. evaluated an array of factors impacting post-treatment continuing care among adolescents to provide a more holistic view of recovery, including integration into mutual aid, relapse prevention and relapse management, relationships, resistance and denial, grief and loss issues, self-esteem issues, family treatment issues, and dual diagnosis.[16]

The complex nature of recovery has led to divergence in how researchers have approached relapse and abstinence for youth. It is critical to note the discrepancies in definitions of "relapse" and the subsequent impact on the evaluation of treatment outcomes and recovery for young people.[17] Relapse and relapse prevention are multifaceted phenomena closely associated with treatment outcomes; yet, the field has been moving away from seeing recovery as requiring abstinence. Chung and associates, for example, implemented a trajectory analysis to demonstrate how a return to use does not necessarily indicate an adolescent is not in recovery or reducing their problematic behavior.[18] As of late, the nascent body of literature dedicated to harm reduction has highlighted the differences between abstinence, reducing use, and using less harmful substances as the dependent variables in research studies. Although there have been few studies of harm reduction for youths, Kaminer and colleagues found that the relationship between abstinence as a post-treatment goal and long-term success is stronger than if the goal is harm reduction.[19] A substantial number of studies have been designed through a treatment outcome lens,

which defaults to "recovery" if an adolescent is abstinent. In essence, for youth, recovery has been studied more as an emergent latent variable than as its own designated entity.

SPECIAL EMPHASIS POPULATIONS

Differences in relapse and relapse prevention among subpopulations of adolescents form a subset of the literature viewing adolescent recovery through a treatment outcome lens. The recovery process post-treatment had a different trajectory based upon various factors, such as the intersectionality of an adolescent's recovery and cultural identity, including gender, race, and/or ethnicity. Populations highlighted here include students and adolescents with co-occurring disorders or traumatic experiences.

Although evaluating co-occurring disorders in adolescence can be problematic due to diagnostic criteria that often exclude people under age 18, there is a small body of literature that studies the impact of psychiatric comorbidity on relapse and treatment outcomes. Psychiatric symptoms have been found to influence post-treatment relapse among adolescents with AUD or other SUD and a co-occurring Axis I diagnosis.[20] Sterling and colleagues found engagement during treatment to be essential for adolescents with co-occurring disorders, because abstinence during the first year was associated with reduced substance use and symptoms of mental health disorders after 3 years.[21] The authors suggested mental health symptomology should not be excluded when evaluating the treatment outcomes and recovery process of adolescents with co-occurring disorders, especially given that positive mental health outcomes during treatment were associated with long-term recovery benefits.[21]

Research evaluating the relationship between a high incidence of alcohol and other substance use for adolescents with trauma histories is growing, but the literature is still limited. The contribution or impact of lifetime trauma on an adolescent's substance use or on the treatment process has been studied, but how trauma relates to an adolescent's recovery has not been examined. For example, the relationship between social anxiety disorder and lifetime trauma, as studied by Pagano and colleagues highlighted the indirect influence of trauma on peer support systems and boundary setting in the treatment process.[22]

Similar to other subpopulations, the prevalence of alcohol or other substance-related disorders for adolescents based on gender, race, and/or ethnic identity has been studied at length. Limited literature, however, is available to explain the impact of these identities on recovery. Research has evaluated post-treatment behaviors that have been impacted by an adolescent's culture. For example, although there are differences in spirituality and religiosity levels between Black and White adolescents receiving treatment for AUD or other SUD, the findings suggested that religiosity was a predictor of 12-step-related behaviors but not of treatment outcomes.[23] In the same study, a significant gender disparity was found in that women were more likely to take the actions outlined in the 12 steps.[23]

Another unique consideration for this age group is the status of student. As most states require people under age 18 to be enrolled in school, studies have not compared recovery processes for student versus nonstudent adolescent samples. There is little research, though, studying the impact of recovery on young people's academic outcomes. In one such study, a neuropsychological test battery evaluating five key domains was used as a proxy for academic outcomes by evaluating cognitive functioning.[24] During early abstinence from heavy episodic drinking, adolescents' prospective memory, cognitive switching, inhibition task accuracy, and visuospatial abilities developed significantly.[24]

It can be surmised that due to the relatively small number of adolescents in recovery, it could be prohibitively challenging to study sample sizes that result in statistically significant findings. Although prevalence of alcohol and

other substance use among specific adolescent subpopulations, such as LGBTQ+ youth, is well documented, there are virtually no articles on the impact of various identities on long-term recovery for youth or how recovery may impact the identities youth hold. Based on the literature, it is clear that substance misuse among adolescents varies among subpopulations. There is, however, scant literature detailing the impact of a youth's cultural intersectionality on the youth's recovery process.

RECOVERY-ORIENTED SYSTEMS OF CARE

Recovery-oriented systems of care (ROSC) arose out of the shortcomings of the linear, acute care model of addiction treatment. ROSC is an umbrella concept that represents the entire network of formal and informal relationships and organizations that foster individual, familial, and community recovery processes over time.[2(p497)] Further explanation and elaboration of ROSC can be found elsewhere in this topic series. Although empirical evidence is mounting for adults, there is scarce literature exploring ROSC for youth. The few studies that have investigated adolescent systems have considered continuing care, mutual aid, peer groups, school programs, and technology.

A key aspect of ROSC is the continuum of care. Continuing care, frequently cited as "aftercare," has been situated as following treatment. Like traditional treatment outcome studies, most continuing care research has studied maintenance of treatment gains. The locus of ROSC, however, has been the recovery support systems and processes themselves rather than simply indicators of treatment success. One long-term outcome study followed a treatment group, a waitlist group, and a community control group over 5.5 years post-treatment and found that involvement in continuing care among the treatment group was positively associated with improved treatment outcomes.[25]

As smartphones have taken an ever-more pervasive place in adolescent communication, they also have begun filling a role in continuing care. A recent randomized controlled trial found that voluntary recovery support provided via phone by other youths had direct and indirect effects.[26] Continuing care was directly associated with increased involvement with pro-recovery peers and recovery management activities. It also was indirectly linked to reductions in alcohol and substance use and problems as well as increased remission. Incremental dose effects were also found—for every 10% increase in support call completion, recovery activities increased by nearly one activity.[26] In similar fashion, Kaminer, Burleson, and Burke compared in-person and brief phone continuing care with no continuing care through a randomized design.[27] Findings indicated that continuing care in general slowed the occurrence of post-treatment alcohol use and, for girls, maintained treatment gains; phone-based continuing care was also as effective as in-person models.[27] More structured, manualized continuing care for adolescents, called assertive continuing care, also surfaced as an impactful model for adolescents.[15] Although there is evidence that continuing care plays a key role in supporting recovery among adolescents, additional investigation into the moderators of both participation and effect are called for.

Another emergent youth-specific element is the incorporation of digital technology in recovery supports. Along with the previously mentioned studies utilizing phones for their financial and geographic flexibility in continuing care,[26,28] Dennis and colleagues investigated and found smartphone apps to be feasible and efficacious for recovery monitoring and support among youth.[29] The scale of benefits received from peer-based and technology-based support merits further investigation.[26,30-32]

The recovery-oriented systems of care model emphasizes communities, especially peer recovery support services. Historically, one of the most common continuing care recommendations for adolescents has been to attend mutual aid groups, such as Alcoholics Anonymous and Narcotics Anonymous.[30] Fellowships based on a 12-step approach appear to provide a supportive social

context for adolescents in recovery.[33] Attendance and involvement in 12-step fellowships, specifically particular aspects such as meeting with a sponsor outside of meetings and verbal participation in meetings, have predicted positive recovery outcomes for adolescents over and above simple attendance, which also has been positively associated with outcomes over time.[28,30,33] Other underlying mechanisms of 12-step benefits have included general social support and providing support to others.[28,34,35] In combination with mutual aid, participation in religious services also was found to positively impact adolescent recovery.[28,36] Expansion of youth-specific 12-step communities has been identified as a way to increase youth recovery support.[28,30,33]

ROSC, of course, is not limited to mutual aid groups. A youth model perhaps best aligned with ROSC is the alternative peer group, which began in the early 1970s. Although more evidence of effectiveness is needed, alternative peer groups (APGs) have been described in the literature as a model that integrates recovering peers, prosocial activities, and evidence-based clinical practices.[32] Key elements of the APG model include psychosocial education, case management, social functions, community recovery support, family support, and counseling.[32] A unique and key component of APGs is their focus on developmentally appropriate recovery support services for adolescents.

In reviewing the available evidence presented for youth recovery within ROSC, including APGs, recovery capital (RC) has surfaced as a useful frame for classification of supports and may help target specific systems or characteristics to foster youth recovery. Recovery capital is the breadth and depth of resources that persons can access to support their recovery across ecological levels.[37] The recovery capital for adolescents model (RCAM) highlights the importance of understanding youth-specific recovery processes across four main domains of capital: human, financial, social, and community.[38] The utility of RCAM was supported among APG participants such that RCAM identified specific recovery assets and barriers for youth as well as reflected the four recovery capital domains previously validated for adults.[31,32,38]

The review also yielded evidence of specific systems or domains of recovery capital situated within a ROSC paradigm that support youth recovery. Recovery high schools, for example, are specifically designed for students recovering from a substance use disorder. Although they have been a resource for adolescents since the late 1970s, they have only begun to be systematically empirically evaluated.[39] A recent systematic review found only one rigorous study to date evaluating recovery high schools[40]—indicating a significant need for further investigation. These institutions of continuing support for youth are dynamic and vary widely in regards to enrollment, fiscal stability, governance, staffing, and organization; however, the tailored supports appear to benefit adolescents' recovery and academic performance.[39,41]

Criminal justice institutions also present a system in which changes in practice can be more supportive for youth recovery. Evidence of the role of social support, religious service attendance, and service to others among youth who have been involved with criminal justice institutions indicated that providing a supportive recovery environment reduces the risk of relapse, incarceration, and violent crime.[34,35]

FAMILIES

The family context has been identified as a significant component in the etiology and progression of adolescent alcohol and substance use for decades.[42] Addiction has been commonly referred to as a family disease. Like most adolescent recovery research, though, the focus has been entrenched in the acute addiction treatment paradigm. Jaffe, for example, identifies family therapies as a key treatment modality for youth.[43]

The familial relationship, however, can be especially complex for adolescents seeking recovery, because they often have parents who also engage in problematic drinking or use.[16] Despite the acknowledgement of how critical family is

for adolescents seeking recovery, there remains a significant gap in the research literature focusing on recovery specifically. Possible explanations include but are not limited to the feasibility of family-based research studies. Including additional family participants in the research design increases cost and demands for methodological rigor. Future investigations into mechanisms of youth recovery are needed to better understand the familial context, as well as to situate families within the ROSC and recovery capital frames.

NON–ABSTINENCE-BASED APPROACHES

As ROSC has emerged out of the gaps of acute care models, non–abstinence-based approaches to recovery have facilitated a new organizing paradigm surrounding multiple pathways of recovery.[5] Although the concept of multiple pathways is not new, the exploration of harm reduction and medication-assisted treatment (MAT) and recovery is relatively recent. Shifting the focus to outcomes such as quality of life, personal relationships, life satisfaction, and improved cognition has presented new avenues for investigation and understanding treatment effectiveness. This new paradigm has particular implications for adolescents.[44]

Although the line between abstinence-based treatment and abstinence-based recovery has become less distinct over time, the lines between MAT and medication-assisted recovery have always been blurry. White said:

> The historical stigma attached to methadone and the broader arena of medication-assisted treatment has denied MAT patients the status of recovery and left them isolated from mainstream community life and existing in limbo between cultures of addiction and cultures of recovery. . . . At the very core of this stigma is the deeply imbedded idea that recovery from opioid addiction does not begin until the day the use of medications like methadone and buprenorphine ends. Recovery from no other chronic health condition rests on such a proposition.[45(p6)]

The limbo may be even more profound for adolescents. Levy and colleagues suggest MAT might be effective in the treatment of opioid use disorder for adolescents;[46] however, Feder, Krawczyk, and Saloner found that only 2% of adolescents in treatment for heroin and opioid use received MAT, compared to 26% of adults.[47] Beyond the long-standing philosophical issues about prescribing medications to treat AUD or other SUD, there are also concrete legal barriers in both national and state statutes that make it difficult for physicians to prescribe some medications such as methadone or buprenorphine to minors.[48]

Additional consideration is needed given the legal repercussions of harm reduction for adolescents—namely, that consumption of alcohol and cannabis is illegal for those under age 21—as well as the neurocognitive variables for the still-developing adolescent brain.[19] Moreover, although De Sousa found that MAT, particularly disulfiram, reduced number of drinking days,[49] Kaminer and colleagues found no evidence that harm reduction motivations for AUD yield more desirable outcomes than abstinence-based motivations among adolescents.[19] Empirical evidence of non–abstinence-based approaches for young people is scant. Future research should explore if these approaches are safe and effective for youths.

DISCUSSION

In a speech delivered at the UCLA/Betty Ford Institute Annual Recovery Conference in 2012, historian William White said: "People are entering recovery younger and younger, and yet little information exists about living a life in recovery that begins at age 15 or 25 rather than 45 or 55."[2(p495)] This review has shown White's comments largely still hold. Recovery from AUD or other SUD remains a complex and challenging concept to define and thus to study, and this is even more evident for recovery that begins in

adolescence. Steps have been taken, however, to distinguish recovery for people under age 18 from recovery in adulthood.

Early efforts to research youth recovery viewed it as the result of successful treatment. Recovery for adolescents was understood to be abstinence-based and usually was assumed to include some form of treatment. Studies suggested the post-treatment recovery process had a different trajectory based upon various person-level factors, including the adolescent's cultural identity, student status, trauma history, and co-occurring disorders. Most of these studies, though, still viewed adolescent recovery through a treatment outcome lens.

The recovery-oriented systems of care approach shifted the structural and empirical locus to the recovery process itself, and it moved away from a program-level orientation to a systemic one. Although many studies of aftercare, or continuing care, still remain situated in a treatment outcome frame, the attention has gradually progressed to specific components of successful recovery for youth. Studies of adolescent ROSC, though still relatively small in number, have considered adolescent continuing care, mutual aid, peer groups, and school-based programs—as well as the impact of smartphone technology on youth recovery. Addiction also has long been understood to be a "family disease," and there have been a few attempts to understand family systems in recovery.

Recovery increasingly has been presented as not requiring abstinence, and non–abstinence-based approaches to recovery have generated more attention in the field. The idea of multiple pathways to recovery has included paths without specialty treatment. Harm reduction and MAT approaches for youth have produced few empirical studies while getting more support philosophically. Traditional outcomes, such as relapse or even reduced days of use, have been supplanted by variables such as quality of life, personal relationships, life satisfaction, and improved cognition.

The arc of the recovery paradigm has been moving from acuteness to chronicity, from programmatic to systemic, from pathology to wellness, from exclusivity to accessibility, from homogeneity to diversity, and from selectivity to inclusivity. Diagnosis and treatment of AUD and SUD have shifted away from seeing recovery as a linear progression toward abstinence to understanding recovery moving along a continuum, which may not necessitate complete abstinence. Indeed, alcohol and other substances have even been removed from recent definitions of recovery to allow room for non–substance-related addictions—as supported by neuroscience suggesting similar brain activity for substance and non–substance-related addictions. The turn toward a "big tent" or "many roads" approach for recovery has benefits, such as mitigating stigma and facilitating healthy lives for millions of people. At the same time, the unique properties of recovery from AUD or other SUD have become harder to glean, especially as sobriety becomes less of a goal. As adolescents fundamentally differ from adults, it is essential to determine when the "big tent"/"many roads" concept—established by and for adults—will help youth and when it will not.

FUTURE RESEARCH

A clear organizing framework is missing from the extant adolescent recovery literature. Promising work in this area includes the seminal article by Brown and Ashford around creating a "recovery science"[50] and an article by Finch and Frieden that provides a synthesis of how classic developmental theories form a foundation for recovery high school environments and culture.[51] It is hoped that a theoretical model will emerge from suggested future research to explain behavior change and maintenance, remission, and sustained recovery for young people.

Harm Reduction and Medication-Assisted Recovery

As harm reduction continues to gain legitimacy as a model of recovery, more evidence is needed to understand how ongoing substance use may impact neurological as well as psychosocial development of adolescents. This review also has shown that more research is needed on how psychopharmacological drugs impact a developing brain differently from an adult brain, and how those differences implicate medication-assisted recovery. Both exploratory and effectiveness studies can guide the discussion away from passionate debates toward grounded understanding and evidence-informed program development.

Expanding Beyond a Treatment Outcome Paradigm

The prevalence data have shown that although the number of youths with AUD or other SUD has been declining steadily over the last 2 decades, large numbers of adolescents with SUD or co-occurring disorders still do not have access to treatment and/or do not receive treatment. Although most of those youths likely do not get into recovery as adolescents, many do, and they are not being captured in the literature on recovery as a treatment outcome. One byproduct of widening the umbrella for people in recovery should be the subsequent broadening of who gets included in programs and studies.

Disparities

Regarding the wider umbrella, adult studies of recovery have considered disparities around intersectional identities and social class in treatment and recovery. Much of the discourse about MAT, harm reduction, and abstinence-based recovery has revolved around racial disparities in the mental and behavioral health system. Youth of color "have less access to, and lower quality of, behavioral health services compared to their White counterparts."[52(p22)] These disparities and their impact on adolescent recovery trajectories need more exploration.

Recovery Capital for Adolescents

More studies also are needed for investigating various support modalities for youth, including recovery residences, recovery high schools, alternative peer groups, mutual aid groups, and family systems, and how different combinations of components may be needed for different people and diverse populations. The nascent work on the recovery capital model for adolescents[38] offers great promise in explaining disparities of access to certain types of recovery support, as well as which factors may benefit one young person more than another. The recovery capital model in combination with a clearer comprehension of adolescent neuroscience of addiction will better tune the field of youth recovery.

Recovery Across the Life Span

Finally, recovery research in general needs more life course studies. Recovery begun in adolescence cannot be fully understood until adulthood. Although retrospective studies can provide some data on origination of AUD and SUD and the pathways of recovery, better precision is needed. Prospective, longitudinal, and life course research, beginning in youth and continuing at regular intervals, is the only way to fully appreciate the complex and cascading nature of recovery across the life span.

LIMITATIONS

Neither "youth" nor "recovery" has a commonly accepted definition. Although the authors were diligent in using the literature to frame both for the purpose of this review, it is possible that defining either concept differently would have taken the review in divergent directions.

In making choices to study adolescents and the recovery process, this review did not include studies of emerging adults (ages 18 to 25) and transitional-age youth (ages 16 to 24), unless youth age 18 and younger were explicitly included in the sample. Although this allowed the authors to focus on adolescents, there may have been studies of

adults whose recovery began in their youth, which were not reviewed.

Similarly, in line with the journal's focus on alcohol, the review required alcohol and recovery to be main components in the literature search, which may have left out articles on SUD that did not explicitly mention alcohol. The language used in extant literature guided the findings. In studies related to recovery and young people, AUD and SUD often were discussed in one category instead of referencing alcohol and various substances in their own capacity. Hennessy and Fisher provide an example of how future studies could review literature related to broader substance use and recovery among young people.[53]

Though population effects are considered here, the review does not fully explore the diversity of adolescent recovery experiences based on intersecting identities or social class. This is due in large part to the lack of diversity in both adolescent recovery support programs and in research studies.

Finally, while using this topic series' own categorizations as an organizing frame allowed for conceptual consistency, it can be acknowledged that different reviewers may have arrived at a different heuristic typology. No review of adolescent recovery at this stage should be considered definitive, and this review is no exception. Rather, the intent was that this integrative review would be well designed, thorough, and an accurate representation of the field to date.

CONCLUSION

As the recovery movement has become established and access to recovery has broadened, the need to explain and study how the concept of recovery pertains specifically to adolescents has increased. This integrative review considered studies of youth and recovery across (1) treatment outcomes, (2) special emphasis populations, (3) recovery-oriented systems of care, (4) families, and (5) non–abstinence-based approaches. Although this review found that the literature on adolescent recovery has grown, the authors make the following recommendations:

- More research is needed about the impact and effectiveness of medication-assisted recovery and harm reduction.
- The field of adolescent recovery needs to widen its scope of practice and research beyond youth who have received treatment to include those who have not received treatment due to personal choice or societal disparities.
- The literature would benefit from more prospective and life course research.

Research must not lose sight of the unique properties of either adolescent development or recovery from alcohol or other substance-related disorders, and there is great promise in the recovery capital model for adolescents and the neuroscience of addiction to provide more precision and direction to the field of recovery and youth.

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Alcohol Screening, Brief Intervention, and Referral to Treatment (SBIRT) for Girls and Women

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Females ages 12 and older are the fastest growing segment of alcohol consumers in the United States, with the past decade showing a 16% increase in alcohol use per 12-month period and a 58% increase in high-risk drinking (i.e., > 3 drinks in a day and/or > 7 drinks in a week) per 12-month period. The increase in alcohol use and risk drinking poses unique and serious consequences for women. Women have a more rapid progression to alcohol-related problems and alcohol use disorders (AUD) than men, and if pregnant, women can potentially expose the fetus to alcohol. Screening, brief intervention, and referral to treatment (SBIRT) is an evidence-based, integrated public health approach used to identify and address risky alcohol use among women in a variety of health and social service settings. This article presents the current status of SBIRT among girls ages 12 and older, women of childbearing age, and older women. Screening instruments, brief interventions, and implementation issues specific to women of all ages are described. Through this review of the current literature, care providers can determine best practices for the prevention and treatment of risk drinking in women of all ages presenting in health care settings.

KEY WORDS: brief intervention; risk; alcohol; SBIRT; screening; women; female adolescents

INTRODUCTION

Alcohol is the most commonly consumed substance among Americans ages 12 and older, and women are the fastest growing segment of alcohol consumers in the United States.[1,2] Female alcohol consumption that meets criteria for risk drinking, defined as more than three drinks in a single day or more than seven drinks per week, has the potential to negatively affect the health and well-being of women across their life spans.[3] Evidence indicates converging patterns of alcohol consumption between men and women resulting from recent increases in female alcohol

use behaviors.[2,4,5] For instance, data collected in the past decade reveal that among U.S. women, alcohol use increased by 16% per 12-month period, high-risk drinking increased by 58% per 12-month period, and diagnoses of alcohol use disorder (AUD)—as defined in the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders*—increased by 84% per 12-month period.[2] These increases have unique and serious consequences for women given that they experience a more rapid progression—at lower consumption levels—to alcohol-related problems and AUD than men.[6,7]

This recent increase in female alcohol consumption underlines a need for additional research and clinical efforts to address alcohol use among girls and women.[2,4] Because risky drinking poses unique and detrimental consequences to all women, age and life circumstances should not preclude any subset of girls or women from research or clinical efforts to address this growing public health concern. Indeed, risky alcohol use is prevalent among young girls;[8,9] pregnant and postpartum women;[10,11] victims of child abuse,[12] sexual trauma,[13] and intimate partner violence;[14] female veterans;[15] incarcerated girls and women;[16] sexual-minority women;[17] and older women.[5] Due to alcohol's nondiscriminatory nature towards varying groups of women, universal screening, brief intervention, and referral to treatment (SBIRT) appears to be an appropriate, evidence-based public health approach capable of identifying and addressing risky alcohol use among females in a variety of health and social service settings.[18] This article presents a review of the literature regarding the role of SBIRT in addressing risky alcohol consumption among girls (ages 12 to 18), women of childbearing age (i.e., ages 18 to 44), and older women (i.e., ages 65 and older). There is a general lack of currently available research data specific to women ages 45 to 64, but other than risk of pregnancy associated with women ages 18 to 44, the role of SBIRT is similar for women ages 45 to 64 to that for younger women. Databases used for this review include PubMed, Cochrane Library, Google Scholar, and Academic Search Complete. The reference lists of selected articles and texts were also explored.

SBIRT

The current SBIRT model is based on a recommendation from the National Academy of Medicine (previously called the Institute of Medicine) to develop integrated service systems that bridge the gap between primary prevention and treatment services for individuals with problematic alcohol and/or illicit drug use.[19] In 2003, the Substance Abuse and Mental Health Services Administration (SAMHSA) established an initial SBIRT grant program, with the intent of integrating behavioral health services into settings where individuals who engaged in risky substance use behaviors could be identified and offered an appropriate level of intervention and care.[20] Findings from this initiative suggest that SBIRT is associated with improvements in alcohol use outcomes.[20,21]

The U.S. Preventive Services Task Force (USPSTF), an independent entity consisting of experts in preventive medicine, recently updated its recommendation for care providers. This update recommends that care providers screen all adults ages 18 and older, including pregnant women, for risky alcohol use and provide brief behavioral counseling interventions, when appropriate, to reduce unhealthy alcohol use.[22] Screening adolescents younger than age 18 was not included in the updated recommendation; the USPSTF concluded that there is insufficient evidence to properly assess the benefits versus risks for alcohol screening and brief interventions (BI).[22] The American Academy of Pediatrics (AAP), however, has recommended the practice of screening and providing BI to adolescent alcohol users, citing low cost, minimal potential for harm, and emerging evidence of the benefit that SBIRT may have among adolescent alcohol users.[23]

SBIRT is intended to identify, reduce, and prevent problematic alcohol use behaviors and is made up of three key components: screening, brief intervention, and referral to treatment. Ideally, the first step of the SBIRT process is to administer a validated prescreen

instrument to all presenting individuals in a practice setting, as part of the routine intake procedure, to identify those who are drinking at or above risky levels.[24,25,26] When prescreen instruments detect consumption at risk levels, measured by standard drinks (14 grams or 0.6 fluid ounces of pure alcohol) consumed, a more comprehensive assessment can be conducted to gauge the severity of alcohol use and inform BI and/or treatment options.[3] For example, the National Council for Behavioral Health recommends that a symptom checklist or other validated assessment be used to obtain alcohol-related symptoms from individuals whose prescreen indicates risky consumption.[26] If it is determined that an individual is consuming alcohol at moderate risk levels (i.e., above NIAAA threshold for low-risk consumption but not at a level indicative of AUD), then the second step in the SBIRT process is to complete a BI protocol. BIs are often based on principles of motivational interviewing (MI) and aim to increase awareness of alcohol-related risks and consequences and to encourage motivation for change. If an individual is identified to be drinking at levels that are suggestive of AUD, then referral to specialized treatment for further assessment and care is recommended.[27]

SCREENING

SBIRT begins with universal screening, the goal of which is to identify individuals who have, or are at risk of developing, alcohol-related problems.[27] Universal screening that is adherent to SBIRT standards, and described in multiple SBIRT practice guides, involves the administration of a validated prescreen instrument that has been limited to a few questions needing only simple responses.[24,26,28,29] Ideal screening instruments have high sensitivity and specificity ratings, with cutoff scores designed to maximize both ratings in order to minimize false positives and false negatives.[30] However, for prescreen instruments that are intended to be universally administered, priority is often given to sensitivity over specificity so that individuals in large clinical populations (e.g., women in primary or reproductive care settings who consume alcohol while pregnant) are appropriately identified for further assessment.[30,31]

This article classifies screening instruments into prescreen and screen categories. The purpose of prescreening is to assess an individual's frequency and quantity of alcohol use to determine whether the person is drinking at age-specific risk levels, whereas the purpose of screening is to elicit alcohol-related symptoms from those that have been identified as drinking at risk levels. Prescreens and screens should work in succession, and because many instruments are capable of serving both screening purposes, this dual process is sometimes consolidated into a single step within clinical practice settings.

Universal prescreening and screening efforts must be conducted using valid, age-appropriate instruments with cutoff scores that are tailored to a population's sex and age (see Table 1).[32] Following is an overview of screening practices and instruments that have been validated for use within specified age groups of girls and women.

Adolescents

NIAAA, SAMHSA, and AAP recommend that care providers screen all adolescents and young adults ages 12 to 21 for alcohol and substance use behaviors using validated screening instruments on a yearly basis and, as needed, during acute care visits.[33] There are currently three prescreen options that are applicable to adolescents: the two age-specific questions found in NIAAA's *Alcohol Screening and Brief Intervention for Youth: A Practitioner's Guide*;[29] the first three questions of the Screening to Brief Intervention (S2BI); and the three-item Alcohol Use Disorders Identification Test–Concise (AUDIT-C).[33] The two age-specific questions found within NIAAA's guide ask about an adolescent's personal alcohol use as well as that of their friends and is appropriate for children and adolescents between the ages of 9 and 18. This AAP-endorsed guide includes elementary, middle, and high school age-appropriate variations of these two questions, which allow for accurate correlation of patient responses to current or potential risky alcohol consumption.[29] The S2BI instrument screens

for alcohol, tobacco, marijuana, and illicit drug use by asking a single frequency-of-use question per substance. This screener is highly sensitive and specific at discerning among various risk categories, from no use to severe substance use disorder (SUD). Although not a formal diagnostic instrument, the S2BI has been shown to closely correspond with the likelihood of current SUD.[34] The AUDIT-C, validated for use with young people ages 12 to 19, has three questions to identify the quantity and frequency of alcohol consumption.[32,35,36]

When adolescents score positive on a prescreen instrument, indicating some level of risky alcohol consumption, they are asked to respond to additional, more specific screening questions to determine whether a BI or referral to treatment is appropriate. Screening instruments that have been validated for use with adolescents and can be used to inform next steps include the 10-item Alcohol Use Disorders Identification Test (AUDIT); the Brief Screener for Tobacco, Alcohol, and Other Drugs (BSTAD); and the Car, Relax, Alone, Forget, Friends, Trouble (CRAFFT) screening instrument.[23,32,37] The AUDIT is the most widely tested alcohol screening instrument and is commonly used to assist in the early identification of individuals engaging in risky drinking behaviors.[22] Furthermore, the AUDIT has been validated for use among young people,and evidence suggests a lack of gender bias between female and male adolescents.[32,35] The BSTAD, an adaptation of the questions found within NIAAA's guide includes questions on alcohol, tobacco, and drugs, and has been shown to be highly sensitive and specific at identifying risky past-year alcohol use among adolescents ages 12 to 17.[38] Recommended by both NIAAA and AAP, the CRAFFT has been validated across pediatric settings to identify risky substance use behaviors among adolescents.[18,39] Interestingly, the CRAFFT was able to detect preconception substance use in a small cohort of pregnant adolescents and young women between ages 17 and 25.[33,40] The CRAFFT has many advantages, including a short administration time and high sensitivity and specificity.[33] It also shows no evidence of gender bias.[36]

Screening adolescents for risky alcohol use can be incorporated into psychosocial approaches. For example, the home environment, education and employment, eating, peer-related activities, drugs, sexuality, suicide/depression, and safety from injury and violence (HEEADSSS) and the strengths, school, home, activities, drugs/substance use, emotions/depression, sexuality, safety (SSHADESS) tools are interview frameworks specifically designed for use with adolescents in health care settings.[23,33] The HEEADSSS interview is a practical, complementary strategy that establishes rapport by asking less threatening questions at the beginning of the encounter before transitioning to more personal or potentially intrusive topics such as substance use.[33] The SSHADESS interview covers the same life areas as the HEEADSSS, but it also underscores adolescents' resiliency by identifying their perceived and realized strengths before asking questions related to environmental context or risky behaviors.[23]

A caveat is that an assurance of confidentiality is needed to improve the accuracy of adolescent screening responses. Because most adolescents are not comfortable discussing topics like alcohol use and sexual activity in the presence of a parent or guardian, clinicians are encouraged to create scripts or other procedures to excuse the accompanying adult from a portion of the health exam.[33] For example, asking the adult to leave the room during the physical exam portion validates the adolescent's developmental need for privacy and creates space for a confidential discussion concerning alcohol and other potentially risky behaviors.[33] Federal and state privacy laws entitle adolescents to privacy regarding substance use treatment, so adolescents may further benefit from a script ensuring that what is disclosed to the provider will not be shared with their caregiver unless an immediate risk of injury to oneself or another is divulged.[33]

Women of Childbearing Age

For women of childbearing age, the USPSTF supports the use of brief prescreening instruments for alcohol with 1 to 3 items—such as the

AUDIT-C or the NIAAA-recommended Single Alcohol Screening Question (SASQ), also referred to as the "single binge drinking question"—to quickly identify women who may be at risk.[22,41,42] The use of a single binge drinking question has also been recommended as a first step to effectively and efficiently identify women who are likely to be at risk of an alcohol-exposed pregnancy (AEP).[43] For example, a single binge drinking question was found to correctly identify 99% of women, from two countries and cultures, who had been identified as at risk of an AEP.[43] The Quick Drinking Screen (QDS) is another brief instrument that is efficacious at initially identifying women at risk of an AEP.[44] Items from the QDS were measured against data collected from a 90-day timeline followback (TLFB) assessment among a sample of women already determined to be at risk of an AEP. The results found that the women's answers to QDS items were highly similar to their 90-day TLFB responses.[43]

Once a brief prescreening measure identifies a woman who is likely to be at risk for alcohol misuse and/or an AEP, it is recommended that a more comprehensive instrument be administered.[22,43] For example, the 10-item AUDIT is an efficacious measure that has been validated for use with this population.[45] There are also several assessments designed specifically for women of childbearing age, including pregnant women and women at risk of an AEP. It is recommended that universal prescreening among women of childbearing age be used to identify and assess women at risk of an AEP.[45,46] Screening this population provides the opportunity for early intervention among women who may have consumed alcohol prior to becoming aware of their pregnancy. Screening also alerts care providers of consumption levels indicative of AUD so that they can refer these women for specialized treatment.

The Tolerance, Annoyed, Cut Down, Eye-Opener (T-ACE) questionnaire was the first validated screening instrument developed to identify drinking among pregnant women. It is often used in reproductive settings, including maternity care and gynecological clinics.[25,31] In comparison to the AUDIT, the four-item T-ACE has shown slightly higher sensitivity at detecting current alcohol consumption among pregnant women.[31] In addition, the T-ACE accurately identifies varying levels of alcohol consumption and is acceptable for use among culturally diverse obstetric populations.[31] The five-item Tolerance, Worried, Eye-Opener, Amnesia, K/Cut Down (TWEAK) screening instrument is another validated questionnaire for identifying drinking among women, including those who are pregnant and those at risk of an AEP.[25,31,45] Although the TWEAK questionnaire appears to be highly sensitive at identifying heavy patterns of alcohol consumption, primarily among white women, it is less sensitive at detecting lower levels of drinking that could still be considered at risk.[25,47]

In addition to the T-ACE and TWEAK, the USPSTF also recommends the Normal Drinker, Eye-Opener, Tolerance (NET), and the Parents, Partner, Past, Present Pregnancy (4P's Plus) as screening measures capable of assessing alcohol use among pregnant women.[22,47,48] Nonetheless, the T-ACE and TWEAK reportedly perform best among pregnant women and do not appear to have a significant advantage over one another, because both are well-validated screening measures that can be quickly administered in a variety of women's health settings.[18]

Older Women

Older women are often missed by screening efforts because their alcohol-related symptoms are often mistaken for signs of aging.[49] For this reason, systems must be put into place to ensure universal screening on a recurring basis in settings that care for older women.[50] Alcohol screening should take place any time new mental or physical health symptoms arise, before prescribing a new medication, in response to major life changes (e.g., retirement, death of a spouse), and on a yearly basis as part of routine physical and mental health services.[50,51] Providers should be aware that a history of risky alcohol use among older adults often predicts future increases in drinking.[50] Prescreening questions like "During your lifetime,

have you ever used alcohol?" followed by "During the past year, have you had four or more drinks on a single occasion?" help to determine whether more comprehensive assessments are warranted.[51,52] The AUDIT-C and the two-item Substance Use Brief Screen (SUBS) are also prescreen options available for use with this population.[53-55]

Several screening instruments have been validated for use with older adults. Measures like the AUDIT include screening questions on lifetime problems to assess current alcohol-related risk.[54,56] Other screening tools include the Cut Down, Annoyed, Guilty, Eye-Opener (CAGE), the Michigan Alcoholism Screening Test—Geriatric Version (MAST-G), the Short MAST-G, and the Comorbidity Alcohol Risk Evaluation Tool (CARET).[54,57] All of these instruments gather information about the level of consumption and offer decision support for care providers.[50,54] In general, alcohol screening and assessment instruments among older women should contain questions about the frequency and quantity of alcohol use, experiences with drinking-related consequences, medication use, and feelings of depression.[50]

SCREENING RECOMMENDATIONS

There are very few studies on alcohol screening specific to adolescent females and older adult females beyond childbearing age, with a majority of information coming from mixed-gender studies. The largest body of evidence on screening women is for those of childbearing age, likely due to the added risks and harms associated with prenatal alcohol exposure. Nonetheless, universal screening should begin in early adolescence and be repeated at regular intervals across settings that provide health care and social services to girls and women. However, although alcohol screening instruments elicit important information about an individual's level of risk and alcohol-related symptoms, these tools are not a replacement for a complete substance use assessment. Because these instruments are brief and, in many cases, can be self-administered, it is often recommended that care providers use them as decision support aids to guide additional steps based on the preliminary level of risk indicated by these alcohol screening instruments.

The successful implementation of a screening protocol depends on the setting in which it is delivered. For example, settings with access to interdisciplinary professionals may find that longer, more thorough assessment instruments are practical, whereas settings with fewer resources are likely to benefit from utilizing brief instruments like the AUDIT, which has been validated for use across age groups.[32,35,56] Additionally, questions or measures may be added to assessment protocols to identify other factors known to be associated with female alcohol use behaviors (e.g., age of onset, depression and anxiety, childhood and/or intimate partner abuse, co-occurring substance use behaviors) to better inform BI and referral to treatment practices.[13,16,58,59] Moreover, care providers need to remain mindful regarding the language they use to describe alcohol-related concerns so as not to further stigmatize female populations.[60] For example, some women may be sensitive to language such as "alcoholic," "addict," or "abuser"; the use of such language may dissuade women from providing relevant information pertaining to their alcohol use behaviors. Therefore, care providers are advised to use medically accurate terms throughout their discussions regarding alcohol and substance use behaviors.[55,60]

BRIEF INTERVENTIONS

BIs are evidence-based practices that are short, targeted conversations between women and clinicians that follow screening results indicative of risky alcohol consumption. The overall goal of BIs is to help adolescent girls and women who are at risk of alcohol-related consequences by increasing their awareness about the ways alcohol use may put them at risk and encouraging their self-motivation for change.[27,61] Common components of BIs include conversations on standard drink sizes, low- versus high-risk drinking limits, and potential health effects and

social consequences of drinking.[3,62] Another common element of BIs is providing personalized normative feedback, with evidence supporting the use of gender-specific feedback for women.[63,64,65] BIs can be delivered by professionals with different backgrounds and expertise, and they can take place in face-to-face settings, over the phone, or through electronic means.[61,66] How effective BIs are can depend on the number of sessions and length of time allotted for each session. For example, systematic reviews and meta-analyses have found that very brief (i.e., ≤ 5 min) and brief single-contact interventions (i.e., 6 to 15 min) tend to be less effective than brief multicontact interventions (i.e., each contact ≤ 15 min), which evidence shows is the most effective across populations and outcomes.[18,63,67] Additionally, one meta-analysis found that extended BIs (defined by the author as BIs that required several visits, or multicontact interventions) resulted in significant change in alcohol consumption for women but not men.[68]

BIs for risky alcohol use are often based on the principles of MI. Using this collaborative, client-centered approach, providers help females explore and resolve their ambivalence toward changing unhealthy behaviors (e.g., alcohol consumption at risk levels).[69] A core tenet of MI is the use of nonconfrontational techniques to allow individuals to guide themselves toward change without feeling the need to defend their choices.[69]

Adolescents

AAP recommends basing the degree of intervention delivery for youth on the level of risk identified at the time of screening. When no alcohol use is reported, clinicians are encouraged to provide positive verbal reinforcements to motivate continued abstinence. Evidence suggests that even a few positive words from a health care provider may delay alcohol use initiation, and thus extend time for adolescent brain maturation.[23] These positive reinforcements may be critical for female adolescents to receive, especially girls at risk of early alcohol initiation,[7,58] because of the detrimental effects of alcohol on the female developing brain.[70] When infrequent alcohol use is endorsed by female adolescents, such as when an S2BI result indicates alcohol use of one to two times the previous year, it is recommended that care providers advise adolescents to abstain. This advice may combine information on negative health consequences with recognition of personal strengths and positive attributes.[23]

BIs are recommended when an adolescent screens positive for drinking at risky levels. Evidence from a recent meta-analysis of 185 studies examining the effects of alcohol-related BIs for adolescents and young adults found that the interventions effectively reduced drinking and alcohol-related consequences, with effects lasting up to 1 year and showing no demographic variance.[65]

BIs that utilize MI have been found to be effective with substance-using adolescent populations. Much of the research supporting this view falls into the harm-reduction continuum: that is, adolescents do not move directly into abstinence but rather gradually decrease their risky behavior.[71,72] In addition to the effectiveness of MI techniques within this population, a systematic review and meta-analysis conducted by Carney and Myers also found that adolescents showed a preference for individualized interventions (i.e., compared with a group format) conducted over multiple sessions (i.e., compared with a single event).[67]

In alignment with the USPSTF finding of there being insufficient evidence to evaluate the utility of BIs among alcohol-using adolescent populations, evidence specific to adolescent females who receive brief alcohol interventions is also lacking and warrants future investigation. In a recent systematic review and meta-analysis of the literature on brief alcohol interventions for adolescents and young adults, Tanner-Smith and Lipsey found a limited number of studies with boy-only or girl-only samples that reported little to no evidence of differential effectiveness based on gender.[65] There is some evidence, however, suggesting that BIs for alcohol use may be particularly effective for adolescent girls, especially when the provider is also female and the information is delivered in the context of an ongoing provider–patient relationship.[73]

Women of Childbearing Age

There is strong evidence supporting the use of BIs among pregnant and nonpregnant women of childbearing age as a means of reducing levels of alcohol consumption and risks associated with AEPs.[18,62,74] For example, in one large multisite trial, approximately 69% of women who, at intake, were drinking at risky levels and not using effective contraceptive methods reduced their risk of an AEP at the 9-month follow-up after receiving an intervention incorporating MI. The women in this study achieved risk reduction by abstaining from alcohol or drinking below risky levels, by using effective contraceptive methods every time they had vaginal intercourse with a fertile male, or both.[75] A number of randomized controlled trials with pregnant women have also reported significant reductions in alcohol use and improved newborn outcomes following the facilitation of BIs.[62]

In addition to previously mentioned common components of BIs (e.g., personalized normative feedback), interventions with women of childbearing age often also include feedback on the potential effects of alcohol on fetal and child development.[25,64] It is recommended that postpartum women receive information on infant exposure to alcohol through breastmilk and that contraceptive use should be incorporated into BIs with nonpregnant women who are at risk of an AEP.[25,64]

Efficacious prevention and intervention programs have been developed for use with women of childbearing age. One example is the CHOICES program and its adaptations: BALANCE, EARLY, and CHOICES Plus.[76,77,78] CHOICES is an established AEP prevention program based on the principles of MI and designed to provide nonpregnant women of childbearing age with information to help them make informed choices on ways to avoid an AEP.[43] The CHOICES protocol has been widely disseminated across health and social service settings (e.g., primary care facilities, jails, sexually transmitted disease clinics).[75,78,79] Also, as a result of meeting rigorous peer-review criteria, the CHOICES program was included in SAMHSA's Evidence-Based Practices Resource Center (https://www.cdc.gov/ncbddd/fasd/choices-importance-preventing-alcohol-exposed-pregnancies.html).

Older Women

Although limited, studies on BIs with older adults suggest that BIs are effective at reducing risky alcohol consumption, with sustained reductions ranging from 2 to 18 months.[80,81,82] The content and format of most BIs are similar, as are the recommendations, whether delivered to younger or older cohorts. For example, providers are advised to use nonstigmatizing and nonjudgmental language when discussing screening results and any potential alcohol-related health consequences with women.[55] Regarding older women, some experts suggest that providers may find that incorporating the women's family and friends into various parts of the BI process may prove successful.[51]

Other BIs

Multiple BI models have been created to aid in the facilitation of BI conversations.[25,27] A systematic review of BIs for risky drinking in primary care settings reported that a majority are arranged according to the SAMHSA-endorsed Feedback, Responsibility, Advice, Menu of strategies, Empathy, Self-efficacy (FRAMES) model.[33,64] Other BI models that are endorsed by SAMHSA include the Feedback, Listen, Options (FLO) model, the Brief Negotiated Interview (BNI) Steps, and the BNI and Active Referral to Treatment: Provider Training Algorithms.[27] All of these models serve as useful guides for delivering BIs and are presumed to be equally efficacious regardless of age or gender. Practitioners should choose the model that best suits their work setting.

In summary, BIs are valuable tools for reducing alcohol consumption and its associated risks (e.g., AEPs). It is vital to consider that despite a number of randomized controlled trials suggesting similar efficacy for brief alcohol interventions among women and men,[83,84] women have been less likely to receive BIs in practice. As such, lending attention to this issue is critical considering that the prevalence rates for alcohol use among women are rising.[85]

REFERRAL TO TREATMENT

Referral to treatment is a process designed to assist women with accessing specialized treatment, selecting facilities, and navigating barriers that may prevent treatment engagement.[27] Treatment options for women with AUD may include residential treatment, outpatient psychological therapy (e.g., family, group, conjoint, individual), medication-assisted treatment, self-help or support group programs (e.g., 12-step programs such as Alcoholics Anonymous), harm reduction approaches, use of a recovery coach, or any combination of these. There are also treatment options that cater exclusively to women, such as the Women for Sobriety program and women-only Alcoholics Anonymous groups. Specialized alcohol treatment should be personalized to the woman, taking into account her medical, social, and cultural needs. Providers should be aware of local treatment options in order to conduct warm handoffs—referrals facilitated in the presence of the patient to encourage communication and partnership between the patient and treatment team—when needed. Providers should also pay special attention to the treatment selection for pregnant and postpartum women to ensure that appropriate medical care and social support options are available.[25] Providers may also choose to access SAMHSA's online resource guide, which includes samples of scripts, procedures, and links to treatment locator websites.[27] Other referral resources include NIAAA's online Alcohol Treatment Navigator tool (https://alcoholtreatment.niaaa.nih.gov) and NIAAA's publicly available resource guides, with information specific to referrals: *Alcohol Screening and Brief Intervention for Youth: A Practitioner's Guide*[29] and *Helping Patients Who Drink Too Much: A Clinician's Guide*.[28]

Referral to treatment is a critical, yet often overlooked, component of SBIRT. Although some studies have found it effective to link individuals to specialty treatments,[86,87] evidence from many others suggests that it is often difficult to link individuals in need of alcohol-related specialized care to substance use treatment services. For example, a meta-analysis of nine studies found no evidence that brief alcohol interventions were efficacious for increasing the use of alcohol-related services.[88] Referral to treatment is further compounded by gender-specific barriers to treatment that impact women's ability to engage in services. In general, women are less likely than men to initiate alcohol treatment services, and when they do, research suggests that women often contend with stigma, negative staff attitudes, lack of affordable or safe childcare options, and concerns over child custody.[89] When they do access treatment services, more women than men present with histories of trauma and abuse, psychological distress and mental health concerns, interpersonal and family-related issues, and financial constraints.[90] Barriers on a systemic level include lack of treatment options because of geographic isolation and lack of awareness among care providers regarding local treatment options that are capable of addressing the unique needs of adolescent girls and women in treatment settings.[89]

BARRIERS AND FACILITATORS TO SBIRT IMPLEMENTATION

A number of health and social service providers (e.g., physicians, nurses, social workers, psychologists, midwives) are qualified to effectively implement SBIRT across a variety of patient and client settings. However, studies of SBIRT implementation reveal that few providers feel comfortable doing so, with the lowest screening and counseling rates seen among young adult and women's reproductive care providers.[18] For example, one study found that one-third of women who endorsed alcohol consumption in women's health clinics were not asked how much they drank and that a majority of women drinking at risk levels did not receive advice on low-risk limits.[91] Another study concluded that approximately half of women at risk of an AEP did not receive information pertaining to this risk from their health care providers.[91] These findings corroborate national survey data of family planning clinicians, which found that of these clinicians,

approximately one-third used a validated screening measure and one-fifth provided a referral that consisted of more than a list of treatment options.[92]

Qualitative analyses conducted among health care providers have revealed several common barriers to implementing SBIRT, including time constraints, competing priorities, cost, and privacy and confidentiality concerns.[93-96] Barriers that pediatric providers cited include concerns regarding the willingness of adolescents to return for follow-up, limited access to and knowledge of adolescent treatment programs or local expertise, and confidentiality concerns.[94] Additional SBIRT barriers that prenatal care providers identified included lack of rapport between providers and women presenting for an initial prenatal consultation; providers' misperception that there is a low prevalence of alcohol use by pregnant women; providers' lack of skills, training, and follow-up protocol; women's underreporting or false disclosure of alcohol consumption; and providers' concerns over creating guilt and anxiety among pregnant women.[95,96]

Many of these provider-identified barriers should be considered in combination with, and resulting from, U.S. state policies mandating that health care providers report perinatal substance use to child welfare agencies.[97,98] For instance, in 2017, Jarlenski and colleagues conducted a systematic content analysis that identified 24 states with statutes around reporting perinatal substance use by health care providers. Twenty of the states identified had mandatory reporting statutes, while 11 states specified a penalty capable of resulting in a misdemeanor charge for health care providers who failed to report known perinatal substance use.[98] Furthermore, some state statutes allow for involuntary commitment and custody loss solely as a result of prenatal substance use, thus creating an ethical and moral dilemma for prenatal care providers because this violates the principles of patient autonomy and beneficence.[99] This issue was further complicated for prenatal care providers by updated recommendations from the American College of Obstetricians and Gynecologists and the Centers for Disease Control and Prevention, which advise providers to conduct universal screening at initial prenatal appointments.[46,98]

In addition to the barriers faced by prenatal care providers, pregnant women engaged in substance use behaviors often face their own barriers to receiving care, such as fear of stigmatization and legal consequences. This may result in a lack of engagement in prenatal care altogether, thus eliminating the potential for SBIRT implementation and posing significant risks to the health of both mother and child.[60]

Older women also face unique barriers to alcohol intervention and treatment efforts. These include financial limitations and lack of mobility and transportation. Older women also report higher rates of stigma, shame, and guilt than younger women, which may lead to an increased prevalence of isolation, anxiety, and depression.[51]

Approaches to Facilitating SBIRT Implementation

In response to the many recognized barriers, research has begun to identify approaches that facilitate successful SBIRT implementation. So far, evidence suggests that having a practice champion, utilizing an interprofessional team, communicating the details of each SBIRT step, developing relationships with referral partners, instituting ongoing SBIRT training for sustainability, aligning SBIRT practices with the organization's flow, and integrating SBIRT into electronic health records are all ways to facilitate ongoing SBIRT efforts.[24] Additionally, a study of ongoing SBIRT facilitation compared usual care and two adolescent SBIRT delivery modalities (pediatrician-only and pediatrician with an embedded behavioral clinician) and found that although substance use outcomes did not differ between pediatrician-only and embedded behavioral clinician groups, adolescents in the embedded group reported fewer depression symptoms at follow-up.[100] The inclusion of a

behavioral clinician in pediatric settings may be especially beneficial to adolescent girls in light of recent evidence that higher levels of depression severity among girls ages 13 to 16 predicted alcohol use in the following year.[59]

Technology

The use of technology is an additional option for overcoming SBIRT barriers in clinical settings that lack available staff and time resources for ongoing face-to-face implementation.[101] Technology is increasingly being used to facilitate various SBIRT components, with preliminary evidence observed among adolescent girls and women looking promising.[74,102,103] A recent systematic review of women's experiences with technology-based screening found that the perception of anonymity made it easier to divulge potentially stigmatizing information compared to in-person, face-to-face screening methods. Therefore, technology-based screening has the potential to increase disclosure rates and intervention receipt.[104] Studies also suggest that women feel less embarrassed and less afraid of judgment when they participate in technology-based interventions, and the flexibility offered by some technology-based treatments may also be appealing to women who are not willing or able to participate in more formal treatment programs because of family and societal roles.[104]

Nevertheless, whether electronic SBIRT can be effective as a stand-alone entity has yet to be established. One recent study demonstrated successful implementation of a technology-based alcohol intervention (i.e., sans personnel) among women of childbearing age;[66] however, interaction findings from other studies suggest that various female groups may have other intervention needs.[105] For example, Choo and colleagues reported that although female victims of intimate partner violence were receptive to electronic screening and advice, they also desired empathy and compassion from human interaction provided during intervention delivery.[105] Still, evidence has suggested that electronically delivered SBIRT components are mutually beneficial to both women and providers.[103,106] In the future, the use of electronic approaches could also assist in the translation of research findings into routine care settings by standardizing intervention delivery methods while maintaining wide applicability across health and social service settings.[107]

FUTURE DIRECTIONS

More research is needed to evaluate the effectiveness, efficacy, and feasibility of SBIRT practices among females, primarily those in younger and older cohorts, and those at risk of AEPs.[4,10,59,64] Recent reports showed increases in alcohol use among adolescent girls, with evidence suggesting a reversal from traditional male excess to slight female excess in 8th grade, and by 12th grade, 35% of girls reported past-month alcohol use, corresponding to a 250% increase from 8th grade.[9,102] Age of alcohol use initiation is particularly worrisome among adolescent females, given that early initiating females drink more than all male adolescents from ages 12 to 17.[8] Additionally, the association between depression severity and alcohol use appears to be more salient for early adolescent girls than for boys of the same age, with observations suggesting that alcohol use both predicts and is a consequence of depression.[59] Research is also needed to address alcohol use among older women due to population increases. Given the aging of the baby-boom generation, population projections estimate that by 2040, the proportion of women to men ages 65 or older will be 127 to 100.[51,108]

SBIRT is essential for the ongoing identification and intervention of risky alcohol use behaviors among adolescent girls and women. As the prevalence rate of female alcohol use increases, so too should the implementation of SBIRT. These prevention and intervention efforts can help promote lifelong health and well-being among women, with special attention paid to younger and older cohorts, and those at risk of an AEP.

Table 1 Alcohol Screening Instruments

Instrument	No. of Items in Instrument	Approx. Time to Administer (min)	Applicable Population	Scoring That Indicates Risk and Statistical Performance (Sensitivity; Specificity)	Copyright, Source(s), and Cost‡‡	Link(s)
NIAAA *Alcohol Screening and Brief Intervention for Youth: A Practitioner's Guide*[29]	2 to 3 depending on severity	~2	Adolescents ages 9 to 18	Elementary or middle school adolescents (≤ 15 years old) reporting any alcohol use (0.89; 0.91)[33] High school adolescents (≥ 16 years old) reporting ≥ 6 days of past-year alcohol use (0.88; 0.81)[33]	Copyright: N/A Source: N/A Cost: Free online	Publicly available NIAAA guide containing screening questions (page 8): https://www.niaaa.nih.gov/sites/default/files/publications/YouthGuide.pdf
Screening to Brief Intervention (S2BI)[34*]	3 (additional 4 if past-year use indicated)	~2	Adolescents ages 12 to 17	Adolescents reporting alcohol use o*nce or twice* in the past year (0.96; 0.92) Adolescents reporting alcohol use *monthly* in the past year (0.79; 0.96) Adolescents reporting alcohol use *weekly or more* in the past year (1.00; 0.88)	Copyright: N/A Source: N/A Cost: Free online	Publicly available NIDA link to online version with options for patient or clinician administration: https://www.drugabuse.gov/ast/s2bi/#/
Brief Screener for Tobacco, Alcohol, and Other Drugs (BSTAD)[38*]	6 (additional 3 to 11 if past-year use indicated)	~2	Adolescents ages 12 to 17	≥ 2 days of past-year alcohol use (0.96; 0.85)	Copyright: N/A Source: N/A Cost: Free online	Publicly available NIDA link to web-based instrument with options for patient or clinician administration: https://www.drugabuse.gov/ast/bstad/#/
Alcohol Use Disorders Identification Test (AUDIT)	10	~2 to 3	Adolescent girls ages 12 to 19, adults,§ pregnant women, older adults	Positive score indicating risk: Adolescent girls: ≥ 5 (0.95; 0.77)[32] Adults: ≥ 8 (0.38–0.73; 0.89–0.97)[18]** Pregnant women: > 0[18] Older adults: ≥ 5 (0.86; 0.87)[54]	Copyright: 1989, Thomas Babor and the World Health Organization Sources: World Health Organization, Division of Mental Health & Prevention of Substance Abuse, 1211 Geneva 27, Switzerland Email: Publications@who.int Thomas F. Babor, Alcohol Research Center, University of Connecticut, Farmington, CT Cost: Core questionnaire can be reproduced without permission; test and manual are free; training module costs $75	Publicly available link to self-report instrument: https://cde.drugabuse.gov/sites/nida_cde/files/AUDIT-SelfReport_v1.0_2014May20.pdf

Instrument	No. of Items in Instrument	Approx. Time to Administer (min)	Applicable Population	Scoring That Indicates Risk and Statistical Performance (Sensitivity; Specificity)	Copyright, Source(s), and Cost‡‡	Link(s)
Alcohol Use Disorders Identification Test-Concise (AUDIT-C)	3	~1	Adolescent girls ages 12 to 19, adult women,† pregnant women, older adults	Adolescent girls: ≥ 3 (0.96; 0.65)[32] Adult women: ≥ 3 (0.73–0.97; 0.34–0.89)[18] Pregnant women: > 0 (NR‡)[18] Older adults: ≥ 4 (0.94; 0.80)[54]	Copyright: N/A Source: N/A Cost: Free online	Publicly available SAMHSA link: https://www.integration.samhsa.gov/images/res/tool_auditc.pdf
Car, Relax, Alone, Forget, Friends, Trouble (CRAFFT)[37]*	4 (additional 5 if past-year use indicated)	~2 to 3	Adolescents ages 12 to 21	≥ 1 (0.94; 0.74)[30,39] Optimal cutoff score indicating heightened risk for SUD: ≥ 2 (0.79; 0.97)[39]	Copyright: 2001, Boston Children's Hospital Source: The Center for Adolescent Substance Abuse Research, Children's Hospital, 300 Longwood Ave., Boston, MA 02115 Phone: 617-355-5433 Email: crafft@childrens.harvard.edu Cost: N/A	Publicly available SAMHSA link which states that the CRAFFT may be reproduced in [this] exact form for use in clinical settings courtesy of the Center for Adolescent Substance Abuse Research at the Boston Children's Hospital: https://www.integration.samhsa.gov/clinical-practice/sbirt/CRAFFT_Screening_interview.pdf Link from Boston Children's Hospital with additional information: http://crafft.org/
NIAAA Single Item Alcohol Screening Questionnaire (SASQ)[52]	1	~1	Adults	≥ 1 (0.82; 0.79)[18]	Copyright: N/A Source: N/A Cost: N/A	Publicly available SAMHSA link to NIAAA's *Helping Patients Who Drink Too Much: A Clinician's Guide,* which includes NIAAA SASQ (page 4): https://www.integration.samhsa.gov/clinical-practice/Helping_Patients_Who_Drink_Too_Much.pdf Publicly available USPSTF Final Recommendation Statement: *Unhealthy Alcohol Use in Adolescents and Adults: Screening and Behavioral Counseling Interventions,* includes NIAAA SASQ question: https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/unhealthy-alcohol-use-in-adolescents-and-adults-screening-and-behavioral-counseling-interventions

Instrument	No. of Items in Instrument	Approx. Time to Administer (min)	Applicable Population	Scoring That Indicates Risk and Statistical Performance (Sensitivity; Specificity)	Copyright, Source(s), and Cost‡‡	Link(s)
Quick Drinking Screen (QDS)[44,109]	3	~1	Adults	Scoring based on presence of NIAAA defined at-risk drinking (i.e., more than 3 drinks on any day or 7 drinks per week for adult women) in past 90 days[43††]	Copyright: 2003, Sobell & Sobell Source: Linda C. Sobell, PhD, ABPP, Center for Psychological Studies, Nova Southeastern University, 3301 College Ave., Fort Lauderdale, FL 33314 Email: sobelll@nova.edu Cost: Free	Publicly available link that states that this screener can be freely used as it is in the public domain: https://www.nova.edu/gsc/forms/quick_drinking_screen.pdf
Tolerance, Annoyed, Cut Down, Eye Opener (T-ACE)[31]	4	~1	Women of childbearing age	≥ 2 (0.69–0.88; 0.71–0.89)[25]	Copyright: 1989, Harcourt Health Sciences; permission needed to publish Sources: S. Martier, Ob/Gyn, 4707 Saint Antoine, Detroit, MI 48201 Permissions Department, Mosby, Inc. (a division of Elsevier), 6277 Sea Harbor Dr., Orlando, FL Phone: 407-345-3994 http://www.us.elsevierhealth.com/ Cost: N/A	Publicly available NIAAA link containing copyright information: https://pubs.niaaa.nih.gov/publications/t_ace.htm Publicly available NIAAA link containing T-ACE questions: https://pubs.niaaa.nih.gov/publications/arh28-2/78-79.htm
Tolerance, Worried, Eye Opener, Amnesia, K-Cut Down (TWEAK)[31]	5	~2	Pregnant women	≥ 2 (0.71–0.91; 0.73–0.83)[25]	Copyright: None Source: Marcia Russell Prevention Research Center, 1995 University Avenue, Suite 450, Berkeley, CA 94704 Phone: 510-883-5703 Email: russell@prev.org Cost: Free	Publicly available NIAAA link with more information: https://pubs.niaaa.nih.gov/publications/assessingalcohol/instrumentpdfs/74_tweak.pdf
Normal Drinker, Eye-Opener, Tolerance (NET)[47]	3	~1	Pregnant women	≥ 2 (0.61; 0.87)[47]	Copyright: 1989, Lippincott Williams & Wilkins Source: Lippincott Williams & Wilkins Permissions Department, 351 West Camden St., Baltimore, MD 21201 Phone: 410-528-4050 Email: permissions@lww.com http://www.lww.com/permissions/index.htm Cost: N/A	Not publicly available
Parents, Partner, Past, Present Pregnancy (4P's Plus)[48]*	5	~1	Pregnant women	≥ 1 (0.87; 0.76)[48]	Copyright: The National Training Institute/NTI Upstream Source: NTI Upstream, 180 N. Michigan Ave., Suite 700, Chicago, IL 60601 Cost: Licensing fees may apply	Publicly available link with more information: https://www.ntiupstream.com/4psabout

Instrument	No. of Items in Instrument	Approx. Time to Administer (min)	Applicable Population	Scoring That Indicates Risk and Statistical Performance (Sensitivity; Specificity)	Copyright, Source(s), and Cost‡‡	Link(s)
Substance Use Brief Screen (SUBS)[53*]	4	~1	Adults	Any response other than "never" on alcohol binge question: (0.85; 0.77)	Copyright: N/A Source: N/A Cost: N/A	Publicly available NIH publication with more information: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4475501/
Cut Down, Annoyed, Guilty, Eye-Opener (CAGE)[57]	4	~1	Adults	≥ 2 (0.14–0.39; 0.97)	Copyright: None Source: N/A Cost: Freely available as it is in the public domain and no permission is necessary unless used in a profit-making endeavor	Publicly available SAMHSA link: https://www.integration.samhsa.gov/clinical-practice/sbirt/CAGE_questionaire.pdf
Michigan Alcohol Screening Test–Geriatric Version (MAST-G)[57]	24	~5 to 10	Older adults	≥ 5 (0.70–0.91; 0.81–0.85)	Copyright: 1991, The Regents of the University of Michigan Source: Frederick C. Blow, PhD, University of Michigan Alcohol Research Center, 400 E. Eisenhower Parkway, Suite A, Ann Arbor, MI 48104 Phone: 313-998-7952 Cost: Free online	Publicly available NIH link to SAMHSA's *Substance Abuse Among Older Adults: Treatment Improvement Protocol No. 26* (page 55): https://www.ncbi.nlm.nih.gov/books/NBK64419/pdf/Bookshelf_NBK64419.pdf
Short Michigan Alcohol Screening Test–Geriatric Version (SMAST-G)[57]	10	Not reported	Older adults	≥ 2 (0.52; 0.96)	Copyright: 1991, The Regents of the University of Michigan Source: N/A Cost: N/A	Publicly available link provided by The Hartford Institute for Geriatric Nursing, New York University, Rory Meyers College of Nursing: https://consultgeri.org/try-this/general-assessment/issue-17.pdf
Comorbidity Alcohol Risk Evaluation Tool (CARET)	10	~2 to 5	Older adults	A positive response in any of the seven risk categories (0.92; 0.51)[54]	Copyright: N/A Source: N/A Cost: N/A	Not publicly available

NIAAA = National Institute on Alcohol Abuse and Alcoholism; NIDA = National Institute on Drug Abuse; NIH = National Institutes of Health; SAMHSA = Substance Abuse and Mental Health Services Administration.

* Instrument screens for alcohol and other substances.

† Recommended AUDIT-C cutoff score is different for adult women (≥ 3) and men (≥ 4).[18]

‡ Not reported.

§ Recommended AUDIT cutoff score is the same for adult women and men (≥ 8).[18]

** Several U.S.-based studies show more optimal balances of sensitivity and specificity at lower AUDIT cutoffs (e.g., 3, 4, 5); preliminary findings from the USPSTF 2018 updated evidence report and systematic review indicates that lower cutoffs may be preferred.[18]

†† Sensitivity and specificity are not reported for this instrument.

‡‡ N/A, information was not available or retrievable. None, the instrument explicitly states that no copyright is held. Cost: N/A, no information was found regarding cost. Free/free online, the information pertaining to the instrument explicitly states that it is available to the public.

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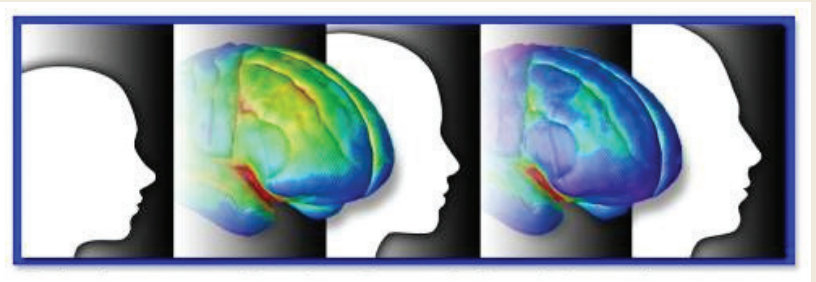
NIH's Adolescent Brain Cognitive Development (ABCD) Study

Alcohol Research: Current Reviews Editorial Staff

Adolescence is the stage of life during which most people begin using alcohol, and it is also a time of considerable social, psychological, and physiological change. The brain, particularly the frontal cortex, continues to develop throughout adolescence and does not fully mature until early adulthood. Adolescent alcohol exposure can impair brain development, compromise short- and long-term cognitive functioning, and increase the likelihood of developing alcohol-related problems during adolescence and later in life. Furthering our understanding of the developing brain—as well as how differences in brain structure and function that exist prior to alcohol and other substance use contribute to substance use disorders—is a high priority for the National Institutes of Health (NIH).

In September 2015, NIH launched the Adolescent Brain Cognitive Development (ABCD) Study, the largest long-term study of brain development and child and adolescent health in the United States. The ABCD Study will recruit more than 11,000 9- to 10-year-olds to capture data before children begin using alcohol or other addictive substances. It will integrate structural and functional brain imaging; genetic testing; and neuropsychological, behavioral, and other health assessments of study participants conducted over a 10-year period, yielding a substantial amount of information about healthy adolescent brain development. Data gathered from participants will allow the creation of



baseline standards for typical brain development (similar to those that currently exist for height, weight, and other physical characteristics). These data are expected to illuminate how brain development is affected by substance use and other childhood experiences, such as patterns of sleep, use of social media, and engagement in sports and with video games. It may also reveal neurobiological, cognitive, and behavioral precursors of substance misuse and other risk behaviors, and ultimately inform preventive and treatment interventions.

The ABCD Consortium consists of a Coordinating Center, a Data Analysis and Informatics Center, and 21 research sites across the country. Recruitment, which began in September 2016, is expected to span 2 years. ABCD workgroups have established standardized and harmonized assessments of neurocognition, physical and mental health, social and emotional functions, and culture and environment. They also have established multimodal structural and functional brain imaging and bioassays. Brain imaging and biospecimen collection for genetic and epigenetic analyses will be done every other year, and the remaining assessments will be conducted semiannually or annually.

One important goal of the ABCD Study is to create a unique data resource for the entire scientific community by embracing an open science model. Curated, anonymized data will be released annually to the research community, along with the computational workflows used to produce the data, beginning 1 year after data collection begins.

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For more information, visit http://abcdstudy.org/index.html.

Effects of Binge Drinking on the Developing Brain

Studies in Humans

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Binge drinking is a pattern of alcohol drinking that raises a person's blood alcohol concentration to at least .08%, which amounts to consuming five alcoholic drinks for men and four alcoholic drinks for women in about 2 hours. It is the most common form of alcohol misuse in adolescents and young adults. Heavy drinking includes the same criterion as binge drinking, but with higher frequency (i.e., 5 or more days in the past 30 days). Although binge drinking or heavy drinking alone is insufficient to meet the criteria for an alcohol use disorder (AUD) diagnosis, there are neurobiological changes, as well as an increased risk of developing an AUD later in life, associated with this form of alcohol misuse. This review describes the recent neuroimaging findings in binge drinking and heavy-drinking adolescents and young adults, a developmental period during which significant neuromaturation occurs.

Key words: Alcohol misuse; binge drinking; college drinking; neurodevelopment; neuroimaging; young adults

It has been well established that the brain undergoes significant maturation during adolescence that continues into young adulthood.[1] Studies using structural magnetic resonance imaging have described linear and nonlinear changes in cortical gray-matter volume and thickness[2-5] and increases in white-matter volume and integrity[2,6-9] occurring during development. Gray-matter volume peaks earlier in females (i.e., around age 11) than in males (i.e., around age 12) and declines during adolescence due to pruning of unused synaptic connections in order to promote efficient communication between neurons.[6] Furthermore, gray matter has been shown to reach earlier maturation in the sensorimotor cortices, whereas the frontal and temporal cortices mature later in development.[4] The prefrontal cortex, which is central to executive control, matures later compared with earlier developing limbic structures thought to be more involved in reward and emotional processing.[6,10,11] The asynchronous development of the prefrontal cortex and emotional and reward circuitry has been hypothesized to result in increased risk-taking behavior during adolescence, such as alcohol use.[12-15] This is especially of concern because ongoing neurodevelopment may render the adolescent brain particularly vulnerable to the neurotoxic effects of alcohol, as has been shown repeatedly in animal models.[16-19]

Binge drinking is a pattern of alcohol drinking that raises a person's blood alcohol concentration to at least .08%, which amounts to consuming five alcoholic drinks for men and four alcoholic drinks for women in about 2 hours.[20] It is the most common pattern of alcohol consumption in adolescents and young adults. As of 2014, 1.5 million adolescents ages 12 to 17 (6.1%) and 13.2 million young adults ages 18 to 25 (37.7%) in the United States reported binge drinking.[21] Heavy drinking includes the same criterion as binge drinking, but with higher frequency (i.e., 5 or more days in the past 30 days).[21] In the National Survey on Drug Use and Health, 257,000 adolescents (1%) and 3.8 million young adults (10.8%) reported heavy drinking.[21] Although binge or heavy drinking alone is insufficient to meet criteria for an alcohol use disorder (AUD) diagnosis, there are neurobiological changes, as well as an increased risk of developing an AUD later in life, associated with this form of alcohol misuse.[22] This article reviews neuroimaging studies assessing the effects of binge and heavy drinking on brain structure and function in adolescents. Studies in which participants met criteria for AUD were not included. Further, the age range included studies in adolescents and young adults, which extends up to a mean age of 25, because brain matu-

ration continues to occur well into the late 20s.[2]

Effects on Brain Structure—Gray Matter

Volume

Cross-sectional studies in binge drinking adolescents and college-age individuals have demonstrated regions of both more and less gray-matter volume compared with nondrinking peers, with volumes often related to frequency and quantity of alcohol consumption. For example, a recent study found that adolescents and young adults who consumed moderate to high levels of alcohol had smaller total-brain, frontal-lobe, and temporal-lobe volumes than their nondrinking peers; however, they also found that a greater number of lifetime drinks was positively associated with greater temporal-lobe volume.[9] In support of the notion that binge drinking is associated with lower gray-matter volume, a study of college-age binge drinkers found that higher Alcohol Use Disorders Identification Test (AUDIT) scores, indicative of greater reported frequency and quantity of alcohol consumption and alcohol-related problems, were associated with smaller frontal-lobe volumes.[23] An association between alcohol use and smaller gray-matter volume also was supported by another study that identified smaller precuneus volumes in a group of college-age binge drinkers compared with alcohol-naïve controls.[24] Further, greater AUDIT scores again were associated with smaller gray-matter volumes in the amygdala and hippocampus.[24] Additionally, among binge drinking adolescents, greater peak number of drinks in the past 3 months was associated with decreased cerebellar gray-matter volume.[25] Together, these findings suggest that binge drinking during development is associated with various regions of lower cortical, subcortical, and cerebellar brain volume, and that these changes often are associated with alcohol drinking characteristics.

Contrary to findings of smaller brain volumes, Howell and colleagues reported greater ventral striatal, thalamic, and lingual-gyrus volumes in college-age binge drinkers compared with control subjects.[24] A study on binge drinking, college-age participants also found increased frontal, occipital, anterior cingulate cortex (ACC), and posterior cingulate cortex volumes compared with nondrinking control subjects.[26] In this study, larger dorsolateral prefrontal cortex (DLPFC) volumes were positively associated with speed and quantity of alcohol consumption and negatively associated with age of onset of alcohol use.[26] It is worth noting that these individuals reported binge drinking for a minimum of 3 years prior to neuroimaging sessions, suggesting that volumetric increases in regional gray matter may be associated with long-term binge drinking.

In addition to these disparate findings in gray-matter volume, sex-specific effects also have been observed in college-age binge drinkers. Kvamme and colleagues noted a significant sex-by-drinking status interaction in numerous prefrontal, parietal, temporal, and striatal regions, such that binge drinking males had smaller volumes than alcohol-naïve males, whereas binge drinking females had larger volumes than alcohol-naïve females.[23] Although these sex-specific effects partially may explain the bidirectional effects seen in previous studies, there are likely many other factors that could contribute to these disparate findings, including the inability of cross-sectional designs to capture alterations in nonlinear developmental trajectories.[2-5]

To better address volume-related changes associated with drinking, longitudinal studies have begun to investigate gray-matter volume both before and after binge drinking. The first of such studies examined heavy-drinking adolescents with a baseline magnetic resonance imaging scan when the subjects were alcohol naïve and a follow-up scan approximately 3 years later, after binge drinking. At baseline, adolescents who later transitioned into heavy drinking had smaller ACC, posterior cingulate cortex, and inferior frontal gyrus (IFG) gray-matter volumes.[27] Furthermore, heavy-drinking adolescents showed accelerated reductions in the thalamus/hypothalamus, inferior temporal gyrus, middle temporal gyrus (miTG), caudate, and brain stem, with greater lifetime alcohol use associated with a greater reduction in gray-matter volume in the left caudate and brainstem.[27]

A follow-up to this study that investigated gray-matter volumes in heavy-drinking adolescents at baseline and during multiple follow-ups found that heavy drinkers exhibited greater reductions in overall neocortex volume, as well as in frontal, lateral frontal, and temporal cortex volumes.[28] Finally, Whelan and colleagues used machine-learning techniques to classify adolescents before and after initiation of binge drinking.[29] They reported that before alcohol use, binge drinking adolescents had lower gray-matter volume in the superior frontal gyri (SFG) and greater volume in the premotor cortex compared to nondrinking control subjects. After alcohol initiation, however, smaller ventral medial prefrontal cortex (PFC) and IFG volumes were observed compared with nondrinking controls.[29] Taken together, these findings suggest that binge drinking during development may result in accelerated decreases in gray-matter volume, above and beyond what is seen in typical maturation, likely caused by the neurotoxic effect of alcohol. It also is possible, based on evidence from cross-sectional studies in college-age individuals (described above), that a longer duration of alcohol use into young adulthood may result in greater gray-matter volumes in young adults who binge drink, potentially because of impaired synaptic pruning. Additional longitudinal studies with multiple time points will be necessary to elucidate alcohol's

effects on the full developmental trajectory across adolescence and young adulthood.

Cortical Thickness

Generally, studies investigating cortical thickness in binge drinking adolescents have supported findings of decreases in gray matter. Similar to their gray-matter volume findings noted above, Pfefferbaum and colleagues noted that alcohol-consuming adolescents had thinner total, frontal, temporal, and cingulate cortices than nondrinkers; moreover, the number of binge drinking episodes in the past year was negatively associated with frontal and parietal cortex thickness.[9] This finding is in agreement with another cross-sectional study of young adults, which determined that binge drinkers had thinner cortical measures in the ACC and posterior cingulate cortex compared with light drinkers (i.e., consuming one or two drinks per week, but no binge episodes).[30] Further, ACC cortical thickness was negatively correlated with the number of drinking occasions and number of drinks per occasion in the past 3 months, indicating that greater frequency and quantity of use is associated with thinner cortices.[30]

Similar to the volumetric study previously cited, sex-specific effects also have become apparent when investigating cortical thickness in binge drinking adolescents.[23] A cross-sectional study in binge drinkers identified sex-by-drinking status interactions for cortical-thickness measures in four frontal regions (i.e., frontal pole, pars orbitalis, medial orbital frontal, and rostral anterior cingulate). Thus, binge drinking males had thinner cortices than alcohol-naïve control subjects, whereas binge drinking females had thicker cortices than alcohol-naïve control subjects.[31] The directionality of these findings is consistent with those of Kvamme and colleagues.[23] The findings suggest that during this particular window of development, alcohol may have differential effects for boys and girls, likely resulting from underlying sex differences in the rate and timing of synaptic pruning in adolescents.[6]

In a longitudinal investigation of the effects of binge drinking on cortical thickness, Luciana and colleagues found that adolescents who initiated alcohol use showed a significantly greater decrease in middle frontal gyrus (miFG) cortical thickness between baseline and revisit compared with adolescents who remained alcohol naïve,[32] suggesting that alcohol has a neurotoxic effect on frontal lobe development. However, this study found no differences in cortical thickness prior to initiation of alcohol use, contrary to a subsequent study observing differences in baseline gray-matter volume.[27] Other studies have investigated the effects of binge drinking on cortical thickness in a longitudinal manner, but without an alcohol-naïve baseline. Jacobus and colleagues examined cortical thickness over 3 years and found that concomitantly binge drinking and marijuana using adolescents had thicker cortices across time in five frontal, eight parietal, one temporal, and one occipital region compared with alcohol- and marijuana-naïve control subjects.[33] Moreover, in three frontal regions, control subjects showed a decrease in cortical thickness across time, whereas concomitantly binge drinking and marijuana using adolescents did not. A prior study had suggested that these effects persisted following abstinence, because concomitantly binge drinking and marijuana using adolescents showed greater thickness in the ACC, medial temporal gyrus, lingual gyrus, and occipital cortex both before and after 28 days of monitored abstinence.[34]

Taken together, these studies suggest that, when combined with marijuana use, binge drinking may result in increases, as opposed to decreases, in cortical thickness, that these increases are cumulative with prolonged use, and that they persist even following a month of abstinence. Furthermore, although these studies contradict some literature,[9,30,32] they may help provide an alternative explanation for the equivocal findings in gray-matter volume described above. In fact, in the longitudinal study by Squeglia and colleagues, although a greater number of lifetime alcohol-use occasions was associated with greater reductions in caudate and brainstem volume, a greater number of lifetime marijuana uses was associated with increases in caudate volume.[27] This provides further evidence that although gray-matter volume and thickness typically decrease in binge drinking adolescents and young adults, concomitant marijuana use may result in observed increased volume and thickness.

Effects on Brain Structure—White Matter

Volume

As opposed to the varied findings in gray-matter volume, results in white-matter volume have been more parsimonious. Cross-sectional studies have shown that a greater number of lifetime drinks was associated with smaller central white-matter volume,[9] and peak number of drinks during a binge episode in the past 3 months was associated with smaller cerebellar volumes.[25] Longitudinal studies tell a similar story, with binge drinking adolescents showing reduced white-matter volumes both before[27] and following initiation of binge drinking.[28,32] Squeglia and colleagues found that heavy-drinking adolescents had lower baseline cerebellar white-matter volumes compared with control subjects, but the investigators identified no regions where white-matter volume changed differentially across time.[27] However, in a follow-up study, heavy-drinking adolescents exhibited significantly attenuated white-matter growth in the pons and corpus callosum between baseline and follow-up scans, compared with controls.[28] Luciana and colleagues reported similar findings, such that alcohol-naïve controls showed an increase in vol-

ume in white-matter regions of the precentral gyrus, miTG, SFG, and lingual gyrus between baseline and follow-up, whereas binge drinking adolescents did not.[32] Taken together, these observations suggest that reduced white-matter volume may precede alcohol use, and that alcohol use during adolescence attenuates the typical maturational increase in white-matter volume observed in adolescence in a dose-related fashion.[2,6-8]

Microstructure

Varied differences in white-matter microstructure have been observed between binge drinking adolescents (with and without concomitant marijuana use) and non–alcohol using controls. First, a cross-sectional diffusion tensor imaging study investigating fractional anisotropy (FA)—a measure thought to reflect white-matter myelination and axonal integrity and coherence—found that binge drinking adolescents had lower FA than control subjects in seven frontal, three parietal, two temporal, four subcortical, and two cerebellar regions. Furthermore, in six of these regions, lower FA was associated with significantly greater lifetime hangover symptoms and higher estimated peak blood alcohol concentrations.[35]

In a second cross-sectional study, concomitant binge drinking and substance using adolescents had lower FA than control subjects in 10 separate frontal, parietal, temporal, and subcortical regions, and reduced FA in these regions was associated with greater lifetime alcohol use.[36] Interestingly, the investigators also noted three regions (i.e., the superior longitudinal fasciculus, internal capsule, and occipital lobe) where FA was greater in concomitant binge drinking and substance using adolescents than in control subjects, and they found that greater FA in these regions was associated with greater lifetime alcohol use.

Finally, a third cross-sectional study of binge drinking adolescents and concomitant binge drinking and substance using adolescents found that binge drinking adolescents, again, had lower FA than control subjects in eight different regions, including the superior corona radiata (SCR), inferior longitudinal fasciculus, superior longitudinal fasciculus (SLF), inferior fronto-occipital fasciculus (IFOF), and cerebellar peduncle.[37] Those with concomitant substance use, in contrast, only had significantly lower FA (compared with control subjects) in three regions, including the SCR and SLF, and they had significantly higher FA than binge drinking adolescents in four regions (i.e., the SCR, SLF, IFOF, and cerebellar peduncle). In this study, greater marijuana use frequency was associated with greater FA in the SCR and SLF, whereas a greater number of lifetime drinks was associated with greater FA in the SLF. Together, these findings suggest that binge drinking during adolescence is associated with reduced FA, but that concomitant marijuana use may interact with the effects of alcohol, resulting in an alteration of this effect.

These cross-sectional findings have been corroborated by numerous longitudinal studies. Luciana and colleagues reported that compared with control subjects, adolescent binge drinkers showed significantly diminished normative increases in FA in the dorsal caudate and IFOF between baseline and follow-up visit.[32] Another study found that concomitant binge drinking and substance using adolescents had reduced FA in the corpus callosum, prefrontal thalamic fibers, and posterior corona radiata at follow-up, compared with control subjects, with no differences reported at baseline.[38]

A series of studies examined FA in a group of binge drinking and concomitant binge drinking and substance using adolescents and young adults at baseline and follow-up.[39-41] First, they found that binge drinking adolescents both with and without concomitant substance use showed a significant, widespread decline in FA across the three visits, resulting in lower FA after 3 years of use compared with control subjects.[39] Moreover, lower FA in the fornix and SCR at baseline in concomitant binge drinking and substance using adolescents predicted greater subsequent use at the first follow-up, above and beyond baseline substance use.[40] It is important to note that in these two studies,[39] adolescent binge drinkers and substance users were not drug and alcohol naïve at baseline; rather, they were drinking and using marijuana throughout the entirety of the study. Lastly, Jacobus and colleagues identified 20 regions in the brain where there was a significant group-by-time interaction, such that adolescents who used both alcohol and marijuana concomitantly showed a sharper decline in FA between baseline and 3-year follow-up than those who only binge drank.[41] In combination, these findings suggest that whereas binge drinking during adolescence and young adulthood appears to be associated with reduced FA, results tend to be less clear when adolescents concomitantly use marijuana. Whereas Jacobus and colleagues found that binge drinkers with concomitant marijuana use initially had had greater FA than those who only binge drank,[37] a longer history of concomitant marijuana use, extending into young adulthood, may eventually result in a steeper decline in FA across development.[41]

Effects on Brain Function

Verbal Encoding

Learning and memory abilities are crucial for an adolescent's success, and development of those abilities may be altered or attenuated by alcohol use. Verbal encoding/learning, using a verbal paired-association task, has been used to investigate the impact of alcohol on learning and memory in binge drinking adolescents with and without comorbid marijuana use. A preliminary study found that binge drinking adolescents had greater activation in the SFG, superior parietal lobule,

inferior parietal lobule (IPL), and the cingulate, as well as lower activation in one cluster encompassing the cuneus, precuneus, lingual gyrus, and parahippocampal gyrus (PHG) during novel word encoding.[42]

In a follow-up investigation, Schweinsburg and colleagues found that binge drinking and concomitant binge drinking and substance using adolescents, when compared with marijuana-only users and control subjects, showed greater encoding-related activation in the postcentral gyrus, IPL, and SFG, and less activation in the fusiform gyrus, PHG, cuneus, precuneus, IPL, IFG, precentral gyrus, and cingulate.[43] They also identified regions of the brain (i.e., the IFG, miFG, SFG, and cuneus) where users of either alcohol or marijuana showed greater brain response than nonusers during novel word encoding, whereas users of both substances resembled nonusers. Because performance on the task was the same between binge drinkers and control subjects,[42,43] these findings suggest that alcohol use during adolescence may cause adolescents to adopt a different neural strategy (e.g., heavier prefrontal-cortex recruitment) to achieve the same successful verbal encoding. Because of the cross-sectional design, it is unknown whether these differences were present prior to or developed as a consequence of alcohol consumption.

Working Memory

Brain response during working memory also has been shown to be altered in binge drinking adolescents and young adults. In a preliminary study, Tapert and colleagues found that brain response during a visual working memory task was negatively associated with subjective response to alcohol, such that adolescents who reported that a greater quantity of alcohol was needed to feel an effect showed greater activation in the SFG, cingulate, cerebellum, and PHG during memory retrieval.[44] A subsequent study showed that binge drinking adolescents had greater activation in the medial frontal gyrus (meFG), SFG, IPL, and supramarginal gyrus, as well as less activation in the middle occipital gyrus, when compared with control subjects.[45] Furthermore, in longitudinal analyses, binge drinking adolescents actually had lower activation in the IPL and meFG at baseline (i.e., prior to drinking), but when compared with control subjects, they showed a greater increase across time. These greater increases in brain activation were associated with a greater peak number of drinks in the past year, more past-month drinking days, and greater withdrawal/hangover symptoms at follow-up.[45] Further, less premorbid activation in the meFG and IPL predicted a higher peak number of drinks and drinking days in the year preceding follow-up.[45] This suggests that binge drinking not only affects neural response during working memory, but that baseline differences in brain activation during working memory may be useful in identifying adolescents who may go on to drink.

These findings also are supported by cross-sectional work using other working memory tasks. One study found that during verbal working memory, binge drinking young adults had greater activation in the parietal cortex (pre–supplementary motor area) than control subjects.[46] Moreover, more drinks per drinking occasion were associated with greater dorsal medial PFC activation, whereas more drinking occasions per week were associated with greater cerebellar, thalamic, and insular activation. In contrast, Squeglia and colleagues reported that binge drinking adolescents had lower activation in the SFG and IFG compared with control subjects.[47] However, this study differed in two ways from the previous studies. Squeglia and colleagues used a spatial working memory task and also reported significant sex differences, such that binge drinking females showed less activation than control subjects, and binge drinking males showed greater activation than control subjects in the SFG, IFG, ACC, miFG, miTG, superior temporal gyrus, and cerebellum. These findings suggest that, in general, adolescents show alcohol-related increases in activation, particularly in fronto-parietal networks during working memory; however, at least for spatial working memory, these findings may be sex specific. Further work is necessary to tease out the different elements (e.g., spatial versus verbal) of working memory and the effects of alcohol on their associated neural responses.

Risk Taking and Reward Response

Because adolescence is a time of increased risk taking, including experimentation with alcohol, it may come as no surprise that binge drinking adolescents show altered brain response during various phases of risk taking. Whereas some investigators have attempted to elucidate binge drinking's effects on a particular aspect of risk-taking behavior,[48-50] others have investigated risk taking more broadly.[51] In a study looking at risk-taking behavior using the Iowa Gambling Task, binge drinking adolescents had greater risk-related activation in the amygdala and insula compared with control subjects, and they had more reported drinking problems related to less activation in the orbitofrontal cortex (OFC) and more activation in the insula.[51] Two recent studies separately investigated the effects of binge drinking during adolescence during decision making and reward receipt. In the first study, binge drinking adolescents, compared with control subjects, showed reduced cerebellar response during reward receipt following initiation of binge drinking, a finding that remained significant when controlling for premorbid activation, and which was associated with more drinks per drinking day in the past 90 days.[48]

A longitudinal investigation found that binge drinking adolescents, compared with control subjects, had lower

activation in the IFG, IPL, miTG, and superior temporal gyrus across time, suggesting a different pattern of brain activation that occurs prior to binge drinking and persists after alcohol initiation.[49] There also was a significant group-by-time interaction in the dorsal caudate, such that binge drinking adolescents showed similar risky decision-making–related brain responses as controls at baseline, but they showed a reduced response following binge drinking. This reduction was associated with a greater number of drinking days and heavy drinking days in the previous 3 months.

Further, Worbe and colleagues used a novel risk-taking gambling task in binge drinking young adults to investigate brain responses during the decision-making and feedback phases of both reward and loss gambles.[50] During decision making in conditions with both a low and high potential for a loss, the study found that binge drinkers had greater activation in the OFC, superior parietal cortex, and DLPFC compared with control subjects. This finding was accompanied by more risky decisions during high-loss selections. Furthermore, although giving feedback during the task reduced the amount of risky decisions in binge drinking young adults, it also was associated with greater activity in the IFG and IPL, when compared with control subjects.

In addition to studies looking at adolescent risk-taking behavior, a study by Whelan and colleagues investigated brain responses during reward anticipation and receipt outside of the context of risk, using the monetary incentive delay task.[29] The study demonstrated that, compared with control subjects, adolescent binge drinkers had greater activation during reward receipt in the SFG prior to initiation of binge drinking, but they had reduced activation during reward anticipation and receipt in the ventral medial PFC and IFG after binge drinking. Taken together, these findings suggest that binge drinking during adolescence and young adulthood is associated with alcohol-related alterations in brain response during decision making and reward/consequence notification. Further, group differences in fronto-parietal brain response during risky decision making and reward receipt that occur prior to drinking may serve as a risk factor for future drinking.[29,49]

Inhibition

Several longitudinal studies have used a standard go/no-go procedure to investigate the effects of binge drinking on brain response during inhibition. One study found that, at baseline, adolescents who went on to engage in heavy drinking had reduced brain response during successful inhibition in the DLPFC, miFG, SFG, IFG, meFG, paracentral lobules, cingulate, putamen, miTG, IPL, and pons, compared with adolescents who remained alcohol naïve.[52] In another study, less activation during successful inhibition in the ventral medial PFC predicted more alcohol dependence symptoms in heavy-drinking adolescents at 18-month follow-up.[53] Meanwhile, in a study investigating the failure to inhibit responding, greater activation in the premotor cortex served as a risk factor for adolescents who later went on to engage in binge drinking.[29] Together, these studies suggest that lower engagement of numerous regions, particularly within the fronto-parietal network, during successful inhibition, as well as greater engagement of premotor regions during unsuccessful inhibition, may precede the onset of binge drinking.

Furthermore, compared with alcohol-naïve control subjects, heavy-drinking adolescents were shown to have significantly lower levels of brain activation during inhibition in the miFG, IPL, putamen, and cerebellum at baseline.[54] They also showed greater increases in inhibition-related brain responses, compared to controls, following initiation of heavy drinking. Greater increases in brain response during response inhibition between baseline and follow-up were associated with more lifetime drinks. The same group of researchers also found that these patterns of activation differed in adolescents who experienced alcohol-induced blackouts. Prior to initiation of heavy drinking, adolescents who did and did not experience alcohol-induced blackouts showed less activation in the IPL compared with control subjects.[55] However, adolescents who went on to experience alcohol-induced blackouts showed greater activation during inhibition in the miFG, miTG, cerebellum, and parietal cortex (pre–supplementary motor area) compared with those who did not experience blackouts. These findings suggest that adolescents who later experience alcohol-induced blackouts show patterns of brain activation during inhibition, which may render them more vulnerable to the memory-impairing effects of alcohol.

Lastly, a recent study in binge drinking young adults found that those who escalated drinking over a 12-month period had greater fronto-parietal activation during inhibition compared with young adults who maintained stable drinking levels.[56] Taken together, it appears that hypoactivation of the fronto-parietal network during inhibition may serve as a risk factor for alcohol use initiation; however, after alcohol use initiation, hyperactivation of the fronto-parietal network during inhibition may serve as a risk factor for escalation of drinking.

Cue Reactivity

Two recent studies have looked at brain activation elicited by an alcohol cue (i.e., cue reactivity), using an alcohol pictures task, in binge drinking adolescents and young adults. Dager and colleagues found that young adults who transitioned from moderate to heavy drinking over a 1-year follow-up had greater activation at baseline in the caudate, ACC, medial prefrontal cortex, precentral gyrus, insula, IFG, and OFC, compared with those who

remained moderate drinkers or heavy drinkers throughout the study.[57] Furthermore, brain activation in this network of regions predicted future drinking and alcohol-related problems, above and beyond baseline drinking characteristics. This suggests that changes in how the brain responds to alcohol cues may help predict which individuals may transition from light to heavy drinking and may be more informative than simply comparing heavy drinkers with control subjects. In another study, heavy-drinking adolescents had greater cue-elicited brain response in the dorsal striatum, cerebellum, PHG, and thalamus than control subjects prior to abstinence; however, the group differences in the cerebellum and ACC no longer remained significant after 28 days of abstinence.[58] This suggests that although cue-elicited brain response may be a predictor of future drinking, if adolescents manage to maintain abstinence, they may be able to reduce that cue-elicited response. This finding has important implications for future intervention strategies.

Effects on Behavior and Cognition

Many of the structural and functional differences observed in adolescent binge drinkers also are associated with changes in cognition and behavior. Several studies have examined neurocognitive changes related to binge drinking and reported poorer performance in many domains, including attention,[59,60] learning and memory,[59,61-66] and visuospatial functioning.[60] Neuroimaging studies have found that the poorer sustained attention observed in binge drinking adolescents is associated with thicker PFCs[31] and lower FA in the inferior longitudinal fasciculus[67]—regions where thickness and FA differed significantly between binge drinking adolescents and control subjects. This suggests that binge drinking during adolescence may cause a delay in the maturation of both gray and white matter, resulting in poorer sustained attention.

Furthermore, binge drinking adolescents and young adults have demonstrated impaired performance on a variety of learning and memory tasks.[59,61,62,64,65] These findings also have been associated with changes in brain structure in binge drinking adolescents in regions of the brain where these adolescents differ from control subjects. Binge drinking–related deficits in working memory also have been demonstrated,[61,63] with one study showing that after 3 years of binge drinking, greater gray-matter volume in the DLPFC was positively associated with working-memory errors.[26] Further, decreased FA in the inferior longitudinal fasciculus in binge drinking and substance using adolescents has been shown to be associated with poorer working-memory performance.[67] In addition, although an initial study found that the number of drinking days in the past year predicted greater reductions in performance on a visuospatial task,[60] a follow-up study showed that thicker frontal cortices corresponded with poorer visuospatial performance in binge drinking females.[31] These findings suggest that delayed cortical maturation may underlie the effects of binge drinking on visuospatial performance.

Binge drinking adolescents also demonstrate impaired, or riskier, decision making,[68] likely resulting from impairments in impulsivity[69] and inhibition.[64] One study found that young adults who showed stable, high levels of binge drinking made riskier choices on the Iowa Gambling Task compared with adolescents who engaged in stable, low levels of binge drinking.[68] Other studies have reported that heavy-drinking adolescents show greater impulsivity than light drinkers[69] and that binge drinking adolescents show impaired inhibition compared with control subjects.[64]

Neuroimaging studies have helped shed some light on the mechanisms underlying this impaired decision making and impulse control. Structurally, greater impulsivity in adolescent binge drinkers has been shown to be associated with smaller DLPFC and IPL volumes and greater dorsal cingulate and precuneus volumes,[70] whereas reduced FA in the fornix of concomitant binge drinking and substance using adolescents has been shown to predict greater amounts of risky behavior a year and a half later.[40] Functionally, riskier behavior on the Iowa Gambling Task in binge drinking adolescents has been accompanied by greater activation in the insula and amygdala, when compared with control subjects.[51] Also, as described above, greater activation in the OFC, superior parietal cortex, and DLPFC, when compared with controls, has been associated with more risky decisions when there was a high potential for loss.[50] Taken together, these findings suggest that the underdevelopment of control regions (e.g., smaller DLPFC and IPL volumes) and hyperactivation of reward-salience regions (e.g., amygdala), both of which are hallmarks of adolescent neurodevelopment, may be exacerbated in adolescents who binge drink and may underlie the observed increase in risk-taking behavior in binge drinking adolescents.

Conclusions

Although evidence is still emerging on how binge drinking during adolescence and young adulthood affects the brain, many general conclusions can be drawn from current literature (for a summary of all replicated findings in binge drinking adolescents and young adults, see Figure 1). First, binge drinking during adolescence appears to result in a decrease in both gray-matter volume and cortical gray-matter thickness,[9,30] with longitudinal studies suggesting that some of these differences may be present prior to binge drinking and continue to worsen as adolescents initiate alcohol consumption.[27,28,32] Although it must be noted that some studies show increased gray-matter volume or thickness in binge drinking

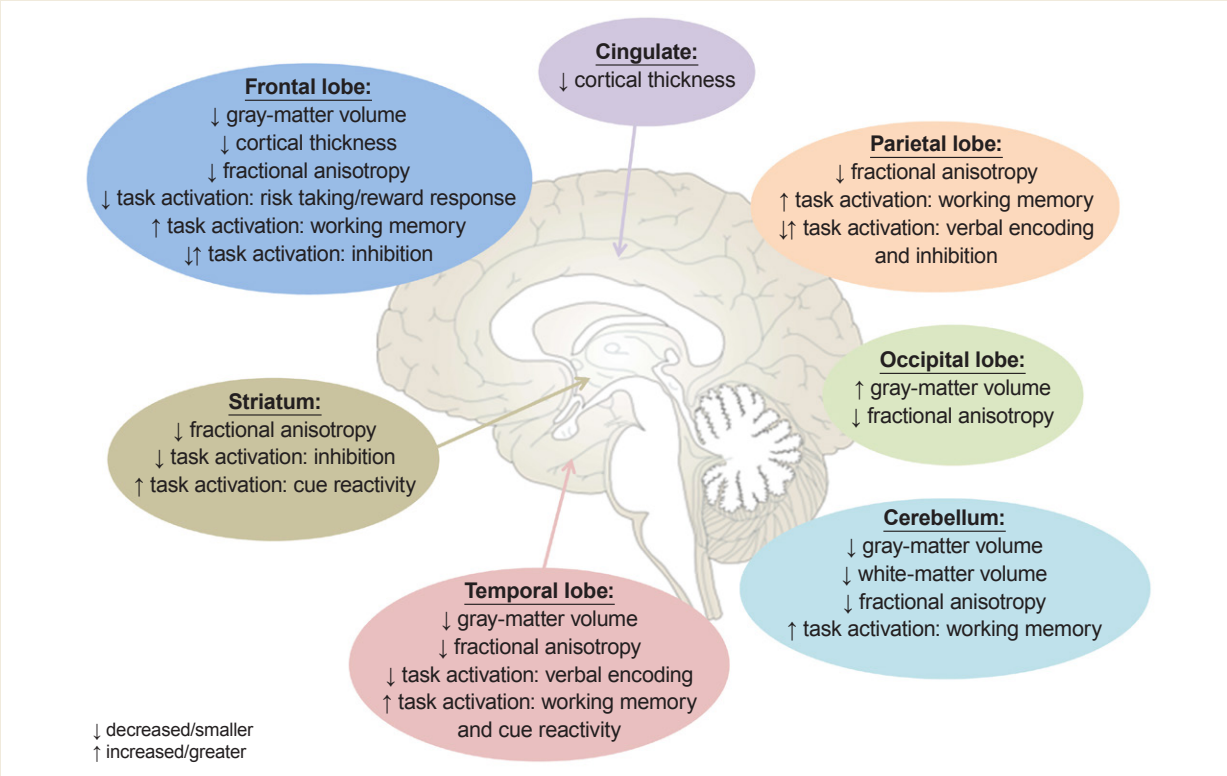

Figure 1 Replicated findings in binge drinking adolescents and young adults.

adolescents, it is plausible that these contradictory findings either are caused by the influence of concomitant marijuana use[33,34] or are the result of examining the effects of binge drinking on a nonlinear developmental pattern[2-5] in a cross-sectional manner.[24,26]

Second, multiple studies consistently have shown that the developmental increases in white-matter volume, often observed in adolescents,[2,6-8] appear to be attenuated in adolescents who binge drink,[27,28,32] and that this attenuation is associated with the degree of substance use.[9,25] However, studies demonstrating altered white-matter microstructure in binge drinking adolescents have yielded mixed results, showing both increases and decreases in FA. Again, it appears that this may partially be explained by the presence of concomitant marijuana use in adolescence.[36,38-41] More studies comparing concomitant users to those using only alcohol or marijuana likely are necessary to completely disentangle these effects.

Functionally, binge drinking during adolescence appears to affect brain responses in numerous regions, across a variety of tasks. Cross-sectional work has identified both increased and decreased brain activation in multiple task domains (e.g., verbal learning, working memory, risk taking, cue reactivity, and inhibition) and demonstrates the necessity of longitudinal studies to determine which effects are a result of alcohol consumption and which reflect an underlying risk phenotype for those who will go on to binge drink. Longitudinal work, specifically in working memory[45] and response inhibition,[52,54] suggests that binge drinking adolescents demonstrate similar or lower levels of brain activation in task-relevant regions at baseline, followed by an exacerbated increase in activation, above and beyond that seen in control subjects, after initiation of binge drinking. A failure to recruit task-relevant regions at baseline in future binge drinkers could lead to poorer task performance, while hyperactivation following alcohol use suggests that binge drinking adolescents require more recruitment of task-relevant networks to achieve desired cognitive outcomes.

Meanwhile, similar or lower levels of brain activation during risk-taking behavior (i.e., risky decision making and reward response) also have been observed in binge drinking adolescents.[48,49] However, unlike during working memory and response inhibition, binge drinking adolescents have lower levels of brain response over time during risky decision making and

reward response. This may suggest not only a pattern of activation during risky decision making that may serve as a risk factor for future drinking,[49] but also a diminished brain response to risky stimuli and rewards following binge drinking.[48,49] This decreased brain response may be what causes binge drinking adolescents to show greater risky behavior and may enhance reward seeking.

Understanding these altered neurobiological features in binge drinking adolescents is extremely relevant, because changes in both brain structure and function have been related to changes in cognition in binge drinking adolescents.[26,31,40,50,51,60,67,70] Moreover, not only do differences in task activation serve as risk factors for future drinking,[45,49,52,54] but neurobiological features, such as fronto-parietal hyperactivation during inhibition and atypical white-matter microstructure, may serve as risk factors for escalated drinking and risk-taking behavior in adolescents who are already drinking.[40,56] Adolescent onset of alcohol use has been associated with an increased risk for developing an AUD later in life;[22] thus, understanding neurobiological markers that are associated with both initiation and escalation of alcohol use is important for advancing future prevention and intervention strategies in an effort to reduce the rates of AUD.

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NIAAA's College Alcohol Intervention Matrix

CollegeAIM

Jessica M. Cronce, Traci L. Toomey, Kathleen Lenk, Toben F. Nelson, Jason R. Kilmer, and Mary E. Larimer

The College Alcohol Intervention Matrix (CollegeAIM) is a user-friendly, interactive decision tool based on a synthesis of the substantial and growing literature on campus alcohol use prevention. It includes strategies targeted at both the individual and environmental levels. Commissioned by the National Institute on Alcohol Abuse and Alcoholism (NIAAA), CollegeAIM reflects the collective knowledge of 16 separate experts in the field, which makes it unique relative to other summaries of the science. CollegeAIM is designed to help college stakeholders compare and contrast different evidence-based prevention strategies to select a mix of individual and environmental strategies that will work best on and around their campuses. CollegeAIM is a living document, which will be updated to keep pace with the science. Colleges are therefore encouraged to ensure that evaluations of individual- or environmental-focused strategies on their campuses or in their communities make it into the published literature.

Key words: CollegeAIM; college drinking; literature review; prevention; research; underage drinking

Most students (81.4%) have consumed alcohol on at least one occasion by the time they reach college or at some point during their college career.[1] Many college students (63.2%) report alcohol consumption within the past 30 days, with 38.4% reporting "being drunk" at least once during that same time frame.[1] Rates of heavy episodic drinking (i.e., binge drinking), defined in this sample as consuming five or more drinks in a row on at least one occasion in the past 2 weeks for both men and women, roughly mirror the reported rates of being drunk (31.9%).[1]

Of course, students who engage in binge drinking may do so more than once during a 2-week period. In fact, Wechsler and colleagues found that, of the 43% of students who said they engaged in binge drinking (defined in this study as four or more drinks in a row for women or five or more drinks in a row for men during the past 2 weeks), nearly half reported three or more such occasions (44%, or 19% of the total sample).[2] In this study, frequent binge drinking was associated with a host of negative health and social consequences and other risk behaviors, including missing class (53.8%), driving after drinking (40.6%), or engaging in unplanned (49.7%) or unprotected (52.3%) sex (percentages represent the proportion of individuals engaging in frequent binge drinking that endorsed experiencing each consequence). These behaviors have long-term consequences that students can readily identify, including academic failure, injury, legal complications, sexually transmitted disease, and death. Binge drinking also has lasting effects on the brain that produce less recognizable consequences, such as impaired working memory and other changes in mental processes that may be less apparent to the individual engaging in binge drinking or others as long as the person is generally functional, but which nonetheless may derail or impair optimal development.[3] The prevalence of binge drinking, paired with the significant potential for both short-term and lasting harm, is why prevention is paramount in this population.

The National Institute on Alcohol Abuse and Alcoholism (NIAAA) is at the forefront of efforts to prevent underage and harmful alcohol use among college students. NIAAA funds research to develop and evaluate prevention strategies

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and creates dissemination tools to put evidence-based prevention approaches into the hands of college stakeholders.

In 2002, NIAAA's Task Force on College Drinking released a report, *A Call to Action: Changing the Culture of Drinking at U.S. Colleges*, outlining the state of alcohol misuse and prevention science in this area.[4] The report included specific recommendations to help colleges and universities determine which strategies were most likely to produce meaningful changes in alcohol use and consequences on their campuses. The Task Force categorized strategies into one of four tiers, based on evidence of their effectiveness and the nature of the evidence available. The strategies that met criteria for inclusion in Tier 1 had evidence of effectiveness among college students and were individual-focused strategies shown to reduce high-risk drinking behavior and/or negative drinking-related consequences. The strategies that met criteria for inclusion in Tier 2 had evidence of success with general populations and could be applied to college environments, but had not been specifically tested with college students. The multiple strategies assigned to Tier 2 were all environmental in nature, targeting the student body as a whole. Tier 3 strategies were defined as, and comprised, strategies that had logical and theoretical promise but had not been fully evaluated. Tier 4 comprised strategies where there was evidence of ineffectiveness.

In 2004, NIAAA mailed the 2002 report to the president of every college and university in the United States and made it available at no cost to anyone who requested a print copy. The report also was made available online on a dedicated website, www.collegedrinkingprevention.gov, along with a host of resources and supporting documentation.

In 2008, Nelson and colleagues assessed the influence of these dissemination efforts and found that 23% of colleges were not employing any recommended Tier 1 or Tier 2 strategies, and 45% were only employing a single recommended strategy.[5] Two-thirds of institutions surveyed offered a Tier 1 strategy (67%), but most did not report implementing any recommended Tier 2 strategies. This suggests a trade-off between individual and environmental approaches. One possible reason for this is that environmental approaches often are not self-contained within the campus and rely on building partnerships with local law enforcement, businesses within the community, community members, and lawmakers. It also is possible that the tier system created a false hierarchy, making individual strategies assigned to Tier 1 appear more effective than environmental strategies assigned to Tier 2, simply because the latter had not been tested specifically within college populations. This, of course, was not the intent of the tier system, as stated in a report on college drinking research: "Central to the Task Force findings was the recognition that successful interventions occur at three distinct levels . . . [that] must operate simultaneously to reach individual students, the student body as a whole, and the greater college community."[6] Thus, dissemination efforts need to adopt organizational structures that make readily apparent the importance of employing both individual and environmental strategies as part of an overall prevention approach.

CollegeAIM

In the 10 years following the 2002 publication of *A Call to Action*, there was an explosion of research on college alcohol use prevention. There were more than 151 studies published just on individual-focused approaches between 2002 and 2012, compared with only 45 in all the years before 2002.[7-10] This exponential increase in the available science prompted a re-evaluation of the Task Force recommendations: What did the science say about the effectiveness of the recommended strategies now? What new strategies had been shown to be effective and should be added to the list? Was the information provided as part of the original recommendations sufficient for colleges to effectively weigh their options, thus adequately supporting adoption and implementation of evidence-based approaches?

NIAAA had these questions in mind when it commissioned and oversaw creation of CollegeAIM, tapping the expertise of two teams of three researchers: a team at the University of Washington examining individual-focused strategies, and a team at the University of Minnesota examining environmental-focused strategies. Both teams worked together to create a comprehensive list of the practical factors that colleges would likely want to consider when choosing an evidence-based approach, including amount of research support, cost, and potential barriers to adoption and implementation. Each team then reviewed the extant research in their area through 2012, rating each strategy that met their inclusion criteria. For the individual-focused strategies, inclusion criteria required that a strategy had been the subject of at least two peer-reviewed, randomized, controlled clinical trials. In addition, a strategy could only be rated on effectiveness if there were at least three trials. For the environmental-focused strategies, ratings were based on review articles, when available, and all identified studies in other areas.

After the teams completed the ratings, they sent them to 10 leading experts within the alcohol prevention field for multiple rounds of peer review. The teams made edits (e.g., adding specific studies from 2013 that would inform ratings and clarifying how ratings were applied) until they achieved consensus across the teams and reviewers. Thus, CollegeAIM reflects the collective knowledge of 16 separate experts in the field (see Table 1), which makes it unique relative to other summaries of the science.

CollegeAIM is organized into two matrices, one summarizing individual-focused strategies and one summarizing environmental-focused strategies, divided into levels of effectiveness and cost. Each matrix also has a companion table that offers more in-depth information on the specific strategies. CollegeAIM also helps colleges consider both individual and environmental strategies by including a planning worksheet that facilitates a direct comparison of

Table 1 CollegeAIM Contributors

Individual-Focused Strategies Team

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strategies along the various rated factors, both across and within these two broad categories. Although CollegeAIM is largely a selection tool, institutions can use the planning worksheet to organize assessment of currently employed prevention strategies. CollegeAIM urges stakeholders to "see if any new, effective approaches might replace . . . existing strategies."[11] Information in the online version of CollegeAIM directs users to outside resources that can assist with planning and taking action to adopt, implement, and evaluate a given strategy. Each of these steps is necessary for effective campus prevention. Evaluation is of particular importance, since local realities (e.g., differences in campus and community culture, available staff) may influence how effective a strategy actually is on a given campus. A college or university's experience may diverge (for better or worse) from the effectiveness rating in CollegeAIM, which is based on the observed aggregate effect across the campuses and communities where they were tested.

Individual-Focused Strategies

CollegeAIM identified 14 strategies as having some effectiveness in the individual-focused strategy matrices. Of these, the researchers deemed 8 to have higher effectiveness, based on the requirement that 75% or more of the studies evaluating a given strategy reported a reduction in alcohol use and/or alcohol-related consequences. Consistent with *A Call to Action*, the science supported multicomponent alcohol skills training that includes information on what constitutes a standard drink, how to calculate and moderate blood alcohol concentration through protective behavioral strategies such as monitoring and setting limits on consumption, how alcohol outcome expectancies shape behavior following alcohol use, and how perceptions of other people's drinking influences personal drinking. This approach is typified by the Alcohol Skills Training Program (ASTP),[12] which is generally delivered to small groups of students. The ASTP was the precursor to the Brief Alcohol Screening and Intervention for College Students (BASICS),[13] which is the basis for the majority of current brief motivational interventions (BMIs). BMIs are generally one-on-one sessions facilitated by a professional in training (i.e., a graduate student in psychology) or professional (e.g., a master's- or doctoral-level counselor) using personalized feedback summarizing the student's alcohol-related behaviors, beliefs, and experiences to guide the conversation. Although limited research has examined whether undergraduate students (e.g., peer health educators) can deliver BMIs effectively, results are generally favorable; however, there is not enough evidence to conclusively determine the conditions under which peers are as effective as professionals. One factor that is thought to be central to the efficacy of BMIs is fidelity to a motivational interviewing (MI) style,[14] which requires regular supervision and review of taped or audio-recorded sessions that have been rated for adherence to the therapeutic spirit and skills of MI. That said, four of the eight highly effective programs are delivered entirely remotely, in the absence of an MI-trained facilitator.

Relative to BMIs, these nonfacilitated programs have been found to be comparable on most outcomes,[7] although in-person BMIs may hold an advantage over feedback-only

programs in terms of reducing alcohol quantity and negative consequences.[15] Two of these four programs are considered personalized feedback interventions (PFIs), which offer the feedback from a BASICS session delivered online, by email or text, or by mail. It is worth noting that some individual-focused strategies that would be considered PFIs are included as having "too few studies to rate effectiveness," since only two studies had been published when CollegeAIM was launched. Given the success of generic PFIs, as well as eCHECKUP TO GO (the only named and commercially available PFI with higher effectiveness), more research on these approaches is warranted. Another commercially named program rated as having higher effectiveness—AlcoholEdu for College—contains personalized feedback but is not considered a PFI, because it incorporates a number of other interactive elements that go beyond merely providing feedback.

The fourth remotely delivered program constitutes a single component of a PFI: correcting normative misperceptions of peer alcohol use in relation to the individual's own alcohol use, that is, personalized normative feedback (PNF). PNF in the form of birthday cards have been used to target 21st-birthday drinking, a known high-risk drinking event for many students; however, this use of PNF has had overall lower effectiveness.

The final two strategies rated as having demonstrated higher effectiveness include goal/intention setting alone and self-monitoring/self-assessment of drinking alone. Both of these strategies often are a part of the other strategies listed above; however, like PNF, these are considered single-component interventions that, in the absence of other elements, decrease student drinking. As their names imply, the former involves helping students set goals or intentions that are contrary to high-risk drinking, while the latter requires students to complete a one-time assessment or longitudinal daily monitoring of their drinking behavior. Assessment is necessary to create the feedback used for BMIs, PFIs, and PNFs, and creates an opportunity for self-reflection that is thought to be amplified by the associated feedback.

Environmental-Focused Strategies

CollegeAIM identified 19 strategies as having some degree of effectiveness in the environmental-focused strategy matrices. Of these, 5 were deemed to have high effectiveness: retaining the minimum legal drinking age (MLDA) of 21, enforcing the MLDA, increasing taxes on alcohol, retaining a ban on Sunday alcohol sales, and enacting bans on happy hours and other price promotions. Retaining the MLDA of 21 remains one of the most highly effective environmental interventions at the population level in terms of reducing alcohol consumption and alcohol-related fatalities.[16] Retaining the MLDA is beyond the control of any given college, but colleges can describe and promote the existing evidence on the effectiveness of the MLDA and work with community coalitions to ensure the drinking age is not lowered. Furthermore, retaining MLDA laws alone is not sufficient; the MLDA must be enforced through mechanisms such as underage compliance checks. Colleges can directly encourage local law enforcement agencies to regularly conduct compliance checks at alcohol establishments most likely to be frequented by their underage students. Increasing taxes on alcohol sales, retaining a ban on Sunday alcohol sales (if applicable), and bans on happy hours or other price promotions are all policies enacted at the state or local levels. Colleges can partner with other organizations or coalitions that influence policymakers to implement or retain these policies. In addition, college representatives can talk individually with local bars and other venues near campus that serve alcohol and ask them to restrict happy hours and other price promotions. Bars surrounding a campus may attempt to attract students to their establishments by underbidding nearby competitors, which can create a dangerous situation that promotes heavy consumption (e.g., buying one drink and getting one for a discounted price, or promoting discounted shots).

Conclusions

NIAAA developed CollegeAIM to offer colleges and universities an array of evidence-based options to address alcohol use on their campuses. Because the evidence changes with more scientific study, CollegeAIM is necessarily a living document, and NIAAA has committed to updating it every few years for the foreseeable future. The next update is planned for the fall of 2018, reviewing literature published through December 2017. Campus stakeholders are encouraged to facilitate future iterations of CollegeAIM by ensuring that evaluations of individual- or environmental-focused strategies on their campuses or in their communities make it into the published literature. Campus alcohol and drug prevention staff members could partner with graduate students and faculty at their own or nearby institutions to conduct the evaluations and collaborate on the publications. Graduate students, in particular, may be a valuable resource, since they need data for theses and dissertations, and they may therefore be willing and able to contribute time to evaluate the strategies in exchange for use of the data. It is, of course, just as important to publish what doesn't work as what does. CollegeAIM also is meant to help colleges learn what strategies are not effective, to avoid wasting resources.

In sum, CollegeAIM is a user-friendly, interactive decision tool based on a synthesis of the substantial and growing literature on campus alcohol use prevention, including strategies targeted at the individual and environmental levels. It is designed to be a strategy selection tool; however, it also offers resources to aid in strategy planning, implementation, and evaluation. The goal of CollegeAIM is to help colleges and communities use their limited resources in the most cost-effective way possible. The hope is that by using a combination of effective individual- and environmental-focused

strategies, colleges can create sustained reductions in risky alcohol use and related problems among their students.

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"Maturing Out" of Binge and Problem Drinking

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This article reviews literature aiming to explain the widespread reductions in binge and problem drinking that begin around the transition to young adulthood (i.e., "maturing out"). Whereas most existing literature on maturing out emphasizes contextual effects of transitions into adult roles and responsibilities, this article also reviews recent work demonstrating further effects of young adult personality maturation. As possible mechanisms of naturally occurring desistance, these processes could inform both public health and clinical interventions aimed at spurring similar types of drinking-related behavior change. This article also draws attention to evidence that the normative trend of age-related reductions in problem drinking extends well beyond young adulthood. Specific factors that may be particularly relevant to problem drinking desistance in these later periods are considered within a broader life span developmental framework.

Binge drinking is strikingly prevalent in the United States. An estimated 66.7 million (24.9%) of Americans age 12 or older report binge drinking in the past month, according to the National Survey on Drug Use and Health (NSDUH).[1] This estimate is based on a binge drinking definition of 4 or more drinks on the same occasion for women, and 5 or more drinks on the same occasion for men, on at least 1 day in the past 30 days (see **Drinking Patterns and Their Definitions** in this issue for a review of binge drinking definitions). In addition to high binge drinking rates, alcohol use disorder (AUD) is among the most prevalent mental health disorders in the United States. An estimated 15.7 million (5.9%) of Americans age 12 or older have a past-year AUD diagnosis.[1] These rates are a public health concern, as problem drinking in the United States costs an estimated $249 billion per year[2] and is the fourth-leading cause of preventable mortality.[3]

Perhaps the most striking demographic feature of problem drinking (and various other risky or deviant behaviors) is its nonlinear association with age, characterized by increases during adolescence, peaks around ages 18 to 22, and reductions beginning in the mid-20s.[4] However, studies showing age differences in drinking-related rates for epidemiologic purposes tend to contrast relatively broad age groups, and a finer-grained depiction is informative from a developmental standpoint. Figure 1 shows the results of the authors' descriptive analyses of age-prevalence gradients for different drinking-related outcomes (and other drug-related outcomes included for contrast).

As shown in Figure 1, prevalence rates for a variety of drinking-related outcomes peak in the early 20s. Specifically, in the early 20s, past-year binge drinking and intoxication rates both reach peaks of around 45%, and past-year AUD rates reach a peak of 19%. Although not depicted, similar drinking-related peaks are observed for college students and their noncollege peers, suggesting the peaks are at least partially driven by more general mechanisms beyond college attendance.[5] Regarding historic trends,

drinking-related declines have been observed across adolescent cohorts in recent years. For instance, 12th-grade rates of past 2-week binge drinking decreased from a peak of 32% in 1998 to an historic low of 17% in 2015.[6] However, college students and young adults have had far more modest cohort declines in binge drinking (i.e., from a 39% peak in 2008 to 32% in 2015 for college students, and from a 41% peak in 1997 to 32% in 2015).[6] Similar conclusions regarding historic changes across adolescent and young adult cohorts can be drawn from NSDUH data on AUD.[1]

Figure 1 also shows that, following peak prevalences in the early 20s, reliable age-related reductions in a variety of drinking-related outcomes occur beginning in the mid-20s and continue throughout the remainder of the life span. For instance, after the peak binge drinking rate of 45% in the early 20s, the rate declines to 38% by the late 20s, 29% by the late 30s, 22% by the late 40s, and 14% by the late 50s. For AUD, reductions appear especially dramatic in young adulthood. Specifically, after peaking at 19% in the early 20s, the rate decreases rapidly to 13% by the late 20s, then more gradually to 10% by the late 30s, 8% by the late 40s, and 3% by the late 50s. Of course, such cross-sectional age differences must be interpreted with caution, as differential mortality of problem drinkers and secular changes in prevalence rates could artifactually create the appearance of a developmental age gradient. However, it is unlikely that such factors could plausibly explain the magnitude of the rate changes with age, given the somewhat limited extent of overall mortality and secular variation. Further, researchers have also observed the age-prevalence curve in a number of longitudinal studies assessing how prevalence rates change as a cohort ages.[7]

This robust age-prevalence curve motivates and informs the conceptualization of problem drinking from a developmental psychopathology standpoint.[8,9] Other articles in this

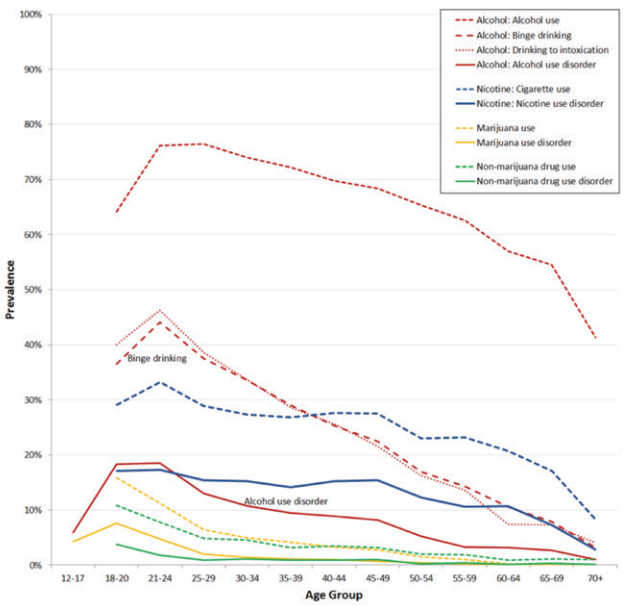

Figure 1 Age-prevalence gradients showing U.S. past-year rates of alcohol-related indices and other drug-related indices across age groups. Prevalence rates for a variety of drinking-related outcomes peak in the early 20s. Following this peak, reliable age-related reductions in a variety of drinking-related outcomes occur beginning in the mid-20s and continue throughout the remainder of the life span. *Note:* Binge drinking was defined as four or more drinks on one occasion for females and five or more drinks on one occasion for males. Disorder rates reflect *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV) criteria for abuse or dependence except for nicotine disorder, which reflects DSM-IV criteria for nicotine dependence. *Source:* Prevalence rates for ages 12 to 17 are based on NSDUH 2002 data from Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality. *Key Substance Use and Mental Health Indicators in the United States: Results From the 2015 National Survey on Drug Use and Health.* Rockville, MD: U.S. Department of Health and Human Services; September 2016. Prevalence rates for ages 18 to 70+ are based on National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) 2001 to 2002 data from Grant BF, Moore TC, Shepard J, et al. *Source and Accuracy Statement: Wave 1 National Epidemiologic Survey on Alcohol and Related Conditions.* Bethesda, MD: National Institute on Alcohol Abuse and Alcoholism, U.S. Department of Health and Human Services; 2003.

special issue describe factors contributing to the escalation and eventual peak of problem drinking leading up to the early 20s. This article focuses on factors contributing to the later trends toward problem-drinking reductions beginning around young adulthood.

Maturing Out of Problem Drinking

The dramatic age-related reductions in problem drinking that begin in young adulthood have motivated empirical efforts to understand desistance from a developmental perspective. Despite the overall trend toward maturing out after young adulthood, a substantial subset of individuals show persistent or escalating problem drinking beyond this developmental period.[10] Knowledge of what differentiates developmentally limited versus persistent patterns of problem drinking can help clarify the nature of problem drinking and inform public health and clinical interventions.[11] Indeed, in addition to the above evidence that maturing out can include desistance of syndromal AUD, research also suggests that problem-drinking reductions during young adulthood are particularly likely to occur among those who were relatively severe problem drinkers prior to this developmental period.[12,13] These findings support the importance of research aimed at understanding maturing out as a means of guiding future interventions.

The following sections review evidence for different possible mechanisms of maturing out, beginning with effects of adult role transitions (e.g., marriage and parenthood) and personality maturation (e.g., decreased impulsivity and neuroticism) during young adulthood. Further sections then discuss the need for more life span developmental research to explain the later drinking reductions observed in developmental periods beyond young adulthood, noting some mechanisms that may be particularly relevant to desistance in these periods (i.e., "natural recovery" processes and health issues). A key point pertaining to all mechanisms reviewed here is that more research is needed on possible historic changes in how these mechanisms have operated. Preliminary descriptive evidence suggests historic differences across cohorts in the age-related trend of escalation followed by maturing out.[5(pp221-222)] Key public policy insights could be gleaned from in-depth analyses of such cohort changes in age trends and how they may relate to cohort changes in desistance mechanisms (e.g., the prevalence, life-course timing, and impact of adult role transitions). It is also noteworthy that evidence exists for gender, racial, and ethnic differences in both patterns and mechanisms of age-related drinking reductions.[4,7,14] Although discussion of such differences is largely beyond the scope of the current brief review, this should be noted as another important topic in need of further exploration in future research.

Young Adult Role Transitions and Maturing Out

The most commonly offered explanation for maturing out of problem drinking during young adulthood is that it is driven by transitions into adult roles like marriage, parenthood, and full-time employment.[15] Young adulthood is marked by widespread adoption of such roles,[15] and well-established developmental theory views these transitions as key young adult developmental tasks.[16] Role incompatibility theory is often referenced to explain how these roles influence maturing out.[17] The theory holds that, when a state of conflict (i.e., incompatibility) exists between a behavior (e.g., drinking) and demands of a social role, this can initiate a process called role socialization, whereby conflict is resolved through changes in the behavior. However, the theory also posits role selection effects in the opposite direction, whereby individual characteristics and behaviors can influence the likelihood of later role adoption. These are two very different processes through which roles and drinking behaviors can become associated, so research investigating possible role socialization effects must consider role selection as an alternative explanation.

Evidence for Role Socialization

With few exceptions,[18-20] both marriage and parenthood during young adulthood are generally predictive of later problem-drinking reductions. Further, although many studies have tested only effects of either marriage or parenthood in isolation,[21-28] there is also research demonstrating that both marriage and parenthood can contribute uniquely to these reductions.[15,29,30] In contrast, research has often failed to show that employment contributes to reduced problem drinking in young adulthood,[15,24,27] although some evidence for this effect has been found within certain occupational categories (e.g., "professional" jobs).[30]

Evidence for Role Selection

Most studies have failed to show that alcohol use reduces the likelihood of young adult marriage, parenthood, or employment,[21,27] with some findings even suggesting the opposite effect.[15] However, results appear more mixed for more severe indices of problem drinking and for illicit substance use. For example, research has shown that AUD can prevent marriage and parenthood,[31,32] and that illicit substance use can prevent marriage and employment.[15,33-35]

Practical Implications of Role Effects on Maturing Out

In addition to evidence that family roles can spur desistance from AUD,[24,36] there is even evidence that these roles may have especially dramatic effects among those who were particularly severe problem drinkers prior to role adoption.[37] These findings support the clinical significance, not only of maturing out in general, but of role-driven pathways to maturing out in particular. Further, beyond family role effects on drinking-related maturing out, there is mounting evidence from diverse literatures that family roles convey various protective effects that can cascade across many domains of life to broadly spur adaptation and mitigate pathology.[38-41]

However, given the potential importance of these processes from a public health standpoint, it is surprising how little is known about the mechanisms through which roles influence substance-related maturing out. Existing mediational findings show the most robust support for mediation of role effects via reduced socializing with peers, with additional mixed evidence for mediation via changes in drinking-related attitudes and increased religiosity.[27,28,30,42] Mediation via peer involvement is particularly consistent with the popular role incompatibility explanation of family role effects on maturing out (described above), as role demands may restrict socializing opportunities. However, as articulated in Platt's commentary on how to achieve "strong inference," future studies should conduct "riskier" tests of role incompatibility theory.[43] This means testing hypotheses that could potentially provide discriminating support for role incompatibility theory over other plausible explanations, and testing hypotheses that could potentially disconfirm the theory in favor of other explanations. For instance, an explicit assessment of conflict between drinking and role demands (role incompatibility) could provide discriminating support for role incompatibility theory,[37] and this should be tested against other plausible mechanisms, such as the interpersonal support, security, and satisfaction that family roles can provide.[44]

Young Adult Personality Development and Maturing Out

A vast, long-standing literature links personality and drinking, although variability in personality models, definitions, and terminology can sometimes complicate interpretation of this work.[45] For instance, "Big Three" models of the traits that compose personality typically include constraint (related to impulsivity and risk taking), neuroticism (e.g., anxiety, depression, and stress reactivity), and extraversion (e.g., sociability),[46] whereas "Big Five" models typically include neuroticism, extraversion, conscientiousness, agreeableness, and openness (or intellect).[47,48] Within Big Five models, distinct components of impulsivity and constraint (e.g., lack of perseverance and negative affect urgency) are represented as smaller facets of the larger broadband traits (e.g., conscientiousness and neuroticism).[49] It is beyond this brief review's scope to broadly review the many ways these and other models of personality have been linked to drinking, but see Sher and colleagues for an in-depth review of personality and alcohol research.[45]

This review focuses on one particularly relevant burgeoning area of personality research that has emphasized movement beyond a static view of personality, acknowledging that normative changes in personality occur throughout the life span. Importantly, findings include evidence for adaptive (i.e., presumably beneficial) changes in personality traits that have been linked closely to heavy and problematic drinking, including impulsivity, conscientiousness, and neuroticism. Further, maturational changes in these traits appear particularly rapid during the transition to young adulthood (i.e., the 20s and 30s), the period when normative age-related declines in drinking generally begin. For instance, Figure 2 depicts meta-analytic evidence for age-related increases throughout the adult life span in both emotional stability (akin to lack of neuroticism) and conscientiousness.[39,50,51]

Correlated Change in Personality and Problem Drinking

Perhaps motivated by the above evidence for personality maturation, a subsequent series of studies has shown that the normative age-related drinking reductions of young adulthood may be partially explained by age-related personality change.[52,53] Longitudinal growth models showed a reduction in average levels of problem drinking from ages 18 to 35, along with corresponding reductions in impulsivity and neuroticism and increases in conscientiousness. Further, parallel-process growth models showed correlated change such that those with greater age-related maturation in these three personality domains also had greater age-related reductions in problem drinking. A follow-up study using the same data also showed that age-related changes in drinking motives mediated effects of age-related personality change on age-related problem-drinking reductions.[54] Specifically, reductions in neuroticism and impulsivity predicted reductions in coping-related drinking motives, which in turn predicted reductions in problem drinking. These are the only studies, to our knowledge, analyzing correlated change in personality and drinking as an explanation for the normative drinking reductions observed around the developmental transition to young adulthood (i.e., maturing out), although other studies have shown similar correlated change in earlier developmental periods of normative drinking-related escalation (i.e., adolescence to the early 20s).[55]

Directional Effects of Personality on Drinking Over the Course of Young Adulthood

The above studies of correlated change between personality and problem drinking have forged an entirely new avenue for research on drinking-related maturing out, with one important next step being investigation of different possible directions of effects. Toward this objective, Lee and colleagues estimated cross-lag models testing bidirectional effects between personality and problem drinking across four waves spanning ages 21 to 34.[56] Results showed some prospective effects of personality on problem drinking, with lower impulsivity and higher conscientiousness at age 29 both predicting lower problem drinking at age 34 (see Figure 3). In contrast,

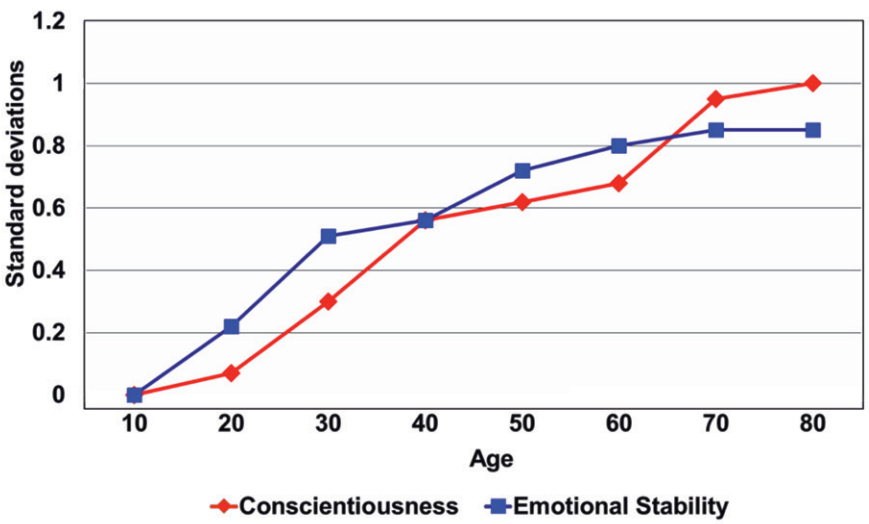

Figure 2 Developmental personality maturation across the life span. Results from a meta-analysis, demonstrating age-related increases throughout the adult life span in both emotional stability and conscientiousness. *Source:* Adapted from Roberts BW, Walton KE, Viechtbauer W. Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies. *Psychol Bull.* 2006;132(1):1-25.

results did not show prospective effects of neuroticism on subsequent problem drinking (nor prospective effects in the opposite direction).

Integrating Adult Role and Personality Effects on Maturing Out

Beyond the largely separate bodies of evidence for family role and personality maturation effects on young adult drinking reductions, little work exists advancing an integrated model of these ameliorative processes. Differing views conceptualize personality maturation as unfolding either (1) due to biologically programmed maturation or (2) as an adaptive response to age-increasing contextual demands (e.g., from family roles).[39] These alternative views imply different predictions regarding possible mediated pathways involving role and personality effects on problem-drinking reductions. To investigate these possibilities, the cross-lag models of Lee and colleagues (discussed above) also included transitions into family roles (marriage or parenthood).[56] Results showed that family role transitions mediated personality effects, with higher conscientiousness and lower impulsivity at age 21 predicting transitions into a family role by age 25, which in turn predicted lower problem drinking at age 29 (see Figure 3). In contrast, personality was not found to mediate role effects, as role transitions consistently failed to predict later personality.

Practical Implications of Personality Development Effects on Maturing Out

The notion of interventions targeting personality change has received increased attention in recent literature.[57] The above-discussed research on personality and maturing out has especially highlighted the potential utility of reducing impulsivity and increasing conscientiousness.

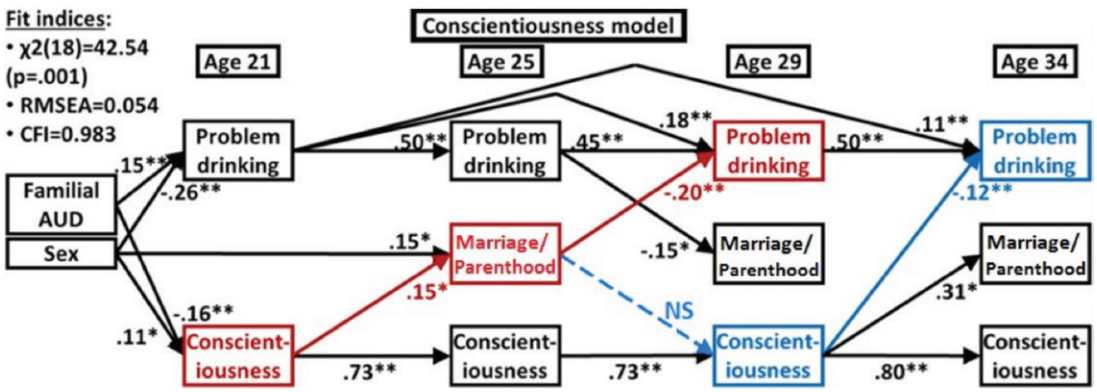

Figure 3 An integrative model of family role and personality effects on young adult maturing out of problem drinking, showing results of a cross-lagged panel model of marriage and parenthood, conscientiousness, and problem drinking across four longitudinal time points. Results of cross-lag models showed some prospective effects of personality on problem drinking, with higher conscientiousness at age 29 predicting lower problem drinking at age 34. Family role transitions mediated personality effects, with higher conscientiousness at age 21 predicting transitions into a family role by age 25, which in turn predicted lower problem drinking at age 29. *Note:* Colors highlight parts of the model testing hypothesized mediation paths. Red variables and paths highlight results confirming the hypothesized mediation of conscientiousness effects on problem drinking via marriage and parenthood. Blue variables and paths highlight results failing to confirm the hypothesized mediation of marriage and parenthood effects on problem drinking via conscientiousness. For marriage/parenthood: 0 = remained never married and a nonparent, 1 = became married or a parent. For family AUD: 0 = family history negative, 1 = family history positive. For sex: 0 = male, 1 = female. *p < .05. **p < .01. *Source:* Adapted from Lee MR, Ellingson JM, Sher KJ. Integrating social-contextual and intrapersonal mechanisms of "maturing out": Joint influences of familial-role transitions and personality maturation on problem-drinking reductions. *Alcohol Clin Exp Res.* 2015;39(9):1775-1787.

Littlefield and colleagues speculated that interventions fostering maturity in these domains might spur relatively durable changes in drinking behaviors.[52] Lee and colleagues noted, based on the above mediation findings, that pre–young adult personality interventions could convey protective effects, in part by aiding successful transitions to family roles in young adulthood.[56] Based on evidence for persistent effects of childhood impulsivity even on midlife outcomes, Moffitt and colleagues argued that universal prevention programs fostering childhood self-control could confer substantial and lasting benefits to most individuals and to an entire population.[58] Indeed, early prevention and intervention programs fostering personality-related maturity could influence many etiologic pathways, thereby conveying protective effects that cascade across multiple developmental stages and domains of life.

However, to bolster confidence in the above implications, additional research is needed to confirm and further characterize the phenomenon of personality maturation and its effects on age-related drinking reductions. Caution is perhaps warranted regarding the use of survey measures to show personality change, as measurement invariance across ages can spuriously influence apparent age-related changes.[59] However, given the magnitude of personality change observed across the life span,[39(p15)] and its associations with changes in various life circumstances,[50] it is unlikely that this phenomenon is largely attributable to a measurement artifact. Nonetheless, confidence could be bolstered by showing this phenomenon with alternative methods. For instance, given the existence of various task-based measures of impulsivity/disinhibition,[60] a key objective should be to confirm age-related changes in these measures and their associations with age-related drinking reductions. Such research could confirm conclusions from survey findings and further inform the practical application of this work.

Further, although clear links have been established among personality maturation, adult role adoption, and drinking reductions, more work is needed to establish directionality of effects within analyses that unambiguously capture developmental change in these constructs. For instance, the cross-lagged panel study by Lee and colleagues[56] addressed the unknown directionality in the growth-modeling studies of Littlefield and colleagues,[52-54] but personality effects in the analyses by Lee and colleagues did not isolate influences of age-related change in personality traits. Thus, creative analytic applications are needed to combine the separate strengths of past research. This work also may require careful conceptualization of the predicted timings and durations of the developmental processes under investigation.

Maturing Out of Problem Drinking Beyond Young Adulthood

As discussed above, age-related drinking reductions are not confined to young adulthood, but instead begin in young adulthood and continue throughout the remaining life span. Beyond the earlier-reviewed epidemiologic evidence, some additional research offers a more precise account of changes in problem drinking across the adult life span. Vergés and colleagues assessed changes across the life span in rates of persistence, new onset, and recurrence of alcohol dependence to understand their unique contributions to overall age-related reductions in alcohol dependence rates.[20] Results showed especially marked age reductions in new onsets (see Figure 4, middle panel). Thus, although the term "maturing out" may be taken to imply age increases in desistance, the continual declines in AUD rates observed throughout the life span instead appear mainly attributable to reductions in new onsets. In contrast, although not emphasized by Vergés and colleagues, rates of desistance appeared to peak in young adulthood. Based on persistence rates in their study, it can be inferred that the rate of desistance peaked at 72% by ages 28 to 32, then declined to a low of 55% by ages 43 to 52 and remained somewhat low thereafter (see Figure 4, upper panel). Thus, an interesting possibility is that risk for AUD onset may continually decline throughout the life span, whereas potential for desistance from an existing AUD may peak in young adulthood. Perhaps confirming and extending the latter notion, ongoing data analyses by the authors[62] have investigated desistance across the life span while differentiating among mild, moderate, and severe AUD (per the *Diagnostic and Statistical Manual of Mental Disorders* [DSM-5] severity grading).[63] Results showed that for those with a severe AUD, desistance rates were substantially higher in young adulthood than in later developmental periods (e.g., severe AUD desistance rates of 46% to 49% at ages 25 to 34 versus 25% to 29% at ages 35 to 55). Of course, given that both above studies used data from

the U.S. National Epidemiologic Survey on Alcohol and Related Conditions (NESARC), these analyses should be replicated in other data sets.

The above evidence for differences across the life span in patterns of desistance suggests there may also be important differences across the life span in mechanisms of desistance. Assessing this possibility should be a key goal of future research, as researchers have clearly gleaned insights through similar attention to developmental variability in etiologic processes of earlier developmental periods (i.e., childhood and adolescence).[64] The following sections consider some specific ways that the mechanisms influencing problem drinking desistance may vary across periods of the adult life span.

Maturing Out Versus Natural Recovery Models of Desistance

Predictions regarding developmental variability in desistance mechanisms can perhaps be made based on Watson and Sher's review highlighting dramatic differences in how desistance is viewed between the "maturing out" and "natural recovery" literatures.[65] As discussed earlier, the maturing out literature focuses on young adulthood and has largely viewed desistance as stemming from contextual changes in this developmental period (e.g., marriage)[15] and accompanying role demands that conflict with alcohol involvement.[17] Importantly, these processes are rarely conceptualized as involving acknowledgment or concern regarding one's drinking.[4,65] A starkly different view of desistance comes from the natural recovery literature, which has investigated

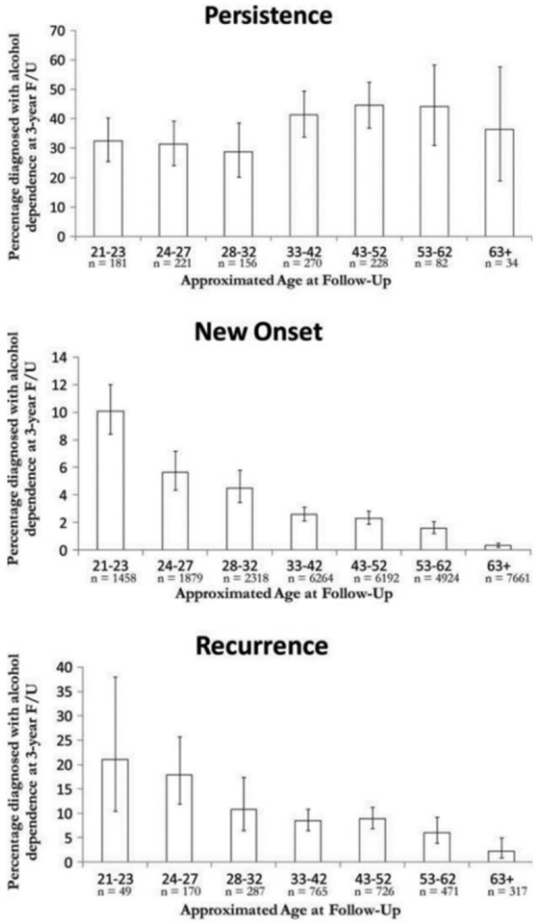

Figure 4 Deconstructing the overall pattern of age differences in alcohol dependence rates, showing separate plots of age differences in persistence (upper panel), onset (middle panel), and recurrence (lower panel) of alcohol dependence, using NESARC data.[61] Brackets show 95% confidence intervals around estimates. *Note:* Persistence rate was defined as the percentage of participants with a past-year alcohol dependence diagnosis at baseline who also had a past-year alcohol dependence diagnosis at the 3-year follow-up. New onset rate was defined as the percentage of participants with no lifetime history of alcohol dependence at baseline who had a diagnosis of past-year alcohol dependence at the 3-year follow-up. Recurrence rate was defined as the percentage of participants with lifetime but no past-year alcohol dependence at baseline who had a diagnosis of past-year alcohol dependence by the 3-year follow-up. *Source:* Adapted from Vergés A, Jackson KM, Bucholz KK, et al. Deconstructing the age-prevalence curve of alcohol dependence: Why "maturing out" is only a small piece of the puzzle. *J Abnorm Psychol.* 2012;121(2):511-523.

precursors of desistance mostly in midlife samples (e.g., mean age = 41 years [*SD* = 9.1] in a review by Sobell and colleagues).[66] Informed in part by models of behavior change (e.g., Stall and Biernacki's stages of spontaneous remission),[67] this literature often views desistance as stemming from an accumulation of drinking consequences that can prompt (1) deliberate reappraisals of one's drinking, followed by (2) self-identification as a problem drinker (i.e., problem recognition), and then (3) targeted efforts to change drinking habits.[68]

Predictions can perhaps stem from an overarching premise that the maturing out and natural recovery literatures may both offer valid conceptualizations of desistance, with maturing out models applying predominantly to young adulthood and natural recovery models applying predominantly to midlife and later developmental periods. That is, desistance in young adulthood may more often stem from the broad cascade of maturational contextual changes that occurs in this period, whereas desistance in later periods may more often stem from more direct processes of deliberate problem recognition and change efforts.

These predictions are consistent with the general idea that contextual effects are stronger earlier in development, whereas intrapersonal effects increase with age[69] as individuals increasingly construct their own environments.[70] It is also noteworthy that there is conceptual similarity between the deliberate reappraisal of one's drinking described in the natural recovery literature and the drinking attitude change believed to mediate personality maturation effects on drinking-related desistance, suggesting a possible point of overlap between natural recovery and personality maturation research. Thus, personality maturation in young adulthood (e.g., conscientiousness increases) may distally potentiate later natural recovery processes of problem recognition and effortful change. Although quite speculative, if the above predictions are supported, this would help bridge divides among different highly influential, yet ostensibly discrepant, views of desistance. More generally, investigating these predictions could help advance the field toward a more unified understanding of desistance across the life span and thereby inform developmental tailoring of public health and clinical interventions.

Older Adult Health and Problem Drinking Desistance

Although health and drinking are, of course, interrelated throughout the life span,[71,72] older adulthood brings various health-related physical and cognitive challenges that may increase in importance as desistance mechanisms in this late developmental stage.[73] There is evidence that more than 50% of U.S. seniors drink at levels deemed risky in the context of co-occurring medical conditions.[74] Further, along with these health issues comes increased use of medications that could interact harmfully with alcohol, with a striking 76% of U.S. seniors using multiple prescription medications.[75] Of the small extant literature on older adult drinking, health issues are among the most commonly reported reasons for desistance.[76] However, studies of prospective effects of health problems on drinking changes are more equivocal,[76,77] perhaps owing to the complex relevance of affect- and coping-related issues to older adult drinking.[78] For instance, there is evidence that health problems can spur drinking reductions except among those who drink to cope, for whom health problems can have the opposite effect.[77,79]

Future studies should expand upon the relative dearth of research in this area. This work should include further study of how affect- and coping-related factors may impede adaptive responding to drinking-related health issues. Attention should also be paid to how these processes are influenced by aging-related increases in alcohol sensitivity[80,81] and changes in social support systems.[73] These questions are particularly important given the increases in older adult problem drinking that are projected to coincide with the aging of the "baby boomer" generation.[82] Indeed, these projections suggest a great future need for research informing policy and clinical interventions for older adult problem drinkers.

Summary of Key Points

Although a distinct peak in problem drinking rates is observed in the early 20s, the reductions that follow (i.e., maturing out) are not confined to the subsequent period of young adulthood. Problem-drinking reductions continue throughout all remaining stages of the adult life span.

In addition to robust evidence that young adult desistance is spurred by transitions into family roles, more recent work shows additional likely influences of developmental personality maturation. Research is needed to further clarify

these ameliorative influences, the mechanisms through which they operate, and how they are interrelated. Such work may yield key practical insights that could inform the design of clinical and public health interventions.

In contrast with developmental models of maturing out, other influential views of desistance (i.e., natural recovery models) place more emphasis on processes of problem recognition and effortful change. A life span developmental perspective on desistance may hold promise for reconciling these ostensibly discrepant models.

More research is needed on health-related mechanisms of problem drinking desistance among older adults.

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The Epidemiology of Binge Drinking Among College-Age Individuals in the United States

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Rates of alcohol consumption continue to be a concern, particularly for individuals who are college age. Drinking patterns have changed over time, with the frequency of binge drinking (consuming four/five or more drinks for women/men) remaining high (30% to 40%). Young adults in the college age range are developmentally and socially at higher risk for drinking at binge levels. Changes in autonomy, parental control, norms, and attitudes affect binge drinking behaviors. This article reviews those changes, as well as the individual and environmental factors that increase or decrease the risk of participating in binge drinking behaviors. Risk factors include risky drinking events (e.g., 21st birthdays), other substance use, and drinking to cope, while protective factors include religious beliefs, low normative perceptions of drinking, and use of protective behavioral strategies. Additionally, this article discusses the physical, social, emotional, and cognitive consequences of consuming alcohol at binge levels. Alcohol policies and prevention and intervention techniques need to incorporate these factors to reduce experiences of alcohol-related problems. Targeting policy changes and prevention and intervention efforts toward young adults may increase effectiveness and prevent both short- and long-term consequences of binge drinking.

Key words: Alcohol consumption; binge drinking; consequences; risk and protective factors; young adults

Binge drinking, particularly among college-age individuals, has been a significant topic of research for more than 20 years because of associations between greater quantity and frequency of alcohol consumption and alcohol-related consequences. To identify factors associated with binge drinking over time, several large-scale studies have assessed trends in binge drinking among young adults. This article aims to summarize those trends and the developmental and social factors that impact the likelihood of, the risk and protective factors related to, and the negative alcohol-related consequences of binge drinking behaviors. Some studies examined young adults who are not in college, but the majority of the literature regarding binge drinking focuses specifically on college students. Further, there is variability in the definition of college students. Some studies sampled only full-time students from four-year institutions, whereas other studies included part-time and community college students.

The term "binge drinking" has a somewhat controversial history. The term was originally defined by Wechsler and colleagues as five or more drinks for men, or four or more drinks for women (5/4+), on a single occasion.[1] Criticisms of this conceptualization of binge drinking were based largely on the substantial variability in blood alcohol concentrations (BACs) due to differences in weight and duration of consumption. When individuals who met these binge drinking criteria had consumed the alcohol over a long period of time, they did not reach BACs higher than .08%.[2,3]

In 2004, the National Institute on Alcohol Abuse and Alcoholism (NIAAA) provided a revised definition of binge drinking, acknowledging that consuming 5/4+ drinks in a 2-hour time period would result in a BAC of at least .08% for most individuals. Although subsequent questions continue to be raised regarding the validity of defining binge drinking at 5+ or 5/4+ on one occasion, these are still the most commonly used definitions in the literature. Research covered in this review includes studies on binge

drinking that use the 5/4+ criteria or a BAC of at least .08%.

Trends in Young Adult Binge Drinking Rates

Binge drinking among young adults has concerned researchers and educators for decades, prompting multiple national initiatives to track patterns in binge drinking. The longest continuous running national survey of drug and alcohol use among adolescents and young adults is the Monitoring the Future (MTF) study, which is funded by the National Institute on Drug Abuse and conducted by the University of Michigan's Institute for Social Research.[4] Approximately 15,000 high school seniors in 133 schools are surveyed each year, and, since 1976, a subset of about 2,400 have been followed biennially by mail. Survey results indicate that the rate of self-reported college student binge drinking in the previous 2 weeks dropped from 1980 (44%) to 1993 (40%) and continued to decrease through 2014 (35%). Estimates for college student engagement in extreme binge drinking, defined as consuming 10 or more drinks on one occasion in the previous 2 weeks, varied from 14% in 2005 to 20% in 2014.

Another national survey assessing college student binge drinking is the Substance Abuse and Mental Health Services Administration's (SAMHSA) National Survey on Drug Use and Health (NSDUH), which includes yearly assessments of 60,000 to 70,000 individuals ages 12 and older. Results indicate that for young adults ages 18 to 25, rates of binge drinking in the previous 30 days decreased slightly from 44.6% in 1988 to 37.7% in 2014.[5]

The Core Alcohol and Drug Survey sampled more than 140,000 students and found a slight decline in the percentage of students who binge drank in the previous 2 weeks, from 45.9% in 2006 to 43.9% in 2013.[6,7] The College Alcohol Survey (CAS) also attempted to assess student drinking rates. At 120 colleges, the CAS measured alcohol use among college students at four time points between 1993 and 2001.[8] The survey included more than 14,000 students and provided the first gender-specific measure of binge drinking (i.e., 5/4+ drinks for males/females). Contrary to findings from the MTF study and the Core Alcohol and Drug Survey, the CAS found little change between 1993 (43.2%) and 2001 (44.5%) in the number of students reporting binge drinking in the previous 2 weeks.[9]

The most recently initiated nationwide survey of college student alcohol use is the National Epidemiologic Survey on Alcohol and Related Conditions. This survey began the first of three waves of data collection in 2001, which included data from approximately 43,000 individuals.[10] Prevalence rates, only reported for 2001, indicate that 57% of 18- to 24-year-olds binge drank in the previous year, and 40% binge drank 12 or more times in the previous year.

College attendance, gender, and ethnic variations in binge drinking have been identified. A number of studies have examined differences in alcohol use between college and same-age noncollege peers, consistently finding higher rates of heavy drinking and alcohol-related problems among college students than among noncollege peers.[11] The annual prevalence of alcohol use reported in the MTF study suggested small differences between male and female drinking rates and modest decreases over time.[4] However, a declining gender gap exists for binge drinking rates, with female binge drinking (i.e., 4+) decreasing from 31% in 1988 to 26% in 2014, and male binge drinking (i.e., 5+) decreasing more substantially, from 52% to 43%.

Currently, the MTF study does not report racial or ethnic differences in binge drinking among college students. However, the U.S. Centers for Disease Control and Prevention reported that more White college students engaged in binge drinking in the previous 30 days (31.6% of females and 49.4% of males) than Hispanic students (22.6% of females and 39.9% of males).[12] Also, African American students (6.1% of males) were less likely to report binge drinking than White students (22.8% of males), although this difference was less pronounced among females.

Rates of binge drinking have also been assessed in military samples. Starting in 1980, the U.S. Department of Defense issued several large-scale, anonymous health surveys (most recently called the Health Related Behaviors Survey) to active-duty military personnel, with the first assessment of binge drinking appearing in 1998. Rates of binge drinking for military personnel overall increased from 35% in 1998 to 47% in 2008.[13] The 2008 survey sampled more than 28,000 service members and found that young adult military personnel (ages 18 to 25) had the highest rates of frequent binge drinking (once a week or more) at 26%.[14] This is significantly higher than the rate for same-age civilians (16%), as reported in the 2007 NSDUH.[15] Rates of binge drinking also differ by military branch.[14]

Developmental and Social Factors

Developmental and social factors are important contributors to binge drinking among college-age adults. The college-age years (approximately ages 18 to 24) correspond with the developmental stage widely referred to as "emerging adulthood."[16,17] Dramatic cultural changes in the United States and other countries with similar socioeconomic structures have occurred over time. Arnett notes that post–high school education rose from 14% in 1940 to more than 60% in the mid-1990s.[16] College attendance has resulted in the delay of traditional adult responsibilities. Consequently, in recent decades this developmental period has become a time when individuals

explore new freedoms and experiment with behaviors that were previously less accessible, including alcohol consumption.[18,19]

In their seminal paper, "Getting Drunk and Growing Up: Trajectories of Frequent Binge Drinking During the Transition to Young Adulthood," Schulenberg and colleagues identified five distinct trajectories of binge drinking that occur in young adults ages 18 to 24.[20] This analysis was one of the first to use a national sample to identify distinct patterns of changes in binge drinking over time. The national sample included four consecutive waves of data from the MTF study. More than 90% of the sample was categorized as engaging in no binge drinking during any wave (35.9%). Or, they were categorized as one of five binge drinking trajectories:

1. Rare (16.7%): binge drinking during at least one wave but no frequent binge drinking, defined as two or more binge episodes in the past 2 weeks.
2. Decreasing (11.7%): frequent binge drinking during Wave 1 and decreasing or no frequent binge drinking by Wave 4.
3. Fling (9.9%): frequent binge drinking during Wave 2 or Wave 3 but no binge drinking in Wave 1 or Wave 4.
4. Increasing (9.5%): no frequent binge drinking during Wave 1 increasing to frequent binge drinking by Wave 4.
5. Chronic (6.7%): frequent binge drinking throughout Waves 1, 2, 3, and 4.

Most young adults reported binge drinking during at least one of the four assessment waves, but less than half of the sample drank at rates that could be considered problematic.[20] Young adults in the Increasing and Chronic categories were identified as having the most difficulty navigating the transition to adulthood. Identified trajectories were associated with stability and changes in alcohol problems, attitudes regarding heavy drinking, and heavy drinking or drug-using peers.

Interrelated factors associated with increased heavy drinking and alcohol-related problems include moving out of the parent home, going to college, and decreased parental involvement, each of which has a unique contribution. Moving out of the parent home contributed to the risk of increased drinking, but additional risk was found for students who lived on campus.[21] White and colleagues found that living in a college environment contributed to increases in heavy drinking more than all the other developmental factors they examined.[22] Further, although peer influences are paramount among college students, one study found that parental involvement played a protective role in reducing the likelihood of problem drinking.[23]

For young adults ages 18 to 24, many of the factors attributed to high rates of binge drinking are social in nature. Perceptions and overestimations of the prevalence and approval of heavy drinking among one's peers have been consistently documented and associated with heavier drinking. Reducing normative misperceptions has been the most consistently supported brief intervention strategy for reducing heavy drinking among young adults. Most studies that successfully used such interventions to reduce perceived norms also demonstrated reductions in drinking.[24-28]

The vast majority of research on the influence of social norms on heavy drinking has been done using college samples. Similar results have been found in the general adult population, with heavy drinkers more likely to view heavy drinking as normative and to overestimate drinking norms.[29] In a large general population study of adults who drank alcohol at least monthly (N = 14,009), age was negatively associated with normative misperceptions of drinking.[30] However, the magnitude of the correlation was only .07, suggesting that age is not a strong predictor of normative perceptions of drinking.

The MTF study collected data (for ages 18 to 30) on perceived close-friend disapproval of respondents' binge drinking once or twice per weekend. Respondents ages 19 to 22 and 23 to 26 reported less disapproval from their friends (54.5% and 52.3%, respectively) relative to respondents ages 18 (65.6%) and ages 27 to 30 (57.1%).[4] Few studies have directly examined perceived norms and their influence on college versus noncollege young adult binge drinking, but the available evidence suggests perceived norms have less influence on noncollege young adults.[31]

Related to social norms, membership in specific groups has been associated with higher rates of binge drinking. Foremost among these are college fraternity or sorority affiliation,[32-34] participation in collegiate athletics,[35,36] and being in the military, especially the U.S. Army or U.S. Marines.[14,37,38]

Risk and Protective Factors

Person-level risk factors. Demographic factors such as age, sex, and race have been linked to binge drinking rates among college students. Individuals who began drinking before age 16 were found to be more likely to binge drink in college.[39] An examination of MTF data found that, among recent cohorts, individuals entering the 18 to 26 age range reported less binge drinking than previous cohorts, and individuals leaving the 18 to 26 age range reported more binge drinking than previous cohorts.[40] Several longitudinal studies found that male college students were more likely than female students to binge drink.[41,42] Also, studies have shown that White college students were more likely to engage in binge drinking than non-White students.[39,43]

Personality traits and individual difference variables have also been identified as risk factors for binge drinking. A longitudinal investigation

using MTF data from 18- to 24-year-olds found that individuals lower in self-efficacy had a greater likelihood of engaging in binge drinking over time.[42] Similarly, another longitudinal study among adults ages 18 to 31 found that, across time points, problem drinkers scored higher on disinhibition.[41]

Binge drinking also has been positively correlated with neuroticism-anxiety and impulsive sensation-seeking. In particular, one study found that women who engaged in binge drinking tended to score higher on neuroticism-anxiety, and men who engaged in binge drinking were more likely to score highly on impulsivity and sensation-seeking.[44] Another study found that binge drinkers tended to be less conscientious and more thrill-seeking than those who did not engage in binge drinking.[45] Also, individuals who scored higher on measures of antisocial personality disorder were more likely to engage in binge drinking.[46]

Other studies report that motivations for drinking and attitudes toward drinking can influence the likelihood of binge drinking. Drinking to cope with negative affect and drinking to fit in with peers have both been associated with binge drinking.[45] Sex-seeking as a motivation for drinking has been associated with binge drinking among college men.[45] Individuals who reported drinking alcohol for the purpose of getting drunk were also more likely to engage in binge drinking.[42] Positive attitudes toward drinking have also been associated with an increased likelihood of binge drinking among college students.[39]

Problem behaviors and other substance use also have been associated with binge drinking. For example, one longitudinal study found that, across ages 18 to 31, heavy drinkers were more likely to exhibit problem behavior.[41] A longitudinal examination of trajectories of binge drinking found that adolescents who reported using drugs and scored low on measures of depression were more likely to engage in binge drinking at an earlier age during young adulthood.[46]

In conclusion, several consistent risk factors for binge drinking have been identified, including early onset of alcohol use, being male, identifying as White, having low self-efficacy, scoring high on disinhibition, scoring high on neuroticism-anxiety (for women), being impulsive and sensation-seeking (especially for men), having higher scores on antisocial personality disorder measures, using alcohol to cope or fit in with others, using alcohol for sex-seeking purposes, drinking to get drunk, exhibiting problem behavior, scoring low on depression, and engaging in other substance use.

Risky contexts and events. Specific events and contexts that promote heavy drinking are additional factors that contribute to high rates of binge drinking. Such events include New Year's Eve, St. Patrick's Day, and Halloween.[47,48] Some high-risk drinking events tend to be more prevalent in young adulthood. For example, homecoming, athletic events, weddings, and graduations are all relatively common events for people in this age range and have been associated with heavy drinking.[49,50] In addition, 21st birthdays,[51] spring break,[48] football tailgating,[52] pregame partying,[53-55] and drinking games[56,57] have all been associated with excessive drinking among college students. For undergraduates, weekends and the beginning of a semester have been associated with higher levels of drinking.[47,49]

Social influences, often from close relationships, can contribute to increased risk of binge drinking among college students. For example, having parents who are alcoholics, having friends who drink, and participating in Greek life have all been associated with a greater likelihood of binge drinking.[46,58-60] Also, peer drinking and use of cigarettes and marijuana have been associated with an increased likelihood of binge drinking.[61]

Person-level protective factors. Several protective factors associated with a lower likelihood of engaging in binge drinking have been identified. Gender is one of these factors. Females tend to drink less than males.[62] Also, females and individuals with higher grade point averages tend to use more protective behavioral strategies, such as alternating drinking alcohol and water.[63] Protective behavioral strategies have been shown to reduce the likelihood of experiencing negative alcohol-related consequences.[62,64]

Protective contexts and events. Certain cultural climates that promote a normative perception of disapproval toward excessive drinking can protect their adherents against binge drinking. For example, parental disapproval of alcohol use protects against binge drinking.[39,61] Many religions disapprove of drinking heavily and promote drinking only in moderation or ban drinking among members altogether. As such, religion can exert a protective influence on college student binge drinking.[61,65] Neighborhood norms against heavy drinking have also been found to protect against binge drinking.[66]

College environments tend to encourage heavy drinking; however, some contextual factors surrounding students can protect against binge drinking and negative alcohol-related consequences. Drinking in college is often a social activity among friends. Close friends who encourage safe drinking can help protect against the negative consequences of excessive drinking.[67] College drinking that occurs in locations that provide food and water or that accompanies a meal has been shown to reduce negative alcohol consequences.[68] Additionally, drinking that occurs in bars is somewhat regulated, because bartenders can stop serving individuals who appear drunk.[69] These specific college drinking contexts allow for use of protective behavioral strategies, such as eating food, drinking water, limiting the number of drinks consumed, and drinking with close friends.[62]

Other factors specific to certain colleges have been associated with lower rates of binge drinking. For instance,

college students who attended schools with higher social capital (defined as the average time students spent volunteering) were less likely to engage in binge drinking.[70] Furthermore, research has suggested that attending commuter schools, all-female colleges, and Protestant religious colleges is associated with lower rates of binge drinking.[39]

Certain social roles and their inherent responsibilities can lead to lower likelihood of binge drinking. For example, studies have found that cohabitation, getting married, and having children all protect against heavy drinking.[71-75]

Alcohol-related laws and policies and their connections to the likelihood of binge drinking have been examined. Plunk, Cavazos-Rehg, Bierut, and Grucza found that more permissive laws regarding the minimum legal drinking age were associated with more binge drinking.[76] Using MTF data collected from 1976 to 2011 from high school seniors who were followed up to age 26, Jager, Keyes, and Schulenberg found that laws dictating the minimum legal drinking age were associated with decreases in binge drinking for 18-year-olds, but those laws were associated with increases in binge drinking rates across all male participants ages 18 to 22.[40] Another study found that lower age requirements for purchasing and consuming alcohol were associated with more hazardous and problematic drinking. These findings have clear implications for alcohol policy.[76]

Another study investigated whether personal endorsement of alcohol policies was associated with college student drinking. The authors found that college students who personally endorsed the alcohol laws and policies were significantly less likely to binge drink.[77] Thus, laws that set a minimum drinking age or a low BAC level for drivers, and personal endorsements of college alcohol policies, can serve as protective contextual factors against college student binge drinking.

Consequences of Binge Drinking

Overall, binge drinking and frequent binge drinking have been consistently, significantly, and positively associated with alcohol-related problems.[78,79] These problems impact multiple aspects of life for young adults and the people around them and include physical, legal, emotional, social, and cognitive consequences, as well as an increased likelihood of having an alcohol use disorder.

Physical and legal outcomes. Binge drinking is associated with significant increased risk for experiencing consequences, including physical harm, legal problems, and failure to meet role obligations (e.g., work responsibilities). Active-duty military personnel who binge drink are about five times as likely to report drinking and driving or riding with someone who has been drinking.[38] College students who binge drank in the previous year were more than twice as likely to be taken advantage of sexually or have unplanned sex, and they were four times as likely to be physically injured.[80] Additionally, individuals who engaged in frequent binge drinking reported experiencing more sick days and having poorer overall physical and mental health than non–binge drinkers.[81] Binge drinkers also reported having greater sleep problems, including having more trouble falling asleep and staying asleep than those who did not binge drink.[82] Binge drinking also increases an individual's likelihood of driving after drinking.[80,83]

Emotional and social outcomes. Binge drinking has been associated with a variety of negative emotional and social outcomes. For example, binge drinkers tended to score higher on measures of depression and anxiety[84-86] and reported lower positive mood than nondrinkers.[86,87] Furthermore, students who binge drank in the previous year were more than twice as likely to report having serious thoughts of suicide.[80] Another study reported that feelings of remorse after drinking were more common following a binge drinking episode than a nonbinge episode.[1] Few longitudinal studies have examined associations between emotions and binge drinking; however, frequent binge drinking in young adulthood has been found to increase risk for depression 5 years later.[88]

Social outcomes related to binge drinking often involve negative interpersonal interactions and failure to meet relational obligations. When compared to infrequent and non–binge drinkers, frequent binge drinkers are twice as likely to experience interpersonal consequences, including arguing with friends,[1] experiencing strain on relationships,[89] and getting into physical fights.[38] Binge drinkers in college were two to three times as likely to miss class and twice as likely to perform poorly or get behind on schoolwork.[1,80] Among active-duty military personnel, frequent binge drinking was associated with failure to be promoted and substandard work performance.[38]

Cognitive outcomes. Binge drinking results in high concentrations of alcohol entering the bloodstream quickly, which can affect cognitive processing. One of the most prevalent cognitive effects of binge drinking is blacking out, a failure to encode memories. Frequent binge drinkers are twice as likely as infrequent binge drinkers to experience blackouts.[1] Several studies reported that the consumption of alcohol at binge levels was associated with poor performance on cognitive tasks, such as recall, spatial recognition, search, and planning tasks.[86,90-92] Also, gender differences in cognitive function have been noted, with women being more susceptible to the negative cognitive effects of binge drinking.[87,93]

Research suggests that binge drinking affects the amygdala and prefrontal cortex, and that repeated binge drinking can damage these brain structures.[94] One study reported that extreme binge drinkers (those who consumed 10 or more drinks per occasion) displayed electroencephalography

(EEG) spectral patterns similar to the patterns displayed in individuals with alcohol use disorder, suggesting that extreme binge drinking can alter the brain negatively and permanently.[95] Examination of the effects of binge drinking on cognitive structures and on performance in young adults continues to expand as more psychological research incorporates cognitive and neurological testing.

Alcohol use and abuse disorders. In addition to the negative consequences of binge drinking, frequent binge drinking is associated with increased likelihood of consuming alcohol at twice (8+/10+ drinks for women/men) or even three (12+/15+ drinks for women/men) times binge drinking levels.[96] These high-intensity levels of drinking likely intensify the risk of experiencing negative alcohol-related consequences.

Young adults who binge drink have alcohol use disorder scores that are double the scores of those who do not meet binge drinking criteria.[97] Also, binge drinkers report consuming twice the alcohol per week and spending a third more time drinking than non–binge drinkers.[97] Both occasional and frequent binge drinking are associated with a significantly greater risk of abusing alcohol and becoming dependent than non–binge drinkers or abstainers.[80,85,98] Rates of alcohol abuse and dependence in college student binge drinkers have been reported to be between 14% and 24%.[99] Furthermore, alcohol withdrawal symptoms have been reported by 15% to 29% of students.[99]

Conclusion

Research on binge drinking in college-age samples suggests that binge drinking rates have decreased over time. Despite this trend, rates still remain high, with 30% to 40% of young adults reporting binge drinking at least once in the previous month. Developmentally and socially, this age range is at higher risk for consuming alcohol at binge levels. This review summarized individual and environmental factors associated with increased or decreased risk for binge drinking. Understanding these factors is important in guiding future prevention and intervention efforts and in shaping alcohol policies. Targeting prevention and intervention efforts toward young adults during their college years may increase the effectiveness of those efforts, reducing the negative consequences of alcohol use and averting problematic trajectories.

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Adolescent Binge Drinking

Developmental Context and Opportunities for Prevention

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Binge drinking, commonly defined as consuming five or more standard drinks per occasion for men and four or more drinks for women, typically begins in adolescence. Adolescents, although they may drink less often, tend to consume higher quantities of alcohol per occasion compared with adults. This developmental difference in pattern of alcohol consumption may result, in part, from maturational changes that involve an adolescent-specific sensitivity to certain alcohol effects and greater propensity for risk-taking behaviors, such as binge drinking. Adolescent binge drinking is associated with a range of acute alcohol-related harms, some of which may persist into adulthood. The prevalence of binge drinking, including high-intensity drinking (i.e., 10 or more and 15 or more drinks per occasion), has declined among adolescents in recent years. Overall, however, the proportion of youth who engage in binge drinking remains high. This article reviews the definition and prevalence of binge drinking in adolescence, trajectories of binge drinking and their correlates, and implications for prevention.

Key words: Alcohol consumption; binge drinking; brain development; college students; high-intensity drinking; underage drinking

Compared with adults, adolescent drinkers tend to consume higher quantities of alcohol per occasion but drink less frequently.[1] Thus, underage drinkers ages 12 to 20 typically consume 4 to 5 drinks per drinking episode, which is nearly double the average of the 2 to 3 drinks usually consumed by adults (older than age 25).[1] Most of the alcohol consumption of underage drinkers occurs during "binge" episodes characterized by drinking high quantities.[2,3] This binge pattern of consumption has been linked to serious alcohol-related harm, such as alcohol poisoning, as well as to sometimes fatal injuries and accidents resulting from acute intoxication.[4] The adverse consequences of adolescent binge drinking affect not only the adolescents but also their families, peers, and community.[5]

This article reviews various definitions of binge drinking, the acute adverse consequences associated with binge drinking, the prevalence of adolescent binge drinking, and demographic factors (e.g., gender and race/ethnicity) associated with adolescent binge drinking. It then discusses the developmental context of adolescent binge drinking, including adolescent-specific sensitivity to certain alcohol effects that may contribute to episodes of high-volume alcohol consumption in adolescence. After a summary of trajectories of binge drinking in adolescence, trajectory correlates representing risk factors and young-adult outcomes, and possible neurocognitive consequences of adolescent binge drinking, the implications of research on adolescent binge drinking for prevention efforts are briefly reviewed.

Definitions of Binge Drinking for Youth

Binge drinking, or an episode of high-volume alcohol consumption, has been defined in various ways.[6,7] (For more information, see **Drinking Patterns and Their Definitions** in this issue.) According to the National Institute on Alcohol Abuse and Alcoholism (NIAAA),[8] "binge drinking" refers to alcohol consumption that brings the blood alcohol concentration (BAC) to .08 g/dL, which is commonly associated with acute impairment in motor coordination and cognitive functioning.[9] BACs of more than .08 g/dL typically occur in men after consuming five or more drinks in about 2 hours, and in women after consuming four or more drinks. This is known as the "5+/4+" binge definition. This definition is consistent with

epidemiological data indicating an association at the population level between greater frequency of 5+/4+ binge episodes and more adverse drinking-related consequences.[10]

When applied to adolescents, binge-drinking definitions based on adult levels of alcohol intake (e.g., 5+/4+ drinks per occasion) often are too high. Children and adolescents are likely to reach BACs of more than .08 g/dL at lower levels of consumption due, in part, to factors such as smaller body size. Donovan used an updated Widmark equation and population data on average body weight in boys and girls to estimate the levels of drinking that would produce BACs of more than .08 g/dL in youth ages 9 to 17.[11] For those ages 9 to 13, a binge episode was estimated to occur with intake of 3 or more drinks within a 2-hour period; for those ages 14 to 15, with 4 or more drinks for boys and 3 or more drinks for girls; and for those ages 16 to 17, with 5 or more drinks for boys and 3 or more drinks for girls. These proposed binge-drinking thresholds for youth are theoretical and based on estimated, rather than observed, BACs. Nevertheless, the identification of lower drinking-quantity thresholds to define binge drinking for younger drinkers suggests that the use of standard adult-based binge definitions may underestimate the prevalence of drinking behavior that leads to BACs of more than .08 g/dL, particularly among females and youth.

Extreme binge, or high-intensity, drinking involves the intake of dangerously high quantities of alcohol per occasion. (For more information, see **High-Intensity Drinking** in this issue.) Thresholds of 10 or more drinks (i.e., double the usual definition of binge drinking of 5 or more drinks) and 15 or more drinks per occasion (i.e., triple the usual definition of binge drinking of 5 or more drinks), as well as gender-specific cutoffs of 8 or more drinks for females and 10 or more drinks for males, respectively, have been used to define high-intensity drinking.[12-14] These definitions specify thresholds that are two to three times higher than the 5+/4+ binge definition and have been examined in part because of limitations in the reliability of the 5+/4+ binge definition for identifying drinkers with BACs of more than .08 g/dL.[15] As a point of reference, among adolescent drinkers, alcohol-related blackouts, or acute alcohol-related memory loss, may occur after consuming nine or more drinks per occasion for males and five or more drinks for females.[16]

Acute Adverse Consequences of Binge Drinking

Acute negative alcohol-related consequences generally show a dose-response relationship with binge drinking,[17] such that greater risk for many adverse consequences has been associated with higher drinking quantities and more frequent binge episodes.[18-20] A significant literature has examined the diverse acute health harms associated with binge drinking, such as alcohol poisoning, alcohol-related blackouts and injury, involvement in car crashes and fatalities, alcohol-related physical and sexual assault, increased risk for sexually transmitted infection, and problems at school or work.[4,21] Risk behaviors associated with binge drinking may include, for example, simultaneous use of other substances (e.g., marijuana) and greater likelihood of riding with an intoxicated driver.[22] Although many of the acute adverse consequences of binge drinking are not unique to adolescents, young drinkers may be at higher risk than adult drinkers for certain acute alcohol-related harms (e.g., alcohol poisoning) because of their relative inexperience with alcohol's effects. Importantly, although some adolescent heavy drinkers meet the criteria for an alcohol use disorder (2.7% of those ages 12 to 17), many more youth report binge alcohol use (6.1%)[23] and may experience acute adverse effects from binge drinking that are not covered by diagnostic criteria.

Prevalence of Adolescent Binge Drinking

Numerous studies have assessed the prevalence of adolescent binge drinking in the United States, as well as in other countries. These studies also have assessed the association between binge-drinking rates and demographic characteristics.

Trends in the Prevalence of Adolescent Binge Drinking in the United States

Three national surveys in the United States provide data on the prevalence of adolescent binge drinking, including the National Survey on Drug Use and Health (NSDUH), which until 2015 defined binge drinking as consumption of five or more drinks on the same occasion;* the Monitoring the Future (MTF) survey, which defines it as five or more drinks in a row; and the Youth Risk Behavior Survey (YRBS), which defines it as five or more drinks of alcohol in a row—that is, within a couple of hours. (For more information on these surveys, see **Surveys That Include Information Relevant to Binge Drinking** in this issue.) Thus, until 2015, these surveys all used the same threshold to define binge drinking in males and females, albeit with slightly different wording and with differences in the time frame used to assess binge drinking (i.e., within the past month for the NSDUH and YRBS, and within the past 2 weeks for the MTF). The NSDUH has collected annual data since 1991 on individuals ages 12 and older using interviews conducted in the home.[5] In contrast, both MTF and YRBS are school-based

*Since 2015, the NSDUH defines binge drinking as consumption of 4 or more drinks for women or 5 or more drinks for men on the same occasion on at least 1 day in the past 30 days.

surveys. MTF has collected annual data since 1975 from 12th graders, and since 1991 from 8th, 10th, and 12th graders.[24] YRBS has collected data biennially since 1991 from 9th to 12th graders.[25]

All three surveys show similar time trends in adolescent binge drinking.[26] The MTF data indicate a peak in the prevalence of youth binge drinking in the late 1970s to early 1980s, followed by a decrease from 41% in 1983 to 28% in 1992.[24] In the 2015 MTF survey, binge drinking in the past 2 weeks was reported by 4.6% of 8th graders, 10.9% of 10th graders, and 17.2% of 12th graders.[24] This reduction in youth binge-drinking prevalence over time may reflect factors such as enactment of a minimum legal drinking age of 21 and other alcohol regulatory policies.[4,27] Time-trend data from the YRBS (from 1999 to 2013) and NSDUH (from 2002 to 2014) indicate a similar decrease in youth binge drinking in recent years.[5,25]

The prevalence of high-intensity drinking (10 or more or 15 or more drinks in a row in the past 2 weeks) was relatively stable among high school seniors in the MTF from 2006 to 2012, but, like binge drinking, has shown a decline in recent years. Thus, the prevalence of consuming 10 or more drinks in a row declined from 10.4% in 2012 to 6.1% in 2015, and the prevalence of consuming 15 or more drinks in a row declined from 5.5% in 2012 to 3.5% in 2015.[24]

In all three national surveys, binge-drinking prevalence increases with age during adolescence. For example, in 2015, the most recent year in which all three national surveys collected data on binge drinking, NSDUH indicated that 9.6% of youth ages 12 to 17 reported alcohol use in the past month, with roughly half (i.e., 5.8%) of these drinkers reporting binge drinking in the past month.[28] Among respondents ages 12 to 17 in the 2015 NSDUH, past-month binge-drinking prevalence increased from 0.5% at ages 12 to 13 to 15.3% at age 17. In the 2015 YRBS, 17.7% of all high school students reported binge drinking in the past month, increasing from 10.4% in 9th graders to 24.6% in 12th graders.[29] According to the 2015 MTF survey, 4.6% of 8th graders, 10.9% of 10th graders, and 17.2% of 12th graders reported binge drinking in the 2 weeks prior to the survey.[24]

The results from these three national surveys are broadly consistent in a given year, although YRBS data generally indicate somewhat higher binge prevalences compared with NSDUH and MTF, and MTF tends to report higher prevalences compared with NSDUH.[26] The differences in binge-drinking prevalence across the surveys may result from methodological differences, such as sampling strategy used, survey location (e.g., school or home), type of data collection (e.g., paper survey or self-administered computer assessment), item wording, and time frames for querying binge drinking.[26] Interpretation of results from these national surveys also needs to consider that use of the "5+" binge definition in these surveys may underestimate the prevalence of binge drinking in younger adolescents and females, because, as mentioned earlier, lower drinking-quantity thresholds to define binge drinking are indicated in this age group.[11]

International Surveys of Adolescent Binge-Drinking Prevalence

International data on the prevalence of adolescent binge drinking are available from sources such as the European School Survey Project on Alcohol and Other Drugs (ESPAD) and the Australian School Students Alcohol and Drug (ASSAD) survey. In 2011, the ESPAD report on 15- to 16-year-old students in 36 European countries indicated that the average prevalence of consuming 5 or more drinks on at least 1 occasion in the past 30 days was 39% across countries.[30] However, ESPAD countries differed in the average alcohol quantity that students reported consuming on their most recent drinking day. Thus, students in Nordic countries and the British Isles generally reported consuming a higher average quantity than did students in southeastern Europe (e.g., Greece or Italy).[30] By comparison, the 2011 ASSAD survey found that among students ages 12 to 17 who reported drinking in the week prior to the survey (17.5% of all students queried), more than one-third (36.2%) drank 5 or more drinks in a day.[31]

In general, countries with lower legal drinking ages have a higher prevalence of adolescent binge drinking compared with countries with higher legal drinking ages.[32] Also, rates of adolescent binge drinking generally are higher in many European countries[4] and Australia[31] than in the United States. However, such variations in binge-drinking prevalence across studies need to be interpreted with caution because methodological differences (e.g., in sampling method, ages covered, item wording, time frames, and the definition of a standard drink) exist across surveys.

Adolescent Binge-Drinking Prevalence by Demographic Characteristics

In general, males tend to report higher rates of binge drinking in adolescence than do females (see Figure 1).[13,14,23,24] These gender differences typically increase with age during adolescence.[22,30,33] However, time-trend data from MTF have indicated a narrowing of the gender gap starting in the mid-1970s, particularly among high school seniors. Thus, in the 1975 MTF, 49% of male high school seniors, but only 26% of females, reported binge drinking, corresponding to a 23-percentage-point difference. By 2014, in contrast, a mere 5-percentage-point difference existed between male (22%) and female (17%) high school seniors who reported binge drinking.[33] Conversely, NSDUH time-trend data from 2002 to 2012 for youth ages 12 to 17 indicate that although binge drinking

decreased for both males (from 11.3% in 2002 to 7.4% in 2012) and females (from 10.2% in 2002 to 6.8% in 2012), with more males than females reporting binge drinking at both time points, there was little support for a narrowing of the gender gap over these years.[34] The time-trend results for gender differences from the MTF and NSDUH surveys are not directly comparable because of differences in the ages covered, as well as in item wording and time frames assessed (i.e., the MTF asked about 5 or more drinks in a row in the past 2 weeks, whereas the NSDUH asked about 5 or more drinks on an occasion in the past month). Nevertheless, both surveys indicate greater binge-drinking prevalence among male than among female adolescents.[22]

The prevalence of adolescent binge drinking in the United States also differs by race/ethnicity (see Figure 1). Among adolescents ages 12 to 17 in the 2014 NSDUH, the prevalence of past-month binge drinking was higher among Whites (7.1%) and Hispanics/Latinos (6.3%) compared with Blacks (3.6%) and Asians (1.5%).[23] MTF time-trend data from 1975 to 2014 suggest that these race/ethnic differences may differ by year in high school.[33] For example, among 8th-grade students, more Hispanics tended to report binge drinking compared with Whites and Blacks. Among 10th- and 12th-grade students, however, Hispanics and Whites were more likely to report binge drinking than were Blacks.

In the United States, binge-drinking prevalence also varies by region, with differences observed between and within states (see Figure 2).[33] For example, based on recent NSDUH data, past-month binge-drinking prevalence among underage drinkers ages 12 to 20 at the state level was highest in four states in the Northeast, four states in the Midwest, the District of Columbia, and one state in the West.[35] Even within a region, such as the District of Columbia, subregions differed in the prevalence of past-month binge drinking, ranging from 10.8% to 42.4% in the District of Columbia, with an overall estimate of 18.0%.[35] High-intensity or extreme binge-drinking prevalence was especially high among high school seniors in the Midwest.[13] Binge-drinking prevalence also differed by urban versus rural setting, with high school students living in rural areas tending to report the highest rates of binge drinking.[33] These regional differences suggest that factors such as local and regional norms regarding alcohol use, as well as local alcohol regulatory policies and enforcement, have an important influence on prevalence of binge drinking.

Developmental Context of Adolescent Binge Drinking

During adolescence, ongoing brain development and rapid changes in physical maturation occur in the context of a shift from parents and family to peers as a primary source of support and guidance.[36,37] These normative, adolescent-specific changes in

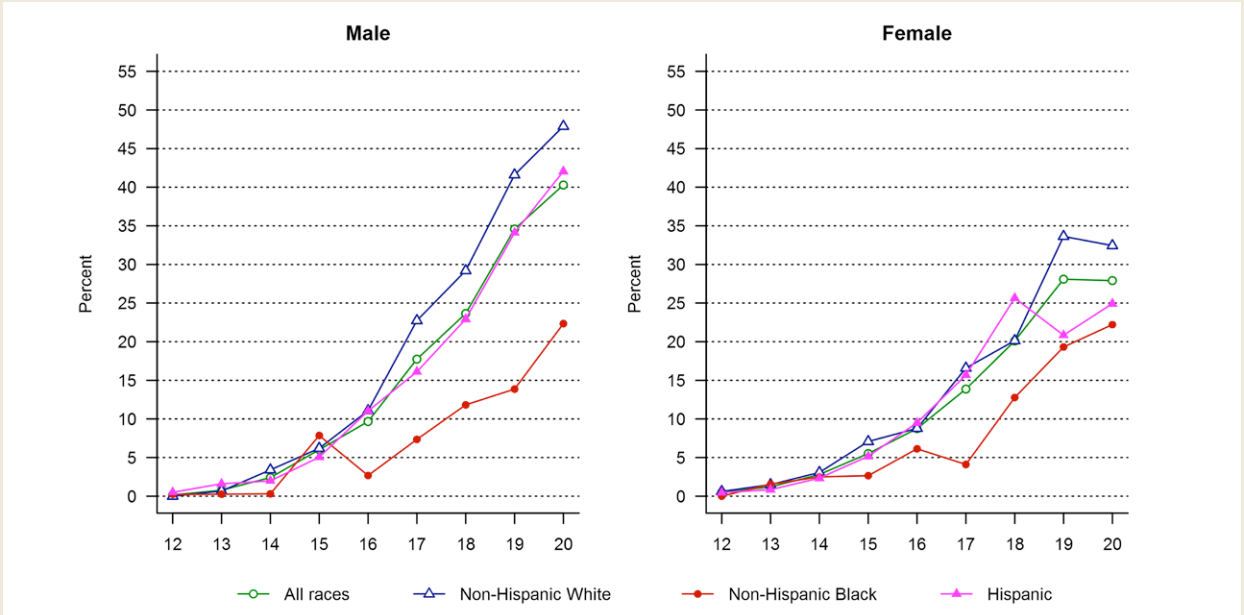

Figure 1 Prevalence of binge drinking in the past 30 days among 12- to 20-year-olds, by age, sex, and race/Hispanic origin, as reported in the 2013 NSDUH.

physical maturation and social context can contribute to the risk for binge drinking. In particular, the fine tuning of the neural circuitry that occurs during this developmental period is associated with an adolescent-specific elevation in the ability to consume alcohol, which appears to be conserved across species.[38] Animal (e.g., rodent) models indicate that neural changes occurring in adolescence may temporarily increase sensitivity to certain alcohol effects (e.g., rewarding effects) that promote consumption within a drinking episode, while reducing sensitivity to other effects (e.g., sedative effects) that may help to limit drinking during an episode.[38] Evidence for such an adolescent-specific sensitivity to alcohol effects in humans is sparse but aligns with animal models to suggest that compared with their adult counterparts, human adolescents may be more sensitive to alcohol's rewarding and stimulant effects[39] and less sensitive to its sedative effects.[40] Related research has found that, among college students, high-intensity binge drinking (i.e., 8 or more/10 or more drinks for females/males) is experienced as more rewarding than non–high-intensity drinking (i.e., less than 8/10 drinks for females/males).[41] Furthermore, many college students reported willingness to tolerate adverse alcohol effects in order to experience the positive effects associated with high-intensity drinking.[41]

The adolescent-specific shift from family to peers as important sources of influence on youth attitudes and behavior also can contribute to risk-taking behaviors, such as binge drinking.[42,43] Higher levels of sensation seeking and impulsivity, which are associated with risk-taking behaviors and binge drinking, tend to be endorsed more often by adolescent males than by females, which may help explain the generally greater prevalence of binge drinking among males.[44] Risk-taking behavior may be facilitated by the presence of peers.[43] Consistent with this observation, adolescent binge drinking tends to occur in social contexts with peers.[45,46] This may encourage episodes of high-volume consumption through mechanisms such as peers providing access to alcohol, peer norms that are favorable to binge-drinking behavior, and positive feelings generated by social activities that involve alcohol use.[37,47]

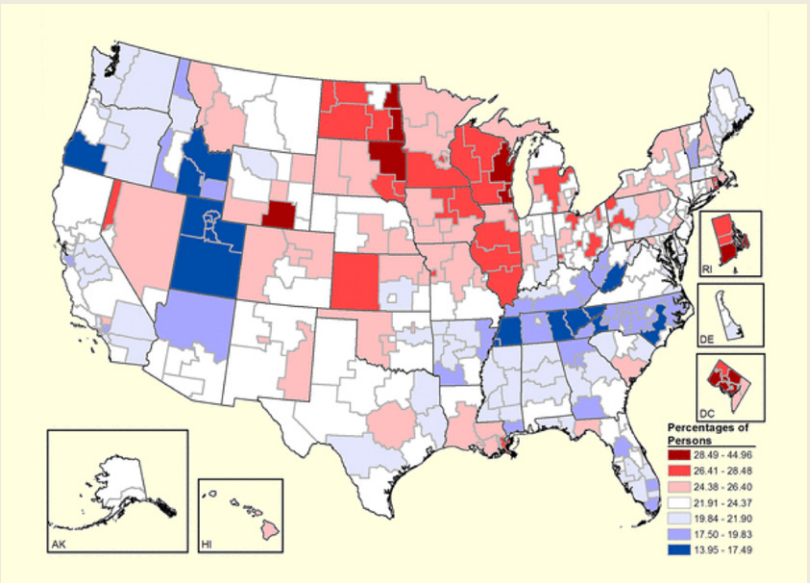

Figure 2 Binge alcohol use in the past month among individuals ages 12 to 20, by substate region in the United States. *Note:* For substate region definitions, see the 2012–2014 NSDUH, substate region definitions at www.samhsa.gov/data. *Source:* SAMHSA, Center for Behavioral Health Statistics and Quality, 2012, 2013, and 2014 NSDUH.

Binge drinking among underage drinkers in the United States often involves distilled spirits, with consumption of beer reported in less than one-third of binge episodes.[48] For some youth, consumption of liquor may reflect the intent to drink to get drunk as quickly as possible. The preferential consumption of liquor by adolescents during binge episodes is particularly concerning because it has been linked with increased risk for alcohol-related consequences, such as blackouts or injury.[49]

Young drinkers also often lack knowledge regarding standard drink servings, particularly for spirits, which can result in overpouring—that is, pouring greater volumes than used for standard drink servings.[50] Overpouring can increase the likelihood of high-volume consumption, rapid intoxication, and risk for certain alcohol-related harms, such as blackouts.[50]

Other contextual factors relevant to adolescent binge drinking include the places where drinking occurs and the temporal patterning (e.g., weekend or seasonal) of drinking. For example, certain places where adolescent binge drinking occurs, such as at someone else's home without parental supervision or at a bar or nightclub, have been associated with greater risk for alcohol-related violence.[51] With regard to temporal patterning, the timing of adolescent binge drinking shows some predictability: Binge drinking may be more likely to occur during weekends, summer and spring breaks, holidays (e.g., New Year's Eve), and occasions such as prom and sports events.[52] These contextual factors, in combination with an adolescent-specific sensitivity pattern to alcohol effects and the peer social context of drinking, may interact with individual difference

factors, such as heritable risk and exposure to trauma, in contributing to increased risk for binge drinking and related harm in adolescence.[38]

Binge-Drinking Trajectories in Adolescence

The onset of alcohol use peaks during grades 7 to 11.[24] By 8th grade, 11% of students report having been drunk (a self-report proxy for high-quantity consumption) at least once in their lifetime, with an increase to 29% among 10th graders and 47% among high school seniors.[24] Reports of the onset of consuming 3 or more drinks per occasion begin to increase between ages 13.5 and 15.5, and reports of an episode of binge drinking (5 or more drinks per occasion) start to rise around age 16.[53] Although rates of binge drinking peak between ages 18 and 25,[54] the onset of binge drinking (i.e., 3 or more or 5 or more drinks per occasion) and episodes of being drunk typically occur in early to mid-adolescence (i.e., ages 12 to 16). Early age of first intoxication (younger than 15 years old) and rapid progression from first drink to first intoxication both are early warning signs of heavy, particularly binge, drinking.[55,56]

Longitudinal studies that span adolescence through emerging adulthood (i.e., ages 12 to 25) have identified three to five prototypical trajectories of binge drinking (see Figure 3).[57-63] The trajectories derived in these studies provide useful heuristics for understanding different patterns of change in binge drinking across adolescence. They highlight heterogeneity in course, and differ with respect to age at onset of binge drinking; timing, rate, and direction of change in binge drinking (e.g., escalation and desistance); and frequency of binge drinking.

Most youth in community samples fall into the low-frequency binge-drinking and nonbinge-drinking trajectories. In some studies, nonbinge trajectories may include youth who drink but do not report binge episodes, as well as abstainers.[59,60] Trajectories indicating persistence of binge drinking from adolescence into young adulthood, which typically represent a minority of youth in community samples, tend to show onset of binge drinking in early adolescence (i.e., at ages 12 to 13) and an increase to weekly or more frequent binges by late adolescence (i.e., at ages 17 to 18).[7] Other binge-drinking trajectories are characterized by earlier (e.g., age 16 and younger) versus later (e.g., age 17 and older) onset of binge drinking or by a pattern of adolescent-limited binge drinking, in which binge drinking peaks in adolescence, then declines in early adulthood.[7] One study that followed a high-risk sample of youth into young adulthood identified four types of binge-drinking† trajectories, including nonbinger (39.5%), infrequent (9.6%), late-onset moderate (30.0%), and early-onset heavy drinking (20.9%).[57] Studies vary in the relative proportions of youth in each trajectory type because of methodological factors, such as differences in sampling (e.g., community vs. high-risk sample), age range, binge-drinking definition, and whether nonbinge trajectories include both abstainers and drinkers who do not report binge episodes.

Correlates of Adolescent Binge-Drinking Trajectories: Risk Factors and Young-Adult Outcomes

Distinct trajectories of binge drinking are thought to reflect different etiologic mechanisms.[64] According to an ecological systems model,[36,65] these etiologic mechanisms represent multiple systems (e.g., family, peer group, and community) that interact across development to influence binge-drinking trajectories.

Developmental factors associated with an increase in binge drinking during adolescence include, for example, reduced parental monitoring as youth mature[37,66] and greater independence (e.g., obtaining a driver's license) in daily activities.[36] In addition, for some youth, onset of binge drinking may be associated with important school transitions (e.g., junior high to high school or high school to college), which can involve restructuring of peer groups and increased opportunities to engage in alcohol use.[36] Importantly, processes of peer selection and peer influence have been associated with changes in binge drinking in adolescence.[67-69] In particular, selection of peers who engage in binge drinking has been associated with an adolescent's initiation and frequency of binge drinking.[69]

Several studies analyzed factors associated with binge trajectories, relative to nonbinge trajectories, at the individual level. Nonbinge trajectories in these studies included youth who abstained and youth who reported alcohol use below a given binge threshold. Risk factors identified in these studies included, for example, engaging in delinquent behavior, exposure to more stressful life events, and lower task persistence.[61-63] Some of these risk factors may be associated with gender; for example, females may be more likely to experience certain stressful life events (e.g., sexual trauma), whereas males may be more likely to be involved in delinquent behavior or to show lower levels of impulse control.[44,70] Moreover, in contrast to youth in binge-drinking trajectories, youth in nonbinge trajectories were more likely to report greater self-efficacy to resist social pressure to engage in substance use,[62] as well as greater religiosity.[63]

With regard to the social context in which youth are nested, parental alcoholism and disrupted family relations (e.g., parental separation or divorce) each were associated with binge-drink-

†The study defined binge drinking as "5+ drinks in a row."

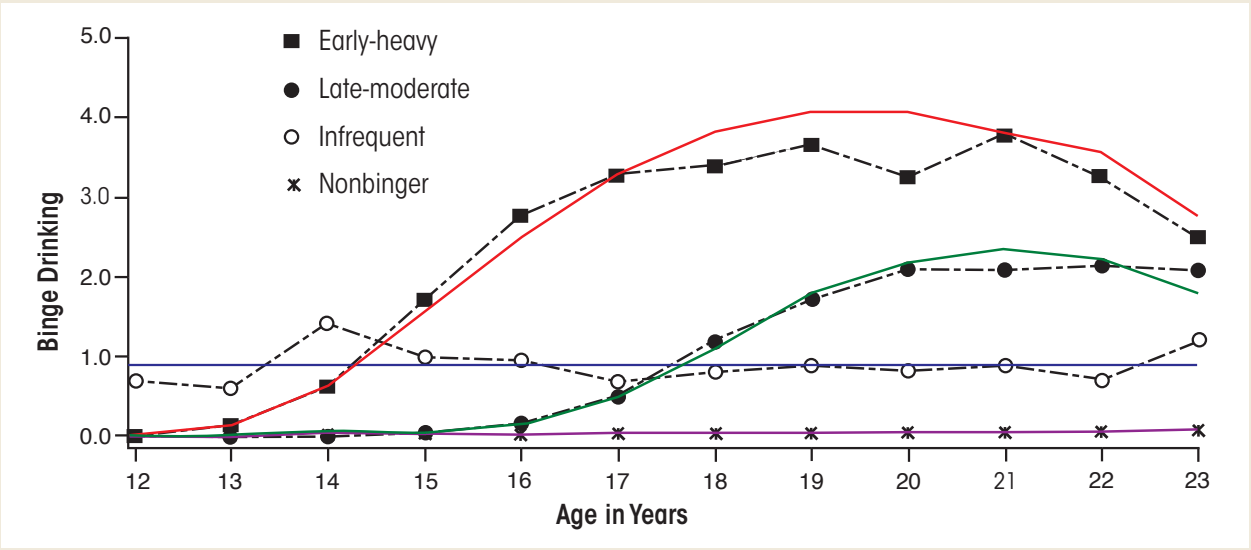

Figure 3 Trajectories of binge drinking from adolescence through emerging adulthood. Estimated growth trajectories for the three groups are indicated by solid lines. Dashed black lines represent observed means of binge drinking at each age for each group. Observed frequencies of binge drinking (past year) ranged from 0 (none) to 5 (one to two times a week). *Note:* Early-heavy group, $n = 99$, 20.9% of the sample. Late-moderate group, $n = 134$, 30.0% of the sample. Infrequent group, $n = 43$, 9.6% of the sample. Nonbinger group, $n = 176$, 39.5% of the sample. *Source:* Chassin L, Pitts SC, Prost J. Binge drinking trajectories from adolescence to emerging adulthood in a high-risk sample: Predictors and substance abuse outcomes. *J Consult Clin Psychol.* 2002;70(1):67-78. Copyright © 2002 by the American Psychological Association. Reprinted with permission.

ing trajectories.[57,62] Conversely, an adolescent's perception of high parental disapproval of substance use was prospectively associated with a nonbinge trajectory.[60] Peer relations also had an impact, because changes in binge drinking tended to occur in parallel with changes in affiliation with drinking peers.[60] However, despite the robust influence of peers on drinking behavior, an adolescent's report of high parental disapproval of substance use weakened the effect of peers on binge drinking,[60,69] indicating the important role that parents play in providing clear messages to their children regarding disapproval of underage drinking. It is important to note, however, that many individual and social risk factors associated with adolescent alcohol and other substance use have a more general influence and are not necessarily specific to binge drinking.

Community-level influences on adolescent binge-drinking trajectories include factors such as neighborhood and school environments, as well as local alcohol regulatory policies and enforcement. For example, one study found that youth living in neighborhoods with higher densities of on-premise alcohol outlets (e.g., bars and nightclubs) were more likely to report binge drinking, controlling for neighborhood-level socioeconomic status.[71] However, neighborhood risks may be buffered by protective factors. In particular, a recent study found that a supportive school environment (e.g., alcohol prevention incorporated into the curriculum) was associated with reduced adolescent binge drinking over and above individual, family, and peer risk factors.[72] Further, comprehensive and stringent local alcohol control policies and enforcement have been associated with lower levels of youth binge drinking, highlighting the importance of these community-level factors.[73] The unique and cumulative effects of family, peer, and community influences on youth binge drinking emphasize the need for coordinated, developmentally tailored prevention programs that address each of these multiple interacting social systems to reduce risk.

Compared with nonbinge trajectories, binge-drinking trajectories in adolescence, particularly frequent and chronic binge drinking, have been associated with poorer functioning in young adulthood. For example, youth in binge trajectories were more likely to have an alcohol or other drug use disorder in young adulthood than those in nonbinge trajectories (which may include abstainers and youth who drink, but do not report binge episodes, depending on the study).[57,62,74,75] In contrast, youth in nonbinge trajectories had better young-adult outcomes across domains such as educational attainment and employment, family and peer relations, and mental and physical health than did those in

binge trajectories, particularly those who engaged in frequent, chronic binge drinking.[57,59,62,76]

Other analyses have compared different binge-drinking trajectories (e.g., chronic vs. adolescent-limited). Such studies found that compared with adolescent-limited trajectories, chronic binge-drinking trajectories exhibited stronger associations with other substance use[75] and with stressful life events.[63] Further, compared with alcohol use that did not meet definitions of binge drinking (i.e., less than five drinks per occasion), adolescent binge drinking (five or more drinks per occasion) was associated with adverse outcomes, such as lower academic performance, greater likelihood of reporting drunk driving in the past month, and other substance use.[58] In sum, a pattern of relatively frequent and chronic binge drinking during adolescence, compared to nonbinge trajectories, was associated with worse young-adult outcomes across multiple domains, including risk for substance use disorder.

Neurocognitive Consequences of Adolescent Binge Drinking

In the context of the ongoing brain maturation that occurs in adolescence and young adulthood,[77,78] binge drinking could result in potentially long-lasting neural alterations. For example, in rodent models, a binge pattern of alcohol exposure in adolescence has been associated with disrupted hippocampal functioning.[79] Further, animal models indicate that binge alcohol exposure during adolescence can have downstream effects on cognition and behavior through epigenetic mechanisms.[80,81] The specific effects of binge drinking during adolescence on the brain and neurocognition may depend on the timing, dose, and chronicity of alcohol exposure.[38,82]

Similar to animal research, in studies of human adolescents, heavy drinking has been associated with deficits in neuropsychological functioning[83,84] and aberrations in brain structure and functioning.[85-88] Some research suggests possible gender-specific adverse consequences of binge alcohol consumption on neurocognition.[89] However, other research has found no difference between adolescent heavy drinkers (defined as 5+/6+ glasses, 10 g alcohol per glass, per occasion for females/males at least weekly) and light/nondrinkers in the maturation of basic executive functions (e.g., working memory).[90] Overall, binge drinking in human adolescents may have relatively subtle effects on neuropsychological measures at the level of behavioral performance; given relatively short drinking histories among youth, differences between young binge drinkers and their healthy counterparts more readily are observed at the level of brain structure and functioning.[86] Importantly, research suggests that after controlling for overall quantity of alcohol consumed, a binge pattern (i.e., consuming five or more drinks per occasion vs. consuming fewer than five drinks per occasion), in particular, was associated with adverse effects on brain functioning in young adults.[91]

Because most of the existing studies on binge drinking and neurocognition in human adolescents have been cross-sectional, the extent to which the findings reflect preexisting characteristics or persistent (vs. possibly transient) consequences of heavy or binge alcohol use are unclear. However, emerging research suggests that aberrations in the brain circuitry underlying decision-making may not only signal risk for binge drinking in adolescence prior to heavy drinking[92] but also may be adversely affected by binge drinking in adolescence and young adulthood.[93] The reversibility of the effects of adolescent binge drinking on brain structure and functioning with sustained abstinence warrants study, particularly because brain maturation continues into young adulthood.[78] Large ongoing multisite studies, such as the National Consortium on Alcohol and Neurodevelopment in Adolescence,[94] the IMAGEN study in Europe,[95] and the Adolescent Brain and Cognitive Development Study (https://abcdstudy.org), which are examining the effects of alcohol and other substance use on the developing brain in adolescence, are poised to address these gaps in knowledge.

Implications for Prevention and Intervention

To reduce binge drinking, coordinated prevention and intervention efforts that operate across multiple levels (e.g., individual, family, community, and national policy), as well as continue across the life span, are needed.[1,21] Such prevention efforts should be timed to begin by late childhood and should be tailored to address risks most salient to specific developmental periods and individual circumstances. For example, gender differences in risk factors for underage drinking[44,70] suggest the potential utility of gender-specific interventions. Increasingly, developmental neuroscience provides the basis for novel prevention and intervention approaches that strengthen the social-emotional and decision-making skills needed to refrain from binge drinking, such as emotion regulation or resisting peer pressure to engage in risky behavior.[95,96] Additional interventions for youth are needed that address alcohol's strongly perceived positive effects. One approach may be to support alternative socially based rewarding and healthy activities, because experiencing adverse alcohol-related consequences may not reduce binge drinking in young populations.[12]

Ideally, prevention should include routine alcohol screening and brief intervention for all youth, as well as supportive guidance for parents and caregivers.[97,98] Community-based prevention and intervention programs have shown effects in reducing underage drinking.[99] School-based programs[100] and easy access to a continuum of services[4] are other examples

of community-level supports for youth and families. At the level of public policy, strong alcohol policy environments[101] and enhanced enforcement of local alcohol regulatory policies,[102] such as the minimum legal drinking age and social-hosting laws, have deterred underage drinking.[4]

Conclusions

Adolescence is a critical period of risk for binge drinking. An adolescent-specific sensitivity to alcohol's effects may interact with a normative propensity for greater risk-taking behavior and peer social environment in contributing to risk for binge drinking during this developmental period. Although there is debate regarding the definition of a binge-drinking episode, a dose-response relationship between episodic high-quantity alcohol consumption and increased risk for adverse consequences generally has been observed.[18-20] Binge drinking in adolescence has been associated with multiple acute harms to health,[4] including possible effects of heavy drinking on neuropsychological functioning[83,84,87] and potential longer term adverse young-adult outcomes.[57] Of particular concern is emerging research with young adults, which suggests that certain negative consequences of alcohol use on neurocognition may be specific to a binge pattern of alcohol consumption.[91] Although the prevalence of adolescent binge drinking has declined since the 1970s, rates are still high. Moreover, binge-drinking prevalence likely is underestimated by surveys that use a binge definition of five or more drinks per occasion, because lower drinking-quantity thresholds to define binge drinking may be indicated, particularly for youth. Strategically coordinated prevention programs that operate across the life span and at multiple levels, ranging from individuals and families to public policy, are essential to reducing adolescent binge drinking.

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Alcohol and Puberty

Mechanisms of Delayed Development

William L. Dees, Ph.D.; Jill K. Hiney, Ph.D.; and Vinod K. Srivastava, Ph.D.

Adolescence represents a vulnerable period for developing youth. Alcohol use and misuse are especially problematic behaviors during this time. Adolescents are more sensitive to alcohol and less tolerant of its detrimental effects than are adults. Research in humans and animals has revealed that early alcohol consumption can result in delayed pubertal development. Animal studies have shown that alcohol detrimentally affects neuroendocrine systems within the hypothalamic region of the brain that are associated with the normal, timely onset of the pubertal process. To effectively restore development and shorten recovery time associated with the adverse effects of alcohol on puberty, researchers must first understand the molecular and physiological mechanisms by which alcohol interferes with critical hypothalamic functions.

Key words: Alcohol consumption; alcohol use and misuse; adverse effects; adolescence; puberty; development; brain; hypothalamus; hypothalamic function; neuroendocrine system

Despite efforts to prevent underage alcohol use, drinking does occur as early as the 6th grade. According to a recent national survey, 9.7 percent of 8th graders and 21.5 percent of 10th graders reported using alcohol at least once in the previous 30 days (Johnston et al. 2016). This is important because people who begin drinking between ages 11 and 14 are at increased risk for developing alcohol use disorder (DeWit et al. 2000), compared with those who begin drinking at later ages. These high-risk age groups also are exactly within the pubertal time frame. Some of the younger adolescents may not have begun the pubertal process. Others, however, are subject to the process being slowed or halted by alcohol, thus impeding further development. Following a brief summary of alcohol's effects on puberty in humans, this review describes the neuroendocrine processes that control puberty and research using animal models to assess the effects of prepubertal alcohol exposure.

Early research demonstrated that alcohol use by adolescent boys causes suppressed serum levels of growth hormone (GH), luteinizing hormone (LH), and testosterone (Diamond et al. 1986; Frias et al. 2000*a*,*b*), as well as lower bone density (Fehily et al. 1992; Neville et al. 2002). In adolescent girls, alcohol use caused suppressed serum GH and estradiol (E_2) levels (Block et al. 1993; Frias et al. 2000*b*). Other studies found evidence for disruptions in stature, weight distribution, and a risk for nutritional deficiencies (Block et al. 1991; Yamamoto et al. 1991). More recently, studies in girls have shown that prepubertal alcohol use was associated with delayed breast development (Peck et al. 2011) and onset of menarche (Richards et al. 2011). This research suggested that prepubertal girls who use alcohol have four times the chance of delayed onset of puberty than those who do not (Peck et al. 2011). This finding is confirmed in animal models, which show that alcohol acts within the hypothalamic region of the brain to suppress key puberty-related genes and hormones responsible for the normal timing of development.

Basic Neuroendocrine Control of Puberty

The onset of puberty results from a complex series of interactions between nerve cells (i.e., neurons) and glial cells (i.e., nonneuronal brain cells) within the hypothalamus that are governed by metabolic signals, as well as genetic and environmental influences. Although age at puberty varies widely between and among mammalian species, the main event that signals puberty onset is basically similar, in that it relies on the increased pulsatile secretory activity of a hypothalamic neuropeptide, luteinizing hormone–releasing hormone (LHRH). This event occurs through the enhanced developmental responsiveness of the LHRH-producing neurons and their nerve terminals to excitatory inputs, such as insulin-like growth factor-1 (IGF-1) (Hiney et al. 1996; Wilson 1998) and the kisspeptins (Kp), a family of neuropeptide products of the *KiSS-1* gene (Navarro et al. 2004; Shahab et al. 2005), as well as leptin (Dearth et al. 2000; Lebrethon et al. 2000), transforming growth factor α (Ojeda et al. 1990), and excitatory amino acids (Claypool et al. 2000; Gay and Plant 1987; Urbanski and Ojeda 1990).

In addition to the development of excitatory inputs, the timing of puberty is influenced by a concomitant and gradual removal of prepubertal inhibitory inputs, such as γ aminobutyric acid (GABA) and the opioid peptides β endorphin and dynorphin (Lehman et al. 2010; Navarro et al. 2009; Srivastava et al. 2015; Terasawa and Fernandez 2001).

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This alteration, often referred to as a "brake" on the pubertal process, is responsible for keeping prepubertal LHRH secretion low. As LHRH secretion increases, it drives the timing of puberty in both sexes by stimulating pituitary gonadotropin secretions, which in turn stimulate gonadal steroid synthesis and secretions for further maturation of the hypothalamus and reproductive organs. Although all of the excitatory and inhibitory influences noted above have been shown to be involved in the pubertal process, the mechanism-of-action portion of this review will concentrate on the most current findings about some of these modulators in relation to their upstream and downstream influences on the pubertal process.

Overall Effects of Alcohol on Puberty-Related Hormones and Indices of Pubertal Development

Initial studies using both female and male rodents revealed that chronic alcohol administration caused delayed puberty (Anderson et al. 1987; Bo et al. 1982; Ramaley 1982). Over the years, researchers have attempted to correlate the timing of puberty with specific puberty-related hormones following chronic prepubertal alcohol exposure. In female rats, alcohol caused delayed vaginal opening and the age at first estrus (Dees and Skelley 1990; Emanuele et al. 2002), as well as suppressed serum levels of GH and LH but not follicle-stimulating hormone (FSH) (Dees and Skelley 1990). In this regard, the differential effects of alcohol on LH and FSH were not surprising, because this previously had been shown in adult rats (Dees and Kozlowski 1984). Significantly, several studies have shown that prepubertal alcohol exposure in females caused suppressed circulating levels of E_2 (Bo et al. 1982; Dees and Skelley 1990; Emanuele et al. 2002), a clear indication of impaired ovarian development and activity. Although less is known about the prepubertal effects of alcohol in males, it has been shown to cause an early suppression in serum LH (Cicero et al. 1990) and to reduce the serum levels of GH and testosterone. Prepubertal alcohol use also can lead to lower testicular weight and smaller secondary sex organs (Anderson et al. 1987; Cicero et al. 1990; Emanuele et al. 1999; Tentler et al. 1997).

Additional research conducted in an animal model that more closely resembled humans, female rhesus monkeys, found that chronically administered alcohol resulted in suppressed GH, LH, and E_2 (Dees et al. 2000), exactly as described above in immature female rats. Furthermore, these actions were associated with the altered development of a regular monthly pattern of menstruation (Dees et al. 2000).

In addition to the effects of alcohol on GH and LH, research has shown that prepubertal alcohol administration caused suppressed serum IGF-1 in immature female rats (Emanuele et al. 2002; Srivastava et al. 1995) and rhesus monkeys (Dees et al. 2000), thereby reducing the amount of peptide available to the prepubertal hypothalamus. This is relevant because IGF-1 normally can act centrally to influence both the hypothalamic–pituitary–gonadal axis and the hypothalamic–pituitary GH axis at puberty. Specifically, IGF-1 has been shown to act at the hypothalamic level to stimulate LHRH/LH secretion (Hiney et al. 1991, 1996) and advance the time of puberty in female rodents (Danilovich et al. 1999; Hiney et al. 1996). The ability of IGF-1 to regulate GH through its actions on hypothalamic growth hormone–releasing hormone and somatostatin (i.e., somatotropin release–inhibiting factor), the latter being a GH-release inhibitor, have been well documented (for review, see Bercu 1996).

It is important to note that the central control of these two hypothalamic systems is complex and interrelated, especially regarding the important integrative and bidirectional influences of IGF-1 on their respective neuro-secretions. Although a detailed discussion of these basic interrelationships is beyond the scope of this review, it also is worth noting that alcohol can affect both of these systems at multiple levels. For example, in addition to the aforementioned alcohol-related suppression of LHRH/LH resulting in suppressed serum E_2, alcohol also causes altered hypothalamic growth hormone–releasing hormone synthesis and secretion (Dees et al. 1990). This then results in decreased pulsatile GH release (Dees et al. 1988), which in turn downregulates IGF-1 synthesis by liver hepatocytes (Srivastava et al. 2002). The resulting alcohol-induced suppression in circulating IGF-1 (Srivastava et al. 1995) causes suppressed body growth and interferes with the maturation and function of several organ systems. Furthermore, the accompanying reduction in circulating IGF-1 to feedback on the hypothalamus further reduces the secretion of LH and GH (for review, see Dees et al. 2009).

All of the above hormones are critical for puberty. However, alcohol's suppression of the pituitary secretion of LH has become a primary focus of research on pubertal onset, because this gonadotropin is regulated by LHRH, the hypothalamic peptide responsible for beginning the pubertal process. Researchers now are examining whether the alcohol-induced effect to suppress LH is a result of a hypothalamic or pituitary site of action.

The Hypothalamic Site of Alcohol's Actions

Studies in female rats, which showed increased hypothalamic LHRH content after chronic prepubertal alcohol administration (Dees et al. 1990), offered the first indirect evidence that alcohol affects this part of the brain. Subsequently, alcohol was shown to block the stimulatory effects of norepinephrine (Hiney and Dees 1991), IGF-1 (Hiney et al. 1998), leptin (Hiney et al. 1999), and *N*-methyl-DL-aspartic acid (NMA) (Nyberg et al. 1993) on the in vitro release of prepubertal LHRH. Although important, these collective observations did not rule out the possibility that alcohol also may act at the level of the pituitary.

To definitively assess the site of alcohol action, prepubertal rhesus monkeys that had been chronically exposed to alcohol were subjected to hypothalamic and

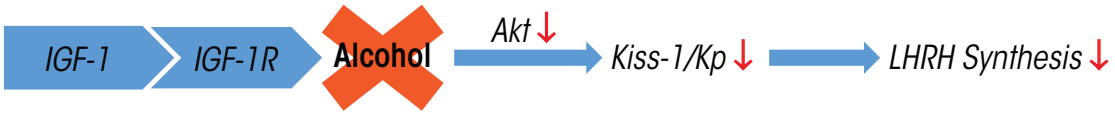

Figure 1 Alcohol blocks the ability of insulin-like growth factor-1 (IGF-1) to induce the *KiSS-1* gene and therefore suppresses production of kisspeptins (Kp), a family of neuropeptide products of *KiSS-1*, by inhibiting IGF-1 receptor (IGF-1R)-induced phosphorylation of Akt, a transduction signal that mediates the actions of IGF-1. Suppressed Kp production subsequently results in reduced synthesis of luteinizing hormone–releasing hormone (LHRH).

SOURCE: Hiney et al. 2010.

pituitary response tests (Dissen et al. 2004). The hypothalamic stimulation test showed that the NMA-induced LH secretion observed in the non–alcohol-treated monkeys was blocked in the alcohol-treated monkeys. This is significant, because NMA causes LH release by first stimulating hypothalamic LHRH secretion and does not act at the pituitary level. Three weeks later, these same animals were given LHRH to test pituitary responsiveness. Results indicated that the LH response to the peptide was the same in both non–alcohol-treated and alcohol-treated monkeys, conclusively demonstrating the hypothalamic site of action.

Mechanisms of Action

Upstream Effects of Alcohol on LHRH Synthesis

The majority of LHRH-synthesizing neurons are localized within the brain preoptic area and the region just posterior to it referred to as the anterior hypothalamic area. This latter area also contains the anteroventral periventricular (AVPV) nucleus. Neurons in the AVPV nucleus produce kisspeptins, which regulate prepubertal LHRH synthesis and are critical for the onset of puberty (de Roux et al. 2003; Keen et al. 2008; Navarro et al. 2004; Shahab et al. 2005). Thus, research focused on discerning which factors affect prepubertal *KiSS-1* expression. Chronic prepubertal alcohol exposure was shown to cause suppressed *KiSS-1* gene expression in the AVPV nucleus of female rats, an action associated with a decrease in the usual level of phosphorylated Akt (Srivastava et al. 2009). Akt is a transduction signal that mediates the actions of IGF-1 (Cardona-Gomez et al. 2002), a peptide known to activate puberty in rats and rhesus monkeys (Hiney et al. 1996; Wilson 1998). Understanding IGF-1's ability to regulate *KiSS-1* was essential to further research. In studies with rats, an injection of IGF-1 directly into the brain's third ventricle caused the upregulation of prepubertal *KiSS-1* gene expression in the AVPV nucleus 6 hours later (Hiney et al. 2009). Subsequently, alcohol was shown to block the IGF-1 induction of *KiSS-1* in the AVPV nucleus by inhibiting IGF-1 receptor (IGF-1R)-induced phosphorylation of Akt (Hiney et al. 2010). Figure 1 depicts this alcohol action, which leads to suppressed Kp and, subsequently, suppression of LHRH synthesis.

Further investigation will determine whether the suppressed Akt activity occurred directly at the level of Kp-containing neurons or through an interneuron or glial cell that also expresses the IGF-1R. However, the fact that alcohol can interfere with this pathway to LHRH synthesis is important, because once the onset of puberty begins, the synthesis of this peptide must keep pace with its release to drive the pubertal process.

Downstream Effects of Alcohol on LHRH Release

Alcohol is known to alter several downstream signals in the hypothalamus that collectively reduce LHRH release at puberty. Although the numerous excitatory substances mentioned above influence LHRH at puberty, the role of *KiSS-1* and Kp also are noteworthy. *KiSS-1* expression increases in the hypothalamus as puberty approaches (Navarro et al. 2004), and Kp is a potent stimulator of prepubertal LHRH secretion (Keen et al. 2008; Navarro et al. 2004). By suppressing prepubertal *KiSS-1*/Kp (Srivastava et al. 2009), alcohol contributes to decreased LHRH secretion at a time when increases are needed as puberty approaches. In addition, alcohol has been shown to stimulate the release of GABA and the opioid peptides (Lomniczi et al. 2000), which, as stated above, are known inhibitors of LHRH release. Alcohol also can activate the hypothalamic–pituitary–adrenal axis (Rivier 1996), and the hormones involved in the stimulation of this stress axis can suppress LH secretion (Kinsey-Jones et al. 2009; Li et al. 2015). Furthermore, the newly described gene *Lin28b* also is associated with the brake on puberty, and its expression has been shown to gradually decrease as puberty approaches (Sangiao-Alvarellos et al. 2013).

Recent research assessed whether alcohol would alter the normal pubertal rise in Kp and decrease in Lin28b protein. Chronic alcohol exposure reversed these actions within the brain region known as the medial basal hypothalamus

(MBH) in prepubertal female rats by suppressing Akt, *KiSS-1*, and Kp (Srivastava et al. 2009, 2015), while stimulating the synthesis of Lin28b (Srivastava et al. 2015). In addition, research showed that Lin28b induced dynorphin (DYN) synthesis and that alcohol stimulated DYN release (Srivastava et al. 2015). DYN inhibits Kp and LHRH secretion (Lehman et al. 2010; Navarro et al. 2009). Because the MBH contains neurons that coexpress Kp and DYN, these observations are relevant to the control of prepubertal LHRH secretion. Figure 2 illustrates the simultaneous and differential effects of alcohol on the excitatory Kp and inhibitory Lin28b pathways. Although LHRH neurons are not localized within the MBH of the rat, they are in primates, including humans. Therefore, both the release and synthesis of LHRH in the MBH of primates may be affected by alcohol.

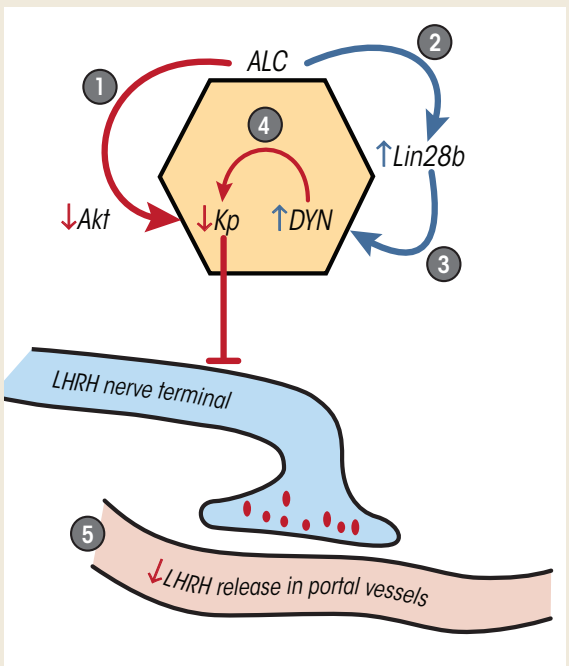

Figure 2 Schematic showing the effects of alcohol (ALC) on critical pathways within the hypothalamus that contribute to the control of luteinizing hormone–releasing hormone (LHRH) secretion. **(1)** Alcohol inhibits Akt, a transduction signal that mediates the actions of insulin-like growth factor-1 (IGF-1). This results in suppressed synthesis of kisspeptins (Kp), peptides that stimulate LHRH secretion. **(2)** Alcohol prevents the normal pubertal decline in the expression of Lin28b, a gene associated with the brake on puberty, by stimulating its synthesis. **(3)** Lin28b then stimulates synthesis of dynorphin (DYN), a peptide that inhibits Kp. **(4)** Alcohol stimulates the release of inhibitory DYN to suppress Kp. **(5)** The suppressed Kp ultimately results in decreased LHRH release. Red indicates suppression/inhibition; Blue indicates stimulation. For clarity, other factors contributing to LHRH release are not shown.

In addition to alcohol's actions on neuronal inputs controlling prepubertal LHRH secretion discussed above, alcohol may affect neuronal-to-glial and glial-to-glial inputs facilitating LHRH release within the MBH. LHRH secretory activity can be modulated by a specific neuronal-glial gene family that synthesizes signaling proteins involved in bidirectional communications at puberty (Ojeda et al. 2010). Chronic prepubertal alcohol exposure decreases the synthesis of glial protein tyrosine phosphatase-β, which is required for binding to the neuronal components contactin and contactin-associated protein-1. This finding demonstrates that alcohol can alter these interactions and interfere with glial–neuronal communications (Srivastava et al. 2011*a*).

Glial-to-glial interactions also are affected by alcohol. Once released, glial-derived epidermal growth factor and transforming growth factor α (TGFα) both bind to the erbB1 receptor on adjacent glial cells and stimulate the release of prostaglandin E_2 (PGE_2) (Ma et al. 1997), a well-known stimulator of LHRH secretion. Alcohol exposure initially was shown to inhibit PGE_2 release induced by epidermal growth factor/TGFα (Hiney et al. 2003). In addition, glial-derived IGF-1 binds to IGF-1R on adjacent glial cells, which produce TGFα, and alcohol exposure altered the synthesis and release of TGFα (Srivastava et al. 2011*b*) and PGE_2 (Hiney et al. 1998; Srivastava et al. 2011*b*), thereby resulting in decreased prepubertal LHRH secretion. Furthermore, specialized glial cells within the MBH known as tanycytes release glial-derived TGFβ1, causing retraction of their processes and allowing for better entry of LHRH into the system of blood vessels that connect the hypothalamus with the pituitary (i.e., hypophyseal portal system) (Prevot et al. 2003). Alcohol blocks IGF-1 from stimulating the synthesis and release of TGFβ1 by altering the IGF-1R synthesis and Akt phosphorylation, therefore further contributing to diminished LHRH secretion (Hiney et al. 2014).

Conclusion

Alcohol use and misuse by adolescents increases the risk for altered neuro-endocrine function, potentially modifying the timing of pubertal development. This review highlights results of research with animal models showing the site and mechanisms by which alcohol causes puberty-related problems. These studies demonstrate that alcohol acts within the hypothalamus to alter the expression and function of excitatory and inhibitory puberty-related genes and neuro-hormones, which are critical for the timely increase in LHRH secretion and the onset of puberty. More research in this field is needed and would no doubt promote a better understanding of normal mechanisms controlling events leading to increased LHRH release at puberty, as well as the cause-and-effect relationships by which alcohol can differentially affect them.

Advancing knowledge in this area will allow researchers to begin to identify potential treatment substances that may lessen the impact and shorten the recovery time of adolescents who show signs of delayed development associated with alcohol use and misuse. It also is significant that delayed puberty is known to be associated with altered gonadal steroid production, which is needed for the development and function of several body systems. Furthermore, delayed pubertal development correlates with other health concerns such as altered bone density or height and weight issues, as well as psychological problems. Thus, the neuroendocrine consequences of alcohol use can result in far-reaching adolescent health concerns.

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Drinking Over the Lifespan

Focus on College Ages

Jennifer E. Merrill, Ph.D., and Kate B. Carey, Ph.D.

Many college students drink heavily and experience myriad associated negative consequences. This review suggests that a developmental perspective can facilitate a better understanding of college drinking. Specifically, using an emerging adulthood framework that considers the ongoing role of parents and neurodevelopmental processes can provide insight into why students drink. Most college students drink and tend to drink more and more heavily than their non–college-attending peers. These drinking patterns are affected by environmental and temporal characteristics specific to the college environment, including residential campus living, the academic week, and the academic year. Additional psychosocial factors are of particular relevance to the drinking behavior of college-age people, and include exaggerated peer norms, the development and use of protective behavioral strategies, and mental health considerations. Understanding the unique interaction of person and environment is key to designing prevention/intervention efforts.

Key words: Alcohol use, abuse, and dependence; alcohol use consequences; college drinking; heavy drinking; drinking patterns; college student; young adult; neurodevelopment; risk factors; protective factors; environmental factors; psychosocial factors; peer norms; parental support; college environment; prevention; intervention

Approximately 41 percent of 18- to 24-year-olds are enrolled in a postsecondary degree-granting institution (National Center for Education Statistics 2013). As a group, college students, and particularly those at residential colleges (Presley et al. 2002), often drink heavily and experience myriad associated negative consequences. This selective review discusses the special characteristics of the college age and environment that put students at risk for hazardous drinking and problems with alcohol. The following sections describe the developmental context in which such drinking behavior occurs and then briefly characterize the risky drinking behavior of college students and the temporal and environmental risk factors associated with college attendance. The article then reviews psychosocial predictors of risky drinking that are relevant to this age group and concludes with intervention implications.

Developmental Considerations

The developmental context in which drinking behavior occurs in college-aged men and women is unique, and developmental considerations can inform both basic and intervention research with this population.

Emerging Adulthood

The sociodevelopmental notion of emerging adulthood is a helpful conceptual framework through which to understand risky drinking during the college years (Arnett 2000, 2005). For emerging adults who attend college, graduating from high school is no longer the entry into adulthood. Rather, these individuals typically delay marriage, parenthood, and a career until completing their education. Arnett describes five dimensions that characterize this developmental stage and that may have implications for alcohol use and misuse.

- Identity exploration. During emerging adulthood, when individuals are figuring out their own identity (particularly in the domains of love and work), alcohol use may be a part of exploring a wide range of lifestyle options before adopting adult roles and identity. Students may also use alcohol to cope with identity confusion (Schwartz et al. 2010).

- Instability. The college years are associated with frequent residential moves and changes in friends and partners, educational status, and jobs. Alcohol use often is elevated during periods of transition (Schulenberg and Maggs 2002) and perhaps is used for self-medication or to promote social activity (Kuntsche et al. 2005).

- Self-focus. Upon college entry, students gain independence from their family and relative freedom from obligations and commitments to others. They make independent decisions, and with weaker social controls from family and other institutions, they experience fewer constraints on risk behaviors. Friends may have the most influence on behavior during this time, and students inclined to use alcohol likely establish friendships that support drinking (Abar and Maggs 2010).

- Feeling in-between. Emerging adults may feel neither adolescent nor fully adult, and therefore may feel a sense of responsibility in some domains but not others. For example, they may feel capable of deciding whether or

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not to use alcohol but may not feel they need to conform to adult standards of comportment. Some students may see the college years as a "time out" from adult responsibilities (Colby et al. 2009) and give themselves permission to enjoy activities such as risky drinking that will be less acceptable later in adulthood.

- Possibilities. Finally, emerging adulthood is a time when people can make dramatic changes in their lives and is characterized by biased optimism. Because college students' expectations for a positive future are so high, they may not acknowledge that negative consequences related to drinking behavior may occur.

The Unique Role of Parents

As mentioned above, once emerging adults head to college, they depart from the structure and oversight provided when living with parents. However, parents do still matter during the college years. For example, research finds that higher levels of perceived parental involvement may buffer students from the effects of peers on alcohol use and problems (Wood et al. 2004); parental knowledge of how their college student is spending his or her time may influence choice of friends, which in turn may influence drinking behavior (Abar and Turrisi 2008); and parental permissiveness of drinking predicts increases in alcohol use and consequences over time (Walls et al. 2009). Overall, continued parental involvement and communication may serve to protect against high-risk drinking and prevent harm even at this stage of emerging adulthood (Turrisi and Ray 2010).

Neurodevelopmental Factors Affecting Self-Regulation

The developmental context of college drinking is characterized not only by psychosocial but also biological factors. A growing body of research reveals that the brain's frontal lobes do not fully mature until the mid-20s (Johnson et al. 2009). During adolescence, the bottom-up impulsive system that responds to rewards and social/emotional factors matures before the top-down controls of the prefrontal cortex (Casey and Jones 2010). Importantly, these top-down pathways from the prefrontal cortex help people slow down and consider the long-term outcomes of their behaviors. An imbalance between the impulsive system and the more reflective system may make emerging adults more vulnerable to engaging in addictive behaviors. In addition, some speculate that engaging in behaviors such as substance abuse may strengthen the bottom-up pathways and trigger this imbalance (Bechara 2005). Thus, the observations that late adolescents and emerging adults often choose short-term rewards over long-term goals may reflect the state of their neurocognitive development.

In the next section, we summarize descriptive data about college student drinking and its consequences, keeping in mind that it occurs within this developmental context characterized by the features of emerging adulthood, a changing but still significant role for parents, and continuing neurocognitive development.

Alcohol Use and Consequences Among College Students

Drinking Behavior

National surveys provide valuable data on the drinking habits of college students in the United States. They include the Harvard College Alcohol Study (e.g., Wechsler et al. 2002), the National Epidemiologic Survey on Alcohol and Related Conditions (e.g., Chen et al. 2004; Dawson et al. 2004), the National Survey on Drug Use and Health (Substance Abuse and Mental Health Services Administration 2014), the Core Institute Project (CORE), and the Monitoring the Future studies (Johnston et al. 2014).

White and Hingson (2013) offer a detailed overview of these surveys and their findings; we will provide a brief summary. To start, the majority of college students (approximately 60 percent) report past-month drinking (Johnston et al. 2014; Substance Abuse and Mental Health Services Administration 2014). Those who drink tend to drink heavily: more than one-third of college students report heavy episodic drinking at least once in the past 2 weeks, with heavy drinking defined as 4 or more drinks in one sitting for females and 5 or more drinks in one sitting for males (Johnston et al. 2014). In addition, approximately 1 of 5 males (19.9 percent) and 1 of 10 females (8.2 percent) consume twice this binge threshold (White et al. 2006). It is worth noting that patterns of drinking are heterogeneous with multiple trajectories in binge-drinking behavior across the 4 years of college (Schulenberg and Maggs 2002).

Negative Consequences

Heavy drinking results in negative consequences for both drinking and nondrinking students:

- A total of 646,000 physical assaults, 97,000 sexual assaults, 599,000 unintentional injuries, and 1,825 deaths are linked to alcohol use among college students annually (Hingson et al. 2009).

- Forty percent of college student drinkers report alcohol-induced memory loss, such as blackouts (White et al. 2002), which is associated with future risk for injury and/or increased drinking (Mundt et al. 2012; Read et al. 2013).

- Twenty-one percent of college student drinkers report unplanned sexual activity while drinking, and 10 percent report unprotected sex while drinking (Wechsler et al.

2002). Such behavior can lead to sexually transmitted infections or unplanned pregnancy (Ingersoll et al. 2008).

- Students also report that drinking alcohol is related to social/interpersonal problems, poor self-care (e.g., eating and/or sleeping poorly), and diminished self-regard (e.g., feeling badly about oneself) (Read et al. 2006).

- Among college students, rates of alcohol abuse as defined in the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* range from 6 to 31 percent, and rates of alcohol dependence range from 6 to 16 percent (Blanco et al. 2008; Dawson et al. 2004; Knight et al. 2002).

From a developmental standpoint, the underdevelopment of the frontal lobes and neurocognitive systems guiding decision making may in part explain some of the consequences of drinking in this age group, particularly those that involve engaging in risky behaviors while drinking. Moreover, as mentioned, because expectations for a positive future are so high during emerging adulthood, college students may feel that they are immune to any negative consequences related to drinking and thus may not take measures to avoid them.

Academic Impairment

Drinking also may influence students' academics, the primary purpose of attending college. This may manifest in poor performance on exams, missing classes, lower grade-point average (GPA), and even dropping out (for a brief review, see White and Hingson 2013). However, the association between alcohol use and academics may be neither direct nor absolute. Although alcohol involvement has been shown to be associated with academic problems at the end of freshman year, this relationship was explained by historical variables (academic aptitude, class rank) that existed when students entered college (Wood et al. 1997). Binge drinking adversely affects GPA in part by reducing study hours (Wolaver 2002). Further, extreme alcohol involvement—dependence but not abuse—clearly compromises first-year academic performance (Aertgeerts and Buntinx 2002).

Demographic Correlates

Just as in the general population, male and white students (Del Boca et al. 2004; Johnston et al. 2014) are at higher risk for excessive drinking. Certain affiliations associated with college life further enhance this risk, such as being a member of a Greek organization (O'Brien et al. 2013; Park et al. 2008) or a collegiate athletic team (Brenner and Swanik 2007; Yusko et al. 2008). Such affiliations are unique to the college environment and can be important sources of identity and social connectedness, which are both important to emerging adults.

College versus Noncollege Comparisons

The drinking behavior among college students is in some ways distinct from that of their same-age peers who do not attend college (Slutske 2005; Slutske et al. 2004). Every year, from 2002 to 2013, rates of past-month binge drinking (4 or more drinks for women and 5 or more for men) were higher among college-attending young adults, ages 18–22, than their peers who do not attend college (Substance Abuse and Mental Health Services Administration 2014). Similar disparities are seen for alcohol use disorder, but some research finds that differences in alcohol use disorder disappear after adjusting for sociodemographic variables such as gender, race/ethnicity, nativity, marital status, and personal and family income (Blanco et al. 2008). Other studies find that variables such as full-time versus part-time status and type of college may be more directly related to variations in alcohol consumption than whether a student attends college (Carter et al. 2010). Selection factors associated with the type of college or choice of living situation may partly explain increased risk (Fromme et al. 2008). Nonetheless, college attendance provides an environmental context affording opportunities for high volume drinking. It also may prolong the sense of being in-between childhood and the responsibilities of adulthood.

Risky Drinking Practices Among College Students

One explanation for increased risk for alcohol misuse and consequences among college students is the tendency to engage in specific types of high-risk drinking behaviors. These include but are not limited to pregaming and drinking games.

Pregaming

Sometimes called "preloading," "frontloading," or "pre-partying," pregaming is defined as consuming alcohol before attending a social event, where additional alcohol may or may not be available and/or consumed (Read et al. 2010; Wells et al. 2009), and is common on U.S. college campuses. In fact, 70 to 75 percent of college drinkers report pregaming (Barnett et al. 2013; DeJong et al. 2010; Hummer et al. 2013; Pedersen and LaBrie 2007, 2008; Read et al. 2010) and say they engage in the practice on about one-third of drinking days (Labhart et al. 2013; Merrill et al. 2009; Read et al. 2010). Pregaming often takes place in college dorm rooms; is time limited because students need to leave for the primary event; and often involves doing shots of hard liquor, resulting in rapid rates of intoxication (DeJong et al. 2010). When students pregame, compared with drinking episodes when they do not, they consume a greater number of drinks and have higher blood alcohol concentrations (BACs) (Barnett et al. 2013; Borsari et al. 2007*a*; Glindemann et al. 2006; LaBrie and Pedersen 2008; Pedersen and LaBrie 2007; Read et al. 2010). In addition, pregaming is linked to more alcohol-

related consequences (Kenney et al. 2010; Labhart et al. 2013; LaBrie and Pedersen 2008; Merrill et al. 2013*a*; Paves et al. 2012; Pedersen et al. 2009), including neglecting responsibilities, feeling sick, passing out, absenteeism at school/work, drunk driving, alcohol poisoning, aggressive or violent acts, and blackouts (DeJong et al. 2010; Hughes et al. 2008; LaBrie and Pedersen 2008; LaBrie et al. 2011; Pedersen and LaBrie 2007; Pedersen et al. 2009).

Drinking Games

Another common and risky practice is playing drinking games (such as beer pong and Kings). According to Zamboanga and colleagues (2013), drinking games involve performing some kind of cognitive and/or physical task, are governed by a set of rules that specify when and how much participants should drink, and are designed specifically to promote increased drinking within short time periods in a social setting. In some cases, a vicious cycle can occur wherein once a participant starts to lose, he or she is forced to drink more as a penalty, thus further diminishing his or her skills in the game and increasing required consumption (Zamboanga 2007*a*; Zamboanga et al. 2010). Individuals may be heckled for refusing to drink during the game (Borsari 2004). It is therefore not surprising that playing drinking games increases risk for heavy drinking and negative alcohol-related outcomes (Ray et al. 2014; Zamboanga et al. 2006). One category of drinking games, including chugging and keg stands, is referred to as consumption or extreme consumption games (Zamboanga et al. 2013). It is this category that may pose the greatest risk for elevated alcohol consumption (LaBrie et al. 2013; Zamboanga et al. 2006, 2007*b*).

Environmental and Temporal Risk Factors for College Students

College attendance places students at increased risk for alcohol consumption and alcohol-related problems in part because of environmental features, including communal living and an academic week that often allows students to select a schedule with long weekends. Furthermore, the rhythm of the academic year includes social holidays and events that happen predictably across college campuses.

Living Situation

Communal living is an important risk factor. For example, Zamboanga and colleagues (2009) found that students at a women's liberal arts college who lived in residence halls reported higher levels of hazardous alcohol use than students living in house-style residences, and Willoughby and Carroll (2009) demonstrated that students living in co-ed housing were more likely than students living in gender-specific housing to binge drink and consume alcohol. In contrast, students who remain living at home with parents drink less (Valliant and Scanlan 1996). In other work, alcohol dependence rates were highest among college students of both genders who live on campus, and rates of alcohol abuse were highest among college men who live off campus (Dawson et al. 2004, 2005*a*). Within the context of the emerging adulthood framework, living situation during the college years can contribute both to instability (frequent moves) and self-focus (weaker social controls upon moving from home to dormitories where the influence of parents may decline and influence of friends may rise).

The Transition Into College

The transition from high school to the first year of college is associated with increases in alcohol use and heavy drinking (Borsari et al. 2007*b*; Sher and Rutledge 2007). Heavy or frequent drinking early in the college experience can compromise academic success (Hoeppner et al. 2012; Upcraft 1995), as problematic patterns of drinking established during the first weeks often continue throughout college (Schulenberg et al. 2001; Task Force of the National Advisory Council on Alcohol Abuse and Alcoholism 2002). A review by Borsari and colleagues (2007*b*) found that the risk for increased drinking associated with college attendance is moderated by a number of variables, including sensation seeking, race, gender, religiosity, precollege alcohol use, and parental influences. This risk also is explained in part by changes in determinants of drinking that occur upon college entry, including changes in alcohol expectancies, drinking motives, perceived norms, Greek membership, and drinking game participation. The emerging adulthood framework predicts increased drinking during this time frame in that alcohol use is used to cope with the need to rebuild a social life or recreate a social identity; alcohol use also can be a result of an enhanced susceptibility to peer influence (Arnett 2005).

The Academic Week

College students typically drink the heaviest on weekends, and, for some, weekend-like drinking begins on Thursday (Hoeppner et al. 2012). However, this trend is moderated by a student's schedule; those with no Friday classes drink twice as much on Thursdays as students with early Friday classes (Ward et al. 2013; Wood et al. 2007). Most colleges afford students the ability to select their own schedule, so heavy drinking students may be least likely to enroll in classes that convene on Friday (Paschall et al. 2006), perhaps in an effort to seek more opportunities to drink.

The Academic Year

Importantly, patterns of drinking across the academic year are not uniform; multiple trajectories characterize the overall pattern of drinking across the first college year (Greenbaum et al. 2005). However, at least among first-year students, some of the heaviest drinking occurs not only during the initial weeks of fall semester, as described above, but also during the initial weeks of spring semester (Del Boca et al.

2004; Tremblay et al. 2010). In contrast, the lightest drinking occurs during exam weeks, both midterms and finals (Del Boca et al. 2004). As described below, research also reveals that the heaviest drinking takes place on holidays and during holiday breaks when students are not on campus.

Holidays and Breaks

Drinking among freshmen peaks during Spring Break, Thanksgiving, Christmas, and New Year's weeks (Del Boca et al. 2004) and tends to be characterized by binge drinking (Beets et al. 2009; Greenbaum et al. 2005). A study of 21-year- old college students found that compared with a typical nonholiday weekend, more students consumed alcohol and they reached higher BACs on New Year's Eve, New Year's Day, July 4th, Spring Break, and graduation (Neighbors et al. 2011).

Drinking and related consequences are higher during Spring Break than the typical week (Beets et al. 2009; Del Boca et al. 2004); however, this is particularly true for students who go on trips with friends (Grekin et al. 2007; Lee et al. 2006, 2009). The highest levels of drinking during Spring Break occur among those who report higher levels of intentions to drink before their trip, those who go on longer trips, and those who previously engaged in more heavy episodic drinking (Patrick and Lee 2012). Notably, however, students who typically drink less experience more negative consequences of drinking during Spring Break (Lee et al. 2009).

21st Birthdays

Extreme drinking and negative alcohol-related consequences also are associated with 21st birthdays (Lewis et al. 2009; Neighbors et al. 2005; Rutledge et al. 2008), which typically occur during students' college years. Half of 21st-birthday drinkers consume more on this day than any other prior occasion (Rutledge et al. 2008), and students drink more than they anticipate they will at this celebration (Brister et al. 2010). Students who do not typically drink heavily but do so the week of their birthday are most likely to experience higher levels of alcohol-related consequences (Lewis et al. 2009). In addition, 21st-birthday drinking is associated with the highest proportion of drinkers and highest BACs compared with other high-risk times (Neighbors et al. 2011).

Campus Events

Drinking also tends to spike during campus- or university-specific events. For example, during "State Patty's Day," a student-constructed, party-focused holiday at Pennsylvania State University, first-year students were more likely to drink and drink heavily (Lefkowitz et al. 2012). On this day, students consumed more alcohol than on other weekend days, even after controlling for gender and drinking motives, and local crime rates increased.

Sporting events also are associated with heavy drinking among college students (Glassman et al. 2010; Neal and Fromme 2007) and also seem to increase risk for consequences. For example, college football homegame days see a 9 percent increase in assaults, a 41 percent increase in arrests for alcohol-related disorderly conduct, and a 76 percent increase in liquor-law violations compared with nongame days (Rees and Schnepel 2009). High-profile sporting events (e.g., winning an NCAA championship) increase game-day drinking on average and more so for heavier and more impulsive drinkers (Neal et al. 2005).

The Transition Out of College and Into Adulthood

Despite the often risky nature of drinking during college, most, although not all, students "mature out" of such behavior (Littlefield et al. 2009). The average decline in drinking behavior following the college years has been attributed to events that are delayed for emerging adults who choose to attend college, namely employment, marriage, and parenthood, each of which may accompany reductions in recreational and social activities that involve drinking (Gotham et al. 2003; O'Malley 2004). Age-related changes in personality also may be associated with reductions in drinking during adulthood (Littlefield et al. 2009). However, students with alcohol use disorder are at higher risk for maintaining problematic drinking patterns: about one-half of students who meet alcohol use disorder criteria at age 19 maintain that status at age 25 (Rohde et al. 2001; Sher and Gotham 1999).

Psychosocial Determinants of Drinking During the College Years

College student drinking is affected by several psychosocial determinants that also influence drinking behavior in similar ways during other developmental periods. For example, like the general populations, college students tend to drink more if they believe drinking will have positive effects and consequences, and they tend to drink less if they have negative expectations about drinking (e.g., Gaher and Simons 2007; Wardell and Read 2013). In addition, how positively or negatively students view the expected effects of alcohol (Gaher and Simons 2007) or view actual recently experienced consequences of drinking (Merrill et al. 2013*b*) are also important predictors of college drinking.

A person's reasons or motives for drinking also influence their alcohol use. For example, drinking to increase positive affect, called enhancement motives, consistently predicts alcohol use and tends to be linked to negative alcohol consequences indirectly, through higher drinking levels (Magid et al. 2007; Merrill and Read 2010; Read et al. 2003). Meanwhile, drinking to alleviate negative affect, or coping motives, are directly associated with negative alcohol consequences in college students (Jones et al. 2014; Kassel et al. 2000; Merrill and Read 2010; Merrill et al. 2014). Certain personality characteristics, such as sensation seeking or impulsivity (Diulio et al. 2014; Kazemi et al. 2014*a*) and neuroticism (Martin and Sher 1994; Vollrath and Torgersen 2002), have been linked

to increased drinking behavior among college students, although findings are mixed. In addition, a person's drinking level prior to entering college predicts drinking behavior during college (Sher and Rutledge 2007; Varvil-Weld et al. 2013).

Below we discuss in more detail common psychosocial determinants that exert influence in a way that is unique to the college years. We highlight exaggerated norms, protective behavioral strategies, and mental health.

Exaggerated Norms

Peers influence young adult drinkers in several direct and indirect ways (Borsari and Carey 2001). Perhaps the most studied has been young adults' perceptions of drinking norms. In fact, when comparing their own drinking behavior (their personal norms) with their perceptions of how much or how often other students drink (descriptive norms) and their perceptions of whether peers approve of drinking and related behaviors (injunctive norms), young adults tend to see others as drinking more and more approving of drinking (Borsari and Carey 2003). When objective evidence of peer drinking is available, the perceived drinking norm is invariably overestimated (e.g., Carey et al. 2006). Research demonstrates the importance of reference group: norms for close friends are more highly correlated with student drinking behavior than those of more distal student groups (Larimer et al. 2009; Neighbors et al. 2008). However, providing students with corrective feedback on drinking norms for other relevant peer groups, because they often are objectively exaggerated, can promote discrepancies that lead to drinking reductions (Larimer et al. 2009). Descriptive and injunctive norms seem to have unique influences on drinking behavior (Larimer et al. 2004). In fact, descriptive norms have a greater influence when there are also permissive injunctive norms, positive outcome expectancies, and higher identification with the referent group (Neighbors et al. 2010; Rimal 2008). The peer-intensive nature of college life affords many opportunities to affiliate with groups that develop their own normative cultures related to drinking (e.g., Greeks, athletic teams, and clubs). Within the context of the emerging adulthood framework, norms are relevant to the factors of both identity exploration (looking to others in the social environment while figuring out his or her own identity) and self-focus (friends as most influential on behavior during this age).

Protective Behavioral Strategies

In light of all of the contextual and developmental factors that contribute to risk described above, it is essential that students learn to drink safely (if they choose to drink) when navigating the novel drinking environment of college. However, the extent to which college students acquire and use safe drinking skills varies. Most emerging adults leave home for college before they attain the minimum legal drinking age. Thus, peers and not parents or other adults often serve as the primary sources for learning how to drink. Protective behavioral strategies—techniques that can be used to minimize harm associated with alcohol use such as setting drink limits, consuming nonalcoholic in addition to alcoholic drinks, avoiding drinking games, and using a designated driver—have received an increasing amount of attention in the college-drinking literature over the past few decades. A recent review highlights several studies that consistently reveal that individuals who report using more protective behavioral strategies also report drinking less and/or experiencing fewer alcohol-related problems (Pearson 2013).

Mental Health

Approximately three-quarters of lifetime mood or anxiety disorders begin by age 24, coinciding with the typical college years (Kessler et al. 2005), and about 11 percent and 12 percent of U.S. college students meet criteria for mood and anxiety disorders, respectively (Blanco et al. 2008). Unfortunately, few college students use mental health services (e.g., Eisenberg et al. 2011), and research finds an association between mental health problems and heavy episodic drinking (Cranford et al. 2009). Moreover, students with mental health symptoms are more likely to experience problems related to alcohol use than students without such symptoms, regardless of drinking level (Dawson et al. 2005*b*; Dennhardt and Murphy 2011; Kenney and LaBrie 2013; LaBrie et al. 2010; Weitzman 2004). Within the emerging adulthood framework, mental health issues are relevant to the factors of both identity exploration (identity confusion may cause distress) and instability (transitions may be disruptive), as alcohol may be used for self-medication purposes among students high on either dimension.

Intervention Implications

The findings reviewed above have several implications for interventions with the special population of college-aged individuals. In general, a harm prevention/harm reduction approach, as opposed to an abstinence-based approach is considered most appropriate for young people who are developing drinking habits and have not exhibited signs of dependence (Ehret et al. 2013; Marlatt and Witkiewitz 2002). Also, given that aspects of the campus environment constitute risk factors for individual drinkers, it is important to implement not only coordinated alcohol abuse prevention efforts involving community and campus environmental management but also group and individual prevention efforts and to identify drinkers in need of treatment services (Toomey et al. 2013; Wolfson et al. 2012). The next section reviews how prevention and intervention efforts can incorporate the patterns and influences we describe above.

Developmental Factors

Despite the importance of the developmental context to college student drinking, to date, developmental considerations have had limited influence on intervention development.

A notable exception is parent-based intervention, which has been well received and shows promise both as a standalone intervention (Ichiyama et al. 2009; Turrisi et al. 2013) and a supplement to student-based interventions (Turrisi et al. 2009). In line with the emerging adulthood concept of "possibilities," interventions highlighting future academic and occupational decisions also may be useful. An example of this comes from a study that modified a traditional brief motivational intervention to include a supplemental session focused on increasing the salience of academic and career goals and discussed behavior patterns that would assist in meeting those goals (Murphy et al. 2012). Students who received the supplement reported fewer alcohol-related consequences at 1- and 6-month followups compared with students who did not receive the supplement. In addition, interventions can address self-regulatory difficulties associated with incomplete prefrontal control by using mobile technologies, which permit real-time assessment (e.g., Mays et al. 2010) and interventions delivered close to drinking events (e.g., Suffoletto et al. 2012). Such approaches seem to be both feasible and acceptable to college students (Kazemi et al. 2014*b*). Additional adaptation of the content and delivery of interventions based on the developmental context of college drinkers is a promising direction for intervention development.

Environmental and Temporal Factors

Tailoring interventions to address environmental issues of the college setting also may be beneficial. Such interventions include establishing substance-free residential options and changing the academic schedule to ensure that students take classes on Fridays and also in the mornings (DeJong and Langford 2002). Increased regulation and/or detection of alcohol use among underage drinkers in particular may be needed at campus events such as football games. Toomey and colleagues (2007) provide a more detailed review of these and other strategies designed for environmental management.

Event-specific prevention (ESP) is an intervention strategy that addresses temporal determinants of drinking behavior (Neighbors et al. 2007). ESP assumes that knowing when and/or where risky drinking will occur provides an opportunity for its prevention. For example, knowing that 21st birthdays and Spring Break are times of greatest risk suggests that resources should be allocated toward prevention around these times, providing a cost-effective approach to preventing alcohol-related consequences associated with these events (Neighbors et al. 2011, 2012). Finally, early preventive interventions for first-year students transitioning into college may help thwart increases in risky drinking behavior. There is modest support that online educational programs are effective for these students (Hustad et al. 2010; Lovecchio et al. 2010). Further, meta-analytic research suggests that behavioral interventions for first-year college students effectively reduce alcohol consumption and alcohol-related problems, with the extent of reductions dependent on intervention content (e.g., personalized feedback provides better outcomes) (Scott-Sheldon et al. 2014).

Psychosocial Determinants

Many of the psychosocial determinants of drinking during emerging adulthood reviewed above have informed the development of alcohol abuse prevention interventions. For example, correcting exaggerated perceived norms is a well-documented active ingredient of successful risk-reduction programs delivered both in person and by computer (Carey et al. 2010; Doumas et al. 2009; Neighbors et al. 2004; Turrisi et al. 2009). Further, interventions increasingly are incorporating protective behavioral strategies (Pearson 2013), which have been shown to mediate intervention effects (Barnett et al. 2007; Larimer et al. 2007; Murphy et al. 2012).

Future Directions for Intervention

Tailoring alcohol risk reduction interventions to students with mental health concerns would be another way to integrate psychosocial determinants of drinking and the emerging adulthood framework into new interventions. For example, interventions that provide alternatives to substance use for coping with negative mood states could prove fruitful for students high on the instability dimension of emerging adulthood and who are experiencing negative affect related to transitions, or for students who experience identity confusion during this time of exploration. In addition, recent data demonstrate that depression may interfere with intervention-related change (Geisner et al. 2015; Merrill et al. 2014). Although the exact mechanisms of this effect are as yet unknown, it may be beneficial to include in brief interventions components that seek to increase substance-free reinforcement (e.g., Murphy et al. 2012) or that broaden students' coping skills.

To date, we have no evidence-based interventions to reduce high-risk practices such as pregaming or drinking games (Read 2014). Such interventions might involve education about factors affecting BAC and the biphasic curve to help sensitize some drinkers to the risk of consuming large quantities in a short time; corrective normative feedback about the frequency, intensity, or approval of high-risk behaviors by peers; and/or the provision of protective behavioral strategies specific to refusing opportunities to pregame or learning to play drinking games safely.

Conclusion

Much progress has been made in understanding the risk for alcohol misuse among college students. However, there still is room to understand the developmental, social, and environmental factors influencing college student drinking, to best design interventions that can ultimately reduce harm for this special population.

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Drinking Over the Lifespan

Focus on Early Adolescents and Youth

Michael Windle, Ph.D.

Historical trends in alcohol use among U.S. adolescents, as well as data regarding alcohol-related traffic fatalities among youth, indicate decreases in alcohol use. Nevertheless, alcohol use patterns still indicate high rates of binge drinking and drunkenness and the co-occurrence of alcohol use among youth with risky sexual activity, illicit substance use, and poor school performance. This article discusses unique elements of alcohol use among adolescents relative to adults that pose risks for alcohol misuse and alcohol-related problems. These differences range from patterns of drinking to differential sensitivity to alcohol. Developmental differences between adolescents and adults also are discussed with regard to age-normative developmental tasks and distinctions in brain development that may affect differences in drinking patterns. Epidemiologic findings on sexual-minority youth are provided, as are global trends in alcohol use among early adolescents and youth. It is proposed that using information about differences between youth and adults will be helpful in directing future etiologic and intervention research by capitalizing on unique biological, psychological, and social factors that may affect the success of efforts to reduce alcohol use among early adolescents and youth.

Key words: Alcohol consumption; alcohol use frequency; alcohol use pattern; alcohol-related problems; alcohol misuse; alcohol sensitivity; binge drinking; heavy drinking; adolescent drinking; underage drinking; adolescent; youth; alcohol and other drug use; alcohol-related traffic fatalities; sexuality; risky sexual behavior; academic performance; risk factors; brain development; growth and development

In describing patterns of alcohol use among early adolescents (ages 12–14) and youth (ages 15–20), there is both good news and bad news. The good news is that research findings with U.S. national epidemiology data from long-term annual surveys of high-school students, such as the Monitoring the Future surveys, have indicated historical shifts toward overall decreases in levels of alcohol use among early adolescents and youth (Johnston et al. 2013). For example, national data from the Monitoring the Future studies have indicated that in 2012, historic lows in the prevalence of alcohol use were reported across all three grade levels assessed (i.e., 8th, 10th, and 12th graders). Self-reported alcohol use in the prior 30 days for the three respective grade levels were 11 percent, 28 percent, and 41 percent. By contrast, in 2000, these respective last 30-day prevalence rates were 22 percent, 41 percent, and 50 percent. Consistent with these findings are those reported in the National Household Survey on Drug Use and Health that indicate decreases in heavy episodic or binge drinking for birth cohorts born in the 1990s relative to birth cohorts born previously, going back as far as the 1950s (Keyes and Miech 2013). The number of drinking-and-driving traffic fatalities involving 16- to 20-year-olds also has decreased from 5,244 in 1982 (which accounted for 66 percent of traffic fatalities) to 1,262 in 2010 (which corresponded to 37 percent of traffic fatalities) (Hingson and White 2014; Voas et al. 2012). These U.S. national epidemiologic findings are encouraging in that the historical trends indicate decreases and, in some instances (e.g., traffic fatalities), substantial decreases in alcohol use and adverse consequences among young people.

The bad news is despite these reductions in the overall prevalence of alcohol use among early adolescents and youth, alcohol remains the substance of choice among early adolescents and youth and still is used by a majority of youth. The table summarizes 2012 U.S. national findings for alcohol use from the Monitoring the Future survey (Johnston et al. 2013). Although historically the prevalence of alcohol use may be decreasing, the rates still are quite high for heavier use, with almost one-quarter of 12th graders reporting binge drinking (i.e., 5 or more drinks in a row in the past 2 weeks) and almost one-half of 12th graders and more than one-quarter of 10th graders reporting being drunk in the past 12 months. The prevalence of any use in the past year also remained high for 10th and 12th graders, and almost one-quarter of 8th graders reported past-year use. The findings in the table also indicate the high prevalence of using flavored alcohol beverages, especially among 8th graders. The ratio (translated to a percentage) of using any flavored alcohol beverages in the past 30 days and any use of alcohol in the past 30 days was 52 percent for 12th graders, 59 percent for 10th graders, and 69 percent for 8th graders. Hence, relatively new alcohol products in the market place, such as those with sweet flavoring, seem to be among the alcohol beverages of choice, especially among early adolescents (i.e., 8th graders), although high rates also were reported by 10th and 12th graders.

Gender differences for the alcohol use indicators in the table tend to reflect a high degree of convergence across

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sexes, especially among 8th and 10th graders. Among 8th graders, girls reported higher levels than boys for the prevalence of alcohol use during the past 12 months and past 30 days, a higher prevalence of using flavored alcohol beverages, and a higher prevalence of binge drinking in the past 2 weeks and having been drunk in the past 12 months. Among 10th graders, the prevalence across alcohol indicators is similar across gender groups, with the exception that girls used more flavored alcohol beverages. Among 12th graders, a higher percentage of boys than girls reported engaging in heavier drinking (i.e., binge drinking in the past 2 weeks and having been drunk in past 12 months). Race/ethnic group differences indicated that for 8th graders, the prevalence of the alcohol use indicators was lower for Whites and African Americans but higher for Hispanics. By contrast, for 10th and 12th graders, Whites and Hispanics reported a higher prevalence of the alcohol use indicators than African Americans. These findings are similar to prior years of the Monitoring the Future surveys in indicating a lower prevalence of alcohol use among African American early adolescents and youth and a higher prevalence among White and Hispanic youth. Similar ethnic group findings also were reported for the 2013 Youth Risk Behavior Surveillance Survey (Kann et al. 2014).

Table Prevalence of Alcohol Use (Percentage) by Demographic Subgroups Among 8th, 10th, and 12th Graders, 2012

	Any Use in Past 12 Months	Any Use in Past 30 Days	Flavored Alcohol Beverages in Past 30 Days	5+ Drinks in a Row in Past 2 Weeks	Been Drunk in Past 12 Months
8th Graders					
Total	23.6	11.0	7.6	5.1	8.6
Gender					
Boys	22.3	10.3	6.1	4.6	7.8
Girls	24.7	11.6	9.2	5.5	9.3
Race/Ethnicity					
White	23.5	10.7	7.4	4.9	9.3
African American	22.4	10.0	8.8	4.3	6.5
Hispanic	33.4	17.5	10.8	9.9	12.6
10th Graders					
Total	48.5	27.6	16.3	15.6	28.2
Gender					
Boys	47.8	28.0	13.5	16.4	28.5
Girls	49.2	27.1	18.5	14.8	28.1
Race/Ethnicity					
White	50.9	29.1	16.5	16.3	31.1
African American	41.0	20.2	10.7	8.2	18.6
Hispanic	51.1	28.4	17.7	17.1	28.2
12th Graders					
Total	63.5	41.5	21.8	23.7	45.0
Gender					
Boys	63.7	43.8	19.9	27.2	47.7
Girls	62.9	38.8	23.3	19.7	41.3
Race/Ethnicity					
White	66.3	43.8	22.9	25.7	47.5
African American	52.4	29.6	17.2	11.3	24.2
Hispanic	64.0	39.8	26.8	21.8	40.2

SOURCE: Johnston et al. 2013.

Alcohol use by early adolescents and youth also remains highly correlated with a range of other risky behaviors, including tobacco use, co-occurring illicit substance use, sexually risky behaviors (e.g., unprotected sex), lower school performance, and externalizing behavioral problems (e.g., conduct problems, delinquency), as well as with the three highest manifestations of adolescent mortality (drinking-and-driving crashes, suicide, and homicide) (Epstein et al. 2013). Furthermore, although substantial strides have been made in reducing alcohol-related traffic fatalities among youth, national findings for 9th through 12th graders from the 2011 Youth Risk Behavioral Survey indicated that the prevalence of drinking and driving in the past 30 days was 8.2 percent and riding with a drinking driver was 24.1 percent (Eaton et al. 2012). Hence, the good news described previously must be tempered with a more comprehensive evaluation of the available data and recognition that many challenges regarding alcohol use among early adolescents and youth remain to be addressed. (See the accompanying sidebar for a brief review of emerging risks from greater access to marijuana and alternative tobacco products, which may interact with adolescent and youth alcohol use.)

This article reviews several issues related to early adolescent and youth alcohol use to further illuminate why this period of development in the lifespan remains of high importance and is a special population. Note that across the research literature a range of definitions are used to describe the adolescent phase in the lifespan. In this article, we use the term early adolescence to refer to the age range 12 through 14 (which includes, among others, 8th graders) and youth for the age range 15 through 20; adolescence refers to the entire age range of 12- to 20-year-olds. This article highlights four areas to demonstrate how this period of the lifespan differs from others with regard to alcohol use, its consequences, and the implications for prevention and treatment. The first part examines differences in alcohol use patterns and sensitivity to alcohol for early adolescents and youth relative to adults. Second, differences between early adolescents and youth and adults are discussed with regard to differences in development, with particular reference to age-normative psychosocial tasks (e.g., puberty, friendship formation) and to brain development that uniquely occurs during this phase of the lifespan. The third section discusses findings regarding alcohol use among sexual minority youth. Fourth, global patterns of alcohol use among early adolescents and youth are presented.

Alcohol Use Patterns and Sensitivity to Alcohol

National household data reveal distinct differences in patterns of alcohol use between early adolescents and youth and adults with regard to number of drinking days per month and usual number of drinks per occasion (Substance Abuse and Mental Health Services Administration [SAMHSA] 2006). Adolescents (summed across ages 12–20) reported 6 drinking days per month on average, whereas young adults (ages 21–25) reported an average of 8 days per month, and adults (ages 26 or older) reported almost 9 days per month. However, adolescents reported an average of 5 drinks per occasion, compared with 4 drinks for young adults and 3 drinks for adults. Hence, drinking among adolescents is less frequent than for adults, but the amount consumed per occasion is considerably more, with average levels of drinking that meet criteria for binge or heavy episodic drinking. Although there is some variation in the definition of binge or heavy episodic drinking it often is defined as at least 5 drinks in a row in the past 2 weeks (Johnston et al. 2013). Adolescents tend to consume alcohol much more opportunistically than adults (e.g., at parties), and heavy drinking is the norm rather than exception when these opportunities arise. Of course, there are situations when adults also drink heavily, but the more general pattern is one of frequent drinking at lower levels. A major issue with the higher frequency of heavier drinking among adolescents is that it may contribute to a broad range of co-occurring problems (e.g., sexual or physical victimization, drinking and driving) that may have short- and long-term adverse consequences.

Adolescents and adults also differ in their sensitivity to the effects of alcohol. Because administering alcohol to human adolescents is fraught with ethical and legal challenges, rats are often used to compare adolescents and adults while experimentally manipulating other variables, such as levels of alcohol exposure. Research findings with rats have indicated that following the administration of ethanol, adolescent rats performed more poorly than adult rats on a range of memory and learning discrimination tasks, thereby suggesting a greater sensitivity to alcohol as manifested by impaired memory performance during adolescence (for review, see Spear and Swartzwelder 2014). Other research comparing adolescent and adult rats has indicated that adolescent rats have reduced sensitivity to alcohol's aversive and undesirable consequences, such as motor impairment and drowsiness (i.e., sedative effects) (Spear and Swartzwelder 2014).

Hence, these comparative studies of adolescent and adult rats, along with human studies that indicate memory differences between younger (early 20s) and somewhat older (late 20s) adults (Acheson et al. 1998), suggest adolescents and adults may manifest differential sensitivity in their acute responses to alcohol. These differential sensitivities may affect patterns and consequences of drinking for these age-groups. For example, if youth are not experiencing the sedative effects of alcohol, they may continue to drink rather than reduce or stop their drinking. Similarly, if learning and memory are impaired as a result of alcohol use, decision making may likewise be impaired and current, immediate situational cues or determinants (e.g., drinking and driving with friends) may override more reflective cognitive processes that, in the absence of alcohol consumption, could lead to less risky behaviors. Caution needs to be exerted in drawing conclusions for human behaviors based on animal model findings. Whereas animal and some human studies have

suggested age differences in response to alcohol, other studies have suggested similarities between human adolescents and adults with regard to some biochemical parameters (e.g., serum acetate concentration) related to alcohol intoxication (Lamminpaa 1995). Nevertheless, the notion of age-related differential sensitivity to alcohol remains a vibrant area of research.

Developmental Tasks and Brain Development

A number of developmental theorists, including Erik Erickson (1950), have postulated that people confront different age-appropriate developmental tasks during phases or periods of the lifespan. The period of adolescence is characterized by a host of developmental changes and challenges, including puberty; significant increases in physical size and changes in physical appearance; confrontation with issues of personal, ethnic, and sexual identity; renegotiating relationships with parents toward a greater acceptance of personal autonomy; becoming more peer involved and influenced; initiating and maintaining dating relationships; and changing schools. These developmental changes and challenges occur during a period of life that intersects with the onset and escalation of alcohol and other substance use and can pose unique risks for adolescents. For instance, early pubertal development by girls may increase their risk of early-onset alcohol use through their involvement with older boys (Lanza and Collins 2002). Similarly, greater affiliation with peers can yield both positive benefits (e.g., increased social skills) and negative costs if alcohol use becomes a dominant element of friendship groups. The intersection between challenging developmental tasks and alcohol use across adolescence was a significant topic associated with the NIAAA Underage Drinking Initiative (2014), and a special supplemental issue of *Pediatrics* provides an expanded discussion of these issues (see Brown et al. 2008; Windle et al. 2008).

Brain development represents another significant area of change that occurs during adolescence. Research has focused on how brain development may influence adolescent alcohol use and vice versa—that is, how alcohol use may influence the developing brain. Although overall brain size achieves its peak in early childhood, maturational changes in brain cortical volume, axonal growth, and refinement of cortical connections (e.g., via synaptic "pruning") continue, especially with regard to the limbic system, including the amygdala and the prefrontal cortex (Bava and Talpert 2010). These brain systems are involved in a broad range of cognitive, affective, and behavioral processes (e.g., learning, decision making, impulsivity) that, in turn, influence alcohol use and other co-occurring problems (e.g., risky sexual behavior).

With regard to the maturation of the brain, important developmental asynchronies exist between some earlier developing limbic and affective portions of the brain relative to the later developing prefrontal cortex. This is significant because in earlier adolescence, the affective portions of the brain may be more dominant with respect to behavioral responses, including the immediate rewarding aspects of alcohol use, whereas the brain functions associated with the prefrontal cortex that involve higher cognitive processing related to executive functioning (e.g., planning, goal setting, inhibitory control), decision making, and cognitive-affective behavioral regulation still are developing. Hence, metaphorically, in earlier adolescence the dominant affective system says "Go" (e.g., drink alcohol for immediate reward) without the counteracting effect of the later-to-develop "Stop" system associated with brain functions of the prefrontal cortex.

The asynchrony described above is unique during adolescence and dovetails with research on reward-seeking behavior among adolescents and reward sensitivity in the dopamine-rich brain striatum (Galvan 2010). This research indicates that during adolescence, an increased activation in reward sensitive areas of the brain contributes to adolescents seeking, or being highly motivated to pursue, appetitive rewards (e.g., alcohol). The neuroscience research indicates that this phenomenon of heightened sensitivity to reward is unique to adolescence and does not occur in childhood or adulthood (Galvan 2010; Spear 2011). Spear summarized research conducted with adolescent rats supporting not only heightened sensitivity to the rewarding effects of alcohol but also to the facilitation of social behavior by alcohol, thereby contributing to rewarding effects of alcohol in social contexts. She further proposed that such reward-oriented propensities during adolescence may contribute to adolescents' differential evaluation of the costs and benefits of alcohol use compared with individuals at other ages (i.e., adolescents would estimate that alcohol use has greater benefits and fewer costs). Hence, the existing neuroscience literature is contributing to a more nuanced understanding of why adolescence is a unique period of development and is identifying cognitive (e.g., impulsive decision making) and affective (e.g., heightened reactivity) mechanisms that may serve as targets for intervention and/or provide clarity for components of intervention programs (Riggs and Greenberg 2009).

Alcohol Use Among Adolescent Sexual-Minority Youth

Sexual orientation and the development of a sexual identity become especially prominent following puberty, with the occurrence of developmental tasks related to establishing a sense of personal and sexual identity, peer selection and socialization, and the initiation and escalation of romantic relationships. Relative to the longer-term study of sexual orientation and alcohol use among adults, large-scale epidemiologic findings of adolescent sexual orientation and alcohol use have a relatively brief history. Nevertheless, several recent studies have yielded consistent findings with regard to sexual orientation and substance use, including alcohol use. Marshal and colleagues (2008) conducted a meta-analysis of existing studies on adolescent sexual orientation and substance use and reported that lesbian, gay,

and bisexual (LGB) youth reported substance use at almost twice the rate of heterosexual youth and that subgroups at particularly high risk were bisexuals and sexual-minority females. Youth who identified as "mostly heterosexual" also used substances at levels similar to bisexual youth. Talley and colleagues (2014) used data from the 2005 and 2008 Youth Risk Behavior Surveys and reported similar findings—sexual-minority youth (i.e., those who self-identified as not exclusively heterosexual) reported higher rates of alcohol use than their heterosexual counterparts. Of particular interest, the age of drinking onset for sexual-minority youth indicated that 35.6 percent had initiated use at or before age 12, relative to 21.7 percent of heterosexuals. The rate of past-month heavy episodic drinking was almost twice as high among sexual-minority youth, as was the number of past-month drinking days, using a cut point of 6 or more days. Bisexual youth, sexual-minority females, and younger sexual-minority youth reported the highest rates of alcohol use.

In addition to these cross-sectional epidemiologic findings indicating higher levels of alcohol and other substance use among sexual-minority youth relative to exclusively heterosexual youth, two studies have used longitudinal data from the National Longitudinal Study of Adolescent Health (AddHealth) to investigate alcohol and substance use outcomes in young adulthood. Marshal and colleagues (2009) used three-wave data (at wave 1 average age about 15.8 years, then a 1-year followup, and an additional 5-year followup). Nonexclusively heterosexual orientation predicted more rapid increases in substance use, including alcohol use and drunkenness, across this adolescent to early young adulthood period. Dermody and colleagues (2014) extended this time window by using four waves of AddHealth data (ages 14–18 at wave 1; 27–31 years at wave 4) to study associations between self-identified sexual-minority youth and exclusively heterosexual youth on a measure of hazardous drinking, defined by frequency of drunkenness. The longitudinal findings indicated that in later young adulthood (ages 27–31), sexual-minority youth, as self-identified during adolescence, had significantly higher levels of hazardous drinking than heterosexual youth and that the magnitude of these differences increased across time, especially among men. Some mechanisms have been proposed for the higher rates of alcohol and other substance use among sexual-minority youth, such as stress-related stigmatization that may contribute to stress-relief drinking (Hatzenbuehler et al. 2008). Nevertheless, considerable research remains to be completed on identifying the underlying mechanisms for a higher prevalence of alcohol use among this sexual-minority population and using this information to guide preventive interventions.

Alcohol Use, Emerging Tobacco Products, and Marijuana Use

Among early adolescents and youth, alcohol use commonly co-occurs with other substance use and problem behaviors (Biglan et al. 2004). Furthermore, with new alcohol and tobacco products being created and marketed to early adolescents and youth, the field of alcohol research must consider the impact of recent historical events and trends manifested in related areas of substance use. Two contemporary trends immediately come to mind.

First, medical marijuana use, along with marijuana de-criminalization and marijuana legalization in some States (the latter in Colorado and Washington), may have an impact on rates of alcohol use, co-use of alcohol and emerging tobacco products, and increased polydrug use of alcohol, marijuana, and tobacco or nicotine-based products. The social norms for the perceived dangers and social acceptability of marijuana use among youth already are shifting toward reduced harm and greater social acceptance (Johnston et al. 2013).

Second, the availability and prevalence of alternative and emerging tobacco products (e.g., snus, cigars, cigarillos, hookah, electronic cigarettes [e-cigarettes]) is increasing. Nicotine use may re-emerge as a prominent gateway substance that fosters further escalation and continued drug use. The advertising associated with many of these alternative tobacco products also is geared toward youth, with flavors (e.g., cherry, cinnamon) reminiscent of the "alcopop" (flavored alcohol beverages) industry and its marketing efforts that target young people. Annual high school surveys from 2007 to 2012 in the State of Florida indicated significant decreases in cigarette use, largely offset by increases in alternative tobacco products (Barnett et al. 2014). The Food and Drug Administration currently is considering regulations for e-cigarettes that contain nicotine but not tar or many of the other carcinogens of tobacco. However, with the current unregulated state of e-cigarettes, nicotine levels vary widely across brands and may undermine arguments for their use as a harm-reduction product.

More research is needed to determine the potential benefits and costs of e-cigarettes. But their rapid and widespread use, along with other alternative tobacco products, in conjunction with a more permissive attitude toward marijuana use, may make it more difficult to prevent co-use and polydrug use patterns. Alternative tobacco products may affect attempts to prevent the onset and escalation of alcohol use, as well as relapse among those treated for alcohol disorders.

Global Patterns of Alcohol Use Among Early Adolescents and Youth

Alcohol use and its adverse consequences among early adolescents and youth have become of increasing interest on the global stage. Gore and colleagues (2011) reported on youth alcohol use in the World Health Organization (WHO) Global Burden of Disease study. This worldwide study derived an index of disability-adjusted life-years (DALYs) for all participants by combining years of life lost because of premature mortality and years of life lost as a result of incident cases of disease or injury. One DALY corresponds to the loss of 1 year of full health. Among youth aged 10–24, the main risk factor for incident DALYs was alcohol use, which accounted for 7 percent of the DALYs. Alcohol was the most prominent risk factor worldwide for 15- to 24-year-olds. Unsafe sex, which often co-occurs with alcohol use, was the second highest risk factor, accounting for 4 percent of the incident DALYs. Gore and colleagues (2011) concluded that many risk factors and noncommunicable diseases, such as alcohol use and alcohol disorders, other psychiatric disorders, and injury, often have not been prioritized by the global public health community and that data such as these findings with youth suggest that a higher priority would be beneficial.

Findings reported in the WHO Health Behavior in School Children (HBSC) study (Currie et al. 2008), an investigation of multiple health behaviors, including alcohol use, across 23 European countries and North American countries, also indicated global patterns of alcohol use among early adolescents and youth. For example, findings from the HBSC using drunkenness as a measure of alcohol misuse indicated a significant increase in drunkenness from ages 11–15, with the steepest increase from ages 13–15; boys reported a higher prevalence of drunkenness than girls across almost all countries, and the prevalence of drunkenness was higher in northern than southern Europe (Currie et al. 2008). A more detailed analysis of changes in adolescent drunkenness from HBSC surveys in 1997–1998 and 2005–2006 indicated a significant decrease (25 percent on average) in adolescent drunkenness among 13 of 16 Western countries but a significant increase (40 percent in mean frequency) in adolescent drunkenness in 7 Eastern European countries (Kuntsche et al. 2011). A more in-depth presentation of the HBSC surveys is beyond the scope of this article, but more extensive findings on cross-national comparisons are provided by Bendtsen and colleagues (2014), and findings specifically on U.S. national data for 6th through 10th graders who participated in the HSBC study are provided by Brooks-Russell and colleagues (2014).

With increasing economic and cultural globalization, alcohol use often is increasing in developing countries where the prevalence of drinking was previously relatively low. For example, Prasad (2009) reported that sales of alcohol in India grew by 8 percent in the previous 3 years. This is thought to be a serious underestimate, because almost two-thirds of the alcohol consumed in India is not recorded (e.g., local home brew, or smuggled into the country). Of particular concern with regard to youth is that drinking alcohol is becoming more prevalent among younger people (under age 21), with rates increasing from 2 percent to 14 percent over the past 15 years. Furthermore, at the national level in India, alcohol-related problems account for 20 percent of hospital admissions, 18 percent of psychiatric admissions, 20 percent of brain injuries, and 60 percent of all injuries in India's emergency rooms. Although these statistics are for all patients, not just early adolescents and youth, they forebode unhealthy outcomes for this population, especially given the recent historical trends toward increases in alcohol use at earlier ages.

Conclusions

Recent U.S. historical trends regarding alcohol use among early adolescents and youth have indicated significant reductions in use that have been paralleled by substantial reductions in alcohol-related traffic fatalities among youth. These trends are positive and suggest that our efforts to modify early adolescent and youth drinking through intervention programs and alcohol policies are yielding valuable gains. Nevertheless, the epidemiologic data still indicate serious problems with alcohol use among early adolescents and youth, with the prevalence of binge drinking, drunkenness, drinking and driving, and driving with someone who has been drinking still at high levels. Sexual-minority youth are at particularly high risk for alcohol misuse, and adolescence is a critical phase in development for establishing personal and sexual identity. Additional research is needed to understand the complexities involved in these higher levels of use among sexual-minority youth. It also is clear that as globalization continues, alcohol use and misuse among early adolescents and youth is becoming more pervasive and impacting youth internationally. A number of characteristics distinguish adolescent from adult drinking, including a higher number of drinks per occasion by adolescents, different sensitivities to the effects of alcohol on adolescents and adults, and developmental differences in psychosocial tasks and brain development. Applying this information about differences between adolescents and adults will be helpful in directing future etiologic and intervention research because it will facilitate a focus on unique biological, psychological, and social factors that may affect the success of efforts to reduce alcohol use among early adolescents and youth.

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Influence of Social Media on Alcohol Use in Adolescents and Young Adults

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Participation in online social media Web sites (e.g., Facebook and Twitter) has skyrocketed in recent years and created a new environment in which adolescents and young adults may be exposed to and influenced by alcohol-related content. Thus, young people are exposed to and display pro-alcohol messages and images through online portrayals of drinking on personal pages as well as unregulated alcohol marketing on social media sites that may reach underage people. Such online displays of alcohol behavior have been correlated with offline alcohol behavior and risky drinking. Health behavior theories have been used to describe the influence of social media sites, including Social Learning Theory, the Media Practice Model, and a more recent conceptual approach called the Facebook Influence Model. Researchers are beginning to assess the potential of social media sites in identifying high-risk drinkers through online display patterns as well as delivering prevention messages and interventions. Future studies need to further expand existing observational work to better understand the role of social media in shaping alcohol-related behaviors and fully exploit the potential of these media for alcohol-related interventions.

Key words: Alcohol use, abuse, and dependence; underage drinking; risky drinking; portrayal of alcohol and other drug use (AODU) in the media; prevention; intervention; adolescent; young adult; technology; Internet; online social media; marketing; social marketing; message; Facebook; Twitter; Social Learning Theory; Media Practice Model; Facebook Influence Model

Today's generation of adolescents and young adults are growing up immersed in social media, such as Facebook and Twitter, that promote user-generated content and interactions between users (Lenhart et al. 2005). The use of such media is especially high among these age groups (Madden et al. 2013*b*). Social media sites are an environment in which alcohol-related content is frequently created and consumed by adolescents and young adults (Moreno et al. 2009*a*,*b*, 2010). Displayed alcohol references on social media may include information and images pertaining to alcohol (Hinduja and Patchin 2008; Moreno et al. 2009*b*, 2010*a*) that may influence viewers (Litt and Stock 2011; Moreno et al. 2009*a*) and be indicative of offline alcohol use (Moreno et al. 2011). This article discusses social media, their popularity, and their social nature that promotes information sharing and peer connections. It also reviews health behavior theories that support the influential nature of social media, including a newer conceptual approach called the Facebook Influence Model. Finally, the article describes first efforts to use social media for alcohol prevention and intervention and explores how future work could enhance such efforts through observational studies and intervention development. The discussion focuses largely on Facebook and Twitter, two of the most popular social-networking sites at present, because the greatest volume of research has been published about these sites. Throughout the discussion, the review emphasizes the characteristics that make social media social: their interactive nature, the presence of user-generated content, and the formation of networks.

Social Media Sites

Social media use has grown exponentially over the past decade, and this growth is expected to continue (see figure 1) (Duggan and Smith 2013). This section provides an overview of social media use and trends, with a focus on Facebook and Twitter.

Social Media Are Interactive

Social media sites are diverse and yet share many similar features. Site users generally create an account; link to a network of other individuals or groups; and use the site to share thoughts, photographs, videos, news stories, and other content (Kietzmann et al. 2011). Social media can be used by individuals to share information about their personal lives as well as by businesses and organizations to promote their products and services. Most of the sites have built-in mechanisms to express approval or disapproval of content; consequently, users can not only form their own impression of a post or video but also can see how many others, and sometimes exactly who, also expressed approval. This multidirectional and user-generated communication about content differentiates social media from traditional mass media

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and from the earlier days of Internet advertising, when Web sites generally just provided content from one entity or posted information about a product (Kaplan and Haenlein 2010).

The Changing Landscape of Social Media

To understand how alcohol-related messages and images displayed on social media may influence young people, it is important to consider the changing landscape of social media. Different social media sites have gained and lost popularity over time, and new ones are continually being launched to cater to specific market niches and demands, leading to a constantly changing landscape of sites and mobile applications. MySpace is one of the older social media sites, with an emphasis on music sharing; it was among the most popular sites globally in the early 2000s (Lenhart and Madden 2007). Facebook was launched in 2004; it initially was available only to students at Harvard University but quickly spread to other colleges and by 2006 was available to the general public. As Facebook expanded beyond its roots as a network only for college students, MySpace's dominance began to decline. Then, in 2006, Twitter emerged with an emphasis on short text messages (Lenhart et al. 2010). In addition to these popular social-networking sites, sites focused on professional networks (e.g., LinkedIn), photo sharing (e.g., Instagram, Snapchat, Pinterest), video sharing (e.g., YouTube, Vimeo), and other niches have arisen.

Facebook and Twitter: Popularity, Access, and Privacy

Facebook and Twitter are among the most-visited Web sites in the United States, particularly among adolescents and young adults. As of 2013, 77 percent of adolescents used Facebook and 24 percent used Twitter (Madden et al. 2013*b*); among young adults, the corresponding percentages were 86 percent and 27 percent (Duggan and Brenner 2013). As a result, any alcohol-related content posted on these sites has the potential to reach a large proportion of adolescents and young adults. Several characteristics of social media sites can influence this risk of exposure to alcohol content, including the formats available for user posts and the options for and culture of anonymity and privacy. These issues are especially salient given that references to personal drinking could be incriminating for individuals under age 21. This section compares Facebook and Twitter with respect to these domains.

Over 1 billion people worldwide use Facebook (The Nielsen Company 2013). The site specifies a minimum age of 13 to participate in the network and requires the user to enter his or her age when creating an account, but there is evidence that children under age 13 participate in Facebook by providing a false age (Jernigan and Rushman 2014; Richtel and Helft 2011). When establishing an account, the Facebook user can create a profile listing numerous aspects of his or her identity, including birthday, hometown, schools attended, jobs held, and relationship status, which indicates whether someone is in a romantic relationship. Facebook

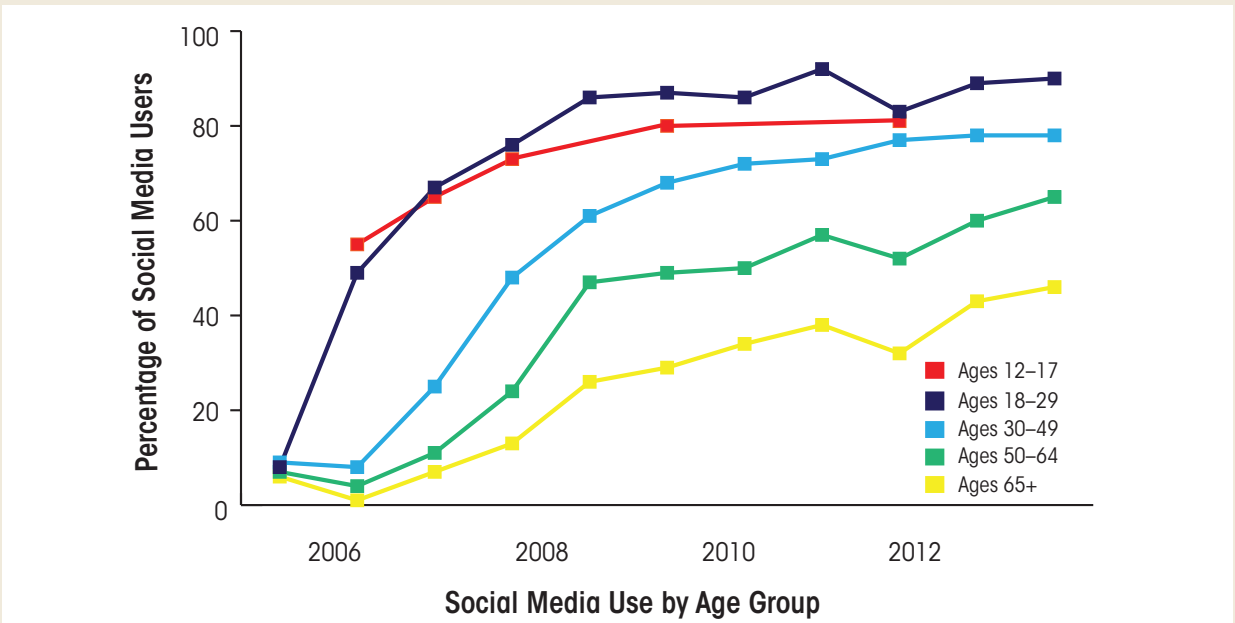

Figure 1 Changes in social media use among Internet users by age group.

SOURCES: Madden, M.; Lenhart, A.; Cortesi, S.; et al. *Teens, Social Media, and Privacy.* Washington, DC: Pew Research Center, 2013*a*. Pew Research Center. *Data Trend: Social Media Use by Age Group Over Time.* Washington, DC: Pew Research Center, 2014. Available at: http://www.pewinternet.org/data-trend/social-media/social-media-use-by-age-group/ Accessed January 4, 2015.

requests that each user register with his or her real name and then use that full name as the identifier for the profile. An overwhelming majority (94.9 percent) of college students use their real names on Facebook (Tufekci 2008). Use of real names helps users identify and connect with individuals whom they know offline.

The Facebook experience in 2014 centers on the user's "wall" or "timeline," where he or she displays status updates, photos, and other items. Users can control who is able to see the content on their timeline through a robust set of privacy settings. A majority of teens on Facebook report using these privacy settings (Madden et al. 2013*a*), but some studies suggest that adolescents may overestimate their understanding of how to establish and maintain private settings (Moreno et al. 2012*b*).

Twitter is less commonly used than Facebook, with 215 million active users in 2013 (Kim 2013). Twitter posts, or tweets, are text messages of no more than 140 characters. Although adolescent participation in Twitter currently is less than participation in Facebook, the number of young users of this site is rapidly growing (Madden et al. 2013*b*). Twitter content often includes a hashtag, connoted by the pound sign followed by a keyword (e.g., #party, #beer). Keywords serve a unique function because they can be searched within Twitter by users to find content related to a particular topic. In contrast to Facebook, Twitter does not ask for the user's age when creating an account, although their policies state that accounts of users discovered to be under age 13 will be deactivated. Madden and colleagues (2013*a*) found that 36 percent of 12-year-old Internet users reported falsifying their age to access a Web site or account. Twitter's privacy settings are limited to either making content fully public or sharing it only with "followers" of the account. Twitter executives have said that 90 percent of the content on the site is fully public (Rao 2010). In 2013, only 24 percent of teen Twitter users reported keeping their tweets private, whereas 60 percent kept their Facebook profiles private (Madden et al. 2013*b*). Part of teens' willingness to disclose information publicly on Twitter may stem from the fact that the company does not make any requests to use a person's real name as the online username.

Both Facebook and Twitter are being used for research purposes, but with somewhat different modes of analysis. Thus, Facebook often is considered as a platform in which the unit of analysis is an individual identity expressed via a profile. In contrast, Twitter frequently is considered to be a platform in which the unit of analysis is a specific topic around which individual users may interact, congregate, or "follow."

Alcohol Content on Social Media

For young people, social media are a source of exposure to two important factors that offline are associated with alcohol use: peer alcohol behavior (Ali and Dwyer 2010; Mundt et al. 2012) and alcohol advertising (Jernigan 2006, 2011). Alcohol researchers have begun to measure exposure to and impact of alcohol-related content and are moving toward developing intervention mechanisms using social media. However, the ways in which social media exposure may be similar to, different from, or reinforcing of offline counterparts are not yet fully understood.

User-Generated Alcohol Content

Content posted by adolescents and young adults likely is seen by peers as well as younger users of these sites. Early studies on the effects of this exposure focused on MySpace; however, research efforts have kept pace with changes in the popular social media platforms to include Facebook and Twitter. Several studies have illustrated that adolescents' displays on social media (i.e., MySpace and Facebook) frequently include portrayal of health-risk behaviors related to alcohol, other substances, and sexual behaviors (Hinduja and Patchin 2008; McGee and Begg 2008; Moreno et al. 2007, 2009*b*). Alcohol-related displays may include texts (e.g., "Matt got drunk last night"), photographs depicting alcohol consumption, or links to alcohol-related groups or companies (Egan and Moreno 2011; Moreno et al. 2010*a*).

The patterns of displaying such health-risk behaviors online commonly are consistent with offline reporting. For example, adolescents who display one health-risk behavior (e.g., sexual activity) on social media are more likely to also display other behaviors (e.g., alcohol use) (Moreno et al. 2009*a*). Also, risk behaviors may be displayed online within peer groups, just as offline peer groups commonly report engagement in similar behaviors. Thus, adolescents are more likely to display references to sexual behavior if a peer displayed similar references (Moreno et al. 2010*b*). Finally, displayed alcohol references have been linked to alcohol behaviors offline, because older adolescents whose Facebook posts suggested problem drinking behaviors are more likely to score as "at risk" on a problem-drinking screen (Moreno et al. 2011).

Whereas health-risk behaviors commonly are displayed on social media sites, negative consequences of these behaviors are not frequently noted. In a study of older adolescents, displays of negative consequences of alcohol use, such as hangovers or embarrassment, on social media sites were rare (Moreno et al. 2010*a*).

More recently, researchers have begun to examine alcohol-related content on Twitter, which provides a more immediate reflection of behaviors as they occur. The extent to which social networks are used in real time to discuss alcohol has implications for surveillance and intervention. Previous studies in other health-related areas have illustrated that Twitter can be used to identify behaviors or intentions across populations (Chew and Eysenbach 2010; Signorini et al. 2011). One study (West et al. 2012) examined keywords that are synonyms for the word "drunk" among a sample of over 5 million tweets from users selected to be geographically representative of the U.S. population. The investigators found that tweets related to intoxication peaked between

the hours of 10 p.m. and 2 a.m. in the user's local time zone and were more prevalent on Friday and Saturday nights. Moreover, the proportion of tweets related to intoxication was 0.53 percent over the New Year's holiday weekend, compared with 0.34 percent during non-holiday weekends. These findings are consistent with studies emphasizing the increased risk for alcohol problems during holidays and other specific events (Neighbors et al. 2011). Thus, at the population level, the timing of tweets about alcohol behaviors correlates with the times when the heaviest drinking and highest proportion of alcohol-related motor vehicle crashes are known to occur. Additional research is needed to examine these findings with other alcohol-related keywords and behaviors and to test, at the individual level, whether tweets about intoxication and impaired driving are correlated with risky drinking behaviors.

Unregulated Marketing on Social Media

In addition to user-generated alcohol-related content, there is growing concern about the extent to which adolescents and young adults are exposed to alcohol marketing on social media sites. Research from both the United States and the United Kingdom indicates that the major alcohol brands maintain a presence on Facebook, Twitter, and YouTube (Jernigan and Rushman 2014; Winpenny et al. 2014).

Analysis of social media marketing for leading alcohol brands in the United Kingdom has identified the most common marketing strategies, including promotion of offline branded events (e.g., at a club or sporting event), interactive games, sponsored online events, and invitations to drink (Nicholls 2012). On Facebook, alcohol companies ask users to "like" their brands and to post pictures of themselves drinking the specific alcohol beverage or participating in real-life events sponsored by the company. On Twitter, brands are encouraging followers who attended an event to post pictures of themselves using a dedicated hashtag, thereby enforcing the brand's identity among Twitter users. This practice is of particular concern given the popularity of Twitter among younger teens. Other examples of advertising on Twitter included tweets noting that it is a specific day of the week on which is a good time to drink a specific brand of alcohol, such as the Bacardi brand using the hashtag #mojitomonday. In contrast, only two of the five brands analyzed included a small number of tweets encouraging followers to drink responsibly and get home safely (Nicholls 2012).

Although restrictions exist to protect young people from exposure to alcohol advertisements on traditional media channels (e.g., recommendations to limit alcohol commercials during youth-oriented television programming) (Ross et al. 2014), adolescents still have access to alcohol advertising in many traditional venues (King et al. 2009; Rhoades and Jernigan 2013). Social media present a new venue for alcohol advertisers, particularly because they can target messages and foster connections with consumers (Jernigan and Rushman 2014). This approach is of particular concern because it can easily reach adolescents and young adults under the legal drinking age. Software is available that would allow alcohol brands to ask for age verification before a user can become a follower of the brand's account and interact with the brand. Such software typically requires the user to enter a birth date indicating that the user is over the legal age to purchase alcohol. However, a recent inquiry into alcohol brands found that none used any external age verification (Jernigan and Rushman 2014).

Influence of Social Media on Young People

The influence of social media alcohol displays on young people can best be determined using theories that illuminate mechanisms of behavior change. Two classic theories in this respect are Social Learning Theory, which supports the importance of peer influence on behavior, and the Media Practice Model, which supports the role of media choices as influences on intentions and behaviors. A newer conceptual approach, the Facebook Influence Model, ties together many previous constructs from health behavior theory to understand how sites such as Facebook may be associated with these underlying constructs.

Social Media Influence: Health Behavior and Media Theory Considerations

Social Learning Theory posits that adolescents learn both by direct experience and by observation (Bandura 1977, 1986). Previous work has indicated that observation of peers is a major source of influence on adolescent health attitudes, intentions, and behaviors (Keefe 1994; Wood et al. 2004). In particular, early alcohol initiation is determined at least in part by alcohol use by adolescents' friends as well as by social network characteristics (Ellickson and Hays 1991; Mundt 2011). Thus, according to Social Learning Theory, observation of peers influences alcohol use intentions and behaviors. In today's world, this observation may occur both online and offline.

The Media Practice Model states that adolescents choose and interact with media based on who they are, or who they want to be, in that moment (Brown 2000). This model suggests that media users explore information or display content based on experiences or behaviors they are considering, which may lead to reinforcement or advancement of these ideas. Thus, an adolescent who is considering initiating alcohol consumption may choose to watch a movie depicting drinking at a party, which in turn may influence him or her to attend such a party in the future.

Exposure to alcohol or tobacco in traditional media (e.g., movies, television) has been associated with adolescent substance use (Dalton et al. 2003, 2009; Gidwani et al. 2002; Titus-Ernstoff et al. 2008). Social media can combine traditional media exposure to alcohol-related content with peer interactivity (e.g., peer endorsement of specific behaviors), resulting in a potentially even more powerful influence on

drinking behavior. For example, adolescents' social media ties within and across networks provide many potential paths of influence. These paths may allow the spread of alcohol-related content or promote alcohol behaviors within a network as well as across networks (Mundt 2011). The potential impact of such messages has been demonstrated repeatedly. Thus, adolescents who view alcohol references on their peers' Facebook profiles find these to be believable and influential sources of information (Moreno et al. 2009*a*). Furthermore, adolescents who perceive alcohol use as normative based on Facebook profiles are more likely to report interest in initiating alcohol use (Litt and Stock 2011). Consequently, social media represent a widespread, readily available, and consistently accessed source of information for today's adolescents and young adults and combine the power of interpersonal persuasion with the reach of mass media. Fogg (2008, p. 23) described "mass interpersonal persuasion" as "the most significant advance in persuasion since radio was invented in the 1890s."

The Facebook Influence Model

A new evaluation of existing health behavior theory models is needed to understand the role of technologies such as social media (Collins et al. 2011). To address this issue, a recent study (Moreno et al. 2013*b*) sought to determine young people's perceptions of which aspects of Facebook are influential. The mixed-methods study applied concept-mapping methodology, a validated five-step method to visually represent complex topics (Trochim et al. 1994). This approach allows the conceptual framework to be built from data based entirely on the views of key stakeholders and resulting in a concept map that visually represents key concepts and their interrelationships.

The resulting Facebook Influence Model includes 13 clusters representing specific aspects of Facebook, such as "influence on identity," "connection to people," and "social norms" (Moreno et al. 2013*b*) (see figure 2). The impact of these 13 clusters can be determined when classifying them into the following 4 categories or concepts characterizing the role of Facebook (see table):

- *Connection:* Facebook provides and enhances peer communication, networking, and connection.
- *Comparison:* Comparison with peers has long been a part of adolescence. Facebook allows this comparison using tangible information, such as photos and stated behaviors, as well as the ability to note peer comments on this information.
- *Identification:* Facebook allows the profile owner to develop an online identity through his or her profile. Profile owners can then reflect and revise that identity via feedback from peers' comments and "likes," or by personal perusal through the Facebook "timeline." The ability to develop one's identity in real time provides a unique multimedia view of the self.
- *Immersive experience:* Facebook has been described as a Web site that provides positive, negative, tool-based, and distracting features toward an immersive and powerful experience for users.

Moreno and colleagues (2013*b*) concluded that although Facebook provides a novel lens through which to consider factors that impact behavior, its influence can best be considered in the context of robust behavioral theory. Thus, each of the four concepts or cluster groups can best be considered alongside the framework of previous supporting work as synergistic with or an expansion of previous theory. For example, the "identification" concept describes the clusters that reflect how users explore and reflect on their identity using Facebook. As mentioned earlier, the Media Practice Model posits that users choose and interact with media based on how they perceive their identity at that time or what they would like their identity to be (Brown 2000). Facebook allows users to develop an online identity through their profile, which they can then reflect on and revise as described above. As a result, young people can develop an online identity in real time, based on a vision of who they want to be as well as exposure to other media content and peer feedback.

Further exploration of these 13 constructs and 4 concepts will provide a comprehensive base for theoretical consideration to inform future work and the potential for intervention development using Facebook.

Social Media and Alcohol-Related Interventions

Despite the broad reach of social media, the literature to date is scant on interventions using social media to reduce harmful alcohol consumption. Consideration of previous work may help suggest future directions for social media–based interventions.

Facebook

Based on previous work that identified links between displayed alcohol references on Facebook and self-reported alcohol behaviors (Moreno et al. 2011), one possible avenue for intervention could involve identifying individuals who may be at risk for alcohol-related problems based on the social media content they post. Screening these displays may represent innovative means to identify at-risk individuals and prompt them to undergo further screening and intervention. Studies have investigated young people's willingness to engage in such interventions (Moreno et al. 2012*a*) as well as communication strategies for those who approach young people who display online content that is worrisome (Whitehill et al. 2013). Important issues to consider for interventions targeting specific individuals include

how to identify those individuals given variation in privacy settings and the fact that the identity of social media users is not always known.

Facebook also provides opportunities to link user-generated content to triggered Facebook advertisements. As described in the Facebook Influence Model, this medium had a significant influence on "identity development," and interventions could build upon this source of influence (Moreno 2013*b*). For example, researchers could consider linking Facebook advertisements to a user's displayed alcohol content. These advertisements could provide messages for a user to consider when deciding whether to display alcohol content as part of an online or offline identity. Such advertisements could be triggered by certain keywords (e.g., terms related to "intoxication") in Facebook posts and could include such messages as "Do you really want being drunk to be part of your identity?"

Twitter

The relatively large volume of public content on Twitter suggests that it may be possible to implement an automated search system that would identify tweets indicating risk of alcohol-related problems and respond with a link to resources or services. However, an ongoing study to determine the feasibility of responding to tweets mentioning the words such as "drink," "drunk," or "drunk drive" found that unless the sender of the response tweet is already a follower of (or followed by) the targeted user, any tweets with a link are blocked by Twitter's spam filter (Whitehill et al. 2014). Thus, the possibility of public health agencies conducting such efforts may be limited. Additional efforts to understand and test the ability to use various social media sites for automated two-way communication to reduce alcohol risk are needed.

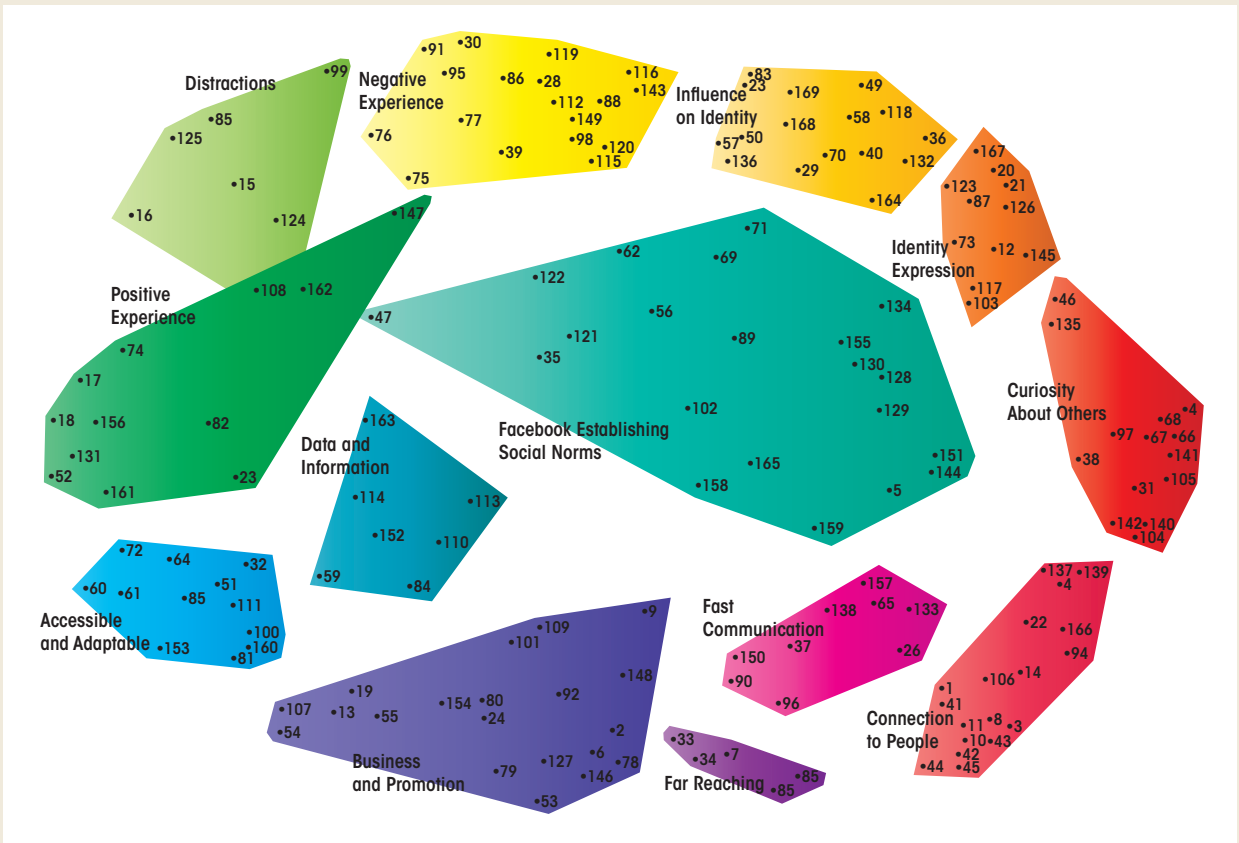

Figure 2 The Facebook Influence Model is a concept map created through Concept Mapping methodology. Each dot represents a single concept described by multiple participants in response to the question, "What makes Facebook influential?" After participants generated a list of concepts through a brainstorming process, they sorted these concepts into groups and ranked their importance. The map was then generated using Concept Mapping software employing a hierarchical cluster analysis to create a visual representation of the ideas arranged into clusters. Items that were similarly categorized by participants appear closer together on the map compared with items not categorized together.

SOURCE: Moreno, M.A.; Kota, R.; Schoohs, S.; and Whitehill, J.M. The Facebook Influence Model: A concept mapping approach. *Cyberpsychology, Behavior and Social Networking* 16:504–511, 2013. PMID: 23621717

Table Characteristics of the Different Clusters in the Facebook Influence Model

Domain	Cluster Label	Example Items Within Cluster
Connection	Connection to people	–Allows people to constantly stay updated with other's lives –Way to get to know acquaintances almost instantly –Keep in touch with people you would not call or text
	Far reaching	–Ability to reach many people with one Web site –Can reach anyone, young and old, rich and poor –Bonding across cultures and distances
	Fast communication	–Feel connected and in the loop constantly –Puts everyone you know and what they are doing in one place –Updates on people's lives faster than with a cell phone
	Business and promotion	–Ability to plan influential events such as protests or sit-ins –Statuses provide a way to blog instantly about events or political topics –Every company uses it to promote business or provide deals
	Accessible and adaptable	–Largest network in human history –Easy to use and navigate –Widely known and talked about
	Data and information	–Huge database of information –Compiled data from millions of individuals –News feature
Identification	Identity expression	–Freedom to express things and let them be heard –Present the best side of yourself –Show off accomplishments to everyone you are friends with on Facebook, not just close friends
	Influence on identity	–Provides others with pictures that can influence perceptions –Display aspects of yourself that you would not share in offline life (sexuality, substance use) –Wonder if you should be doing what you see everyone doing in pictures
Comparison	Curiosity about others	–Can know what people are up to without asking them about it and without them knowing you know –Creep culture/stalking –See who associates with whom with pictures and comments
	Facebook establishing social norms	–Reinforces beliefs or opinions by seeing that others hold same beliefs or opinions –Can see what is popular by observation –Can follow norms
Facebook as an experience	Distractions	–Procrastination –Addictive –Huge distraction
	Positive experiences	–Facebook is referenced in daily life –Provides entertainment at any time –Status updates can promote a good mood
	Negative experiences	–Changes the nature of communication from face to face to screen to screen –People willing to sacrifice privacy –Inspires competition in people

SOURCE: Moreno, M.A.; Kota, R.; Schoohs, S.; and Whitehill, J.M.; The Facebook Influence Model: A concept mapping approach. *Cyberpsycholology, Behavior, and Social Networking* 16(7):504–511, 2013. PMID: 23621717

Social Media Advertisements

Another possible approach is to use social media for social marketing. In this way, social media could be used similarly to how traditional media outlets have promoted responsible alcohol use and increased awareness of alcohol-related harm. Advertisements could be pegged to the same keywords used by alcohol beverage advertising, with the goal of reaching the same target audiences and providing educational messages or links to online interventions.

Mobile Devices

Other potential approaches to interventions may be based on the widespread use of social media sites from mobile devices, raising the potential that social media could be used to reach individuals in real time in the settings where drinking occurs. One pilot study of alcohol-using college students indicated that 42 percent used Facebook or Twitter during a drinking festival (Whitehill et al. 2012). Both Facebook and Twitter allow users to use the GPS feature of their phone to check in at their current location, and some specialized social-networking sites such as FourSquare allow users to locate friends nearby. It may be possible to use social media–based advertising and the location-based features of mobile phones to promote alternatives to drinking, safe transportation, free condoms, and other services to reduce the harms associated with alcohol consumption. Before such interventions could be developed, however, formative work is needed in this area to better understand the behavior of young people as it relates to their mobile social network use during the course of a drinking episode.

Future Research Directions

Adolescents and young adults are particularly vulnerable to the effects of social media because they are at once early adopters and nearly ubiquitous users, as well as highly susceptible to peer influences (Ellison et al. 2007; Lenhart and Madden 2007; Lenhart et al. 2005, 2010). However, the field of social media research in this population is still in its infancy, and further work is needed in several arenas.

First, studies should expand and deepen observational research on social media sites. Past studies have described the content and timing of posts on sites such as MySpace, Facebook, and Twitter (Hinduja and Patchin 2008; Moreno et al. 2009*b*, 2010*a*; West et al. 2012). According to McCreanor and colleagues (2013, p. 119), "currently research is preliminary and descriptive, and we need innovative methods and detailed in-depth studies to gain greater understanding of young people's mediated drinking cultures and commercial alcohol promotion." Thus, studies have not yet fully harnessed the social aspects of social media by studying interactions between peers, distribution of content through a social network, or interactions between adolescents and adults. These types of studies would help deepen our understanding of how alcohol content is distributed and shared through networks and potentially identify intervention partners who have access to and are willing to confront adolescents and young adults regarding displayed references to alcohol.

Second, researchers should further explore the interactive nature of social media sites that provides new opportunities for interventions. Such interventions must be developed with an understanding of the privacy settings within each network. Only individuals who are able to view the content and are comfortable communicating about it would be able to conduct such interventions. Understanding to what extent parents, teachers, college resident advisors, and other influential adults are privy to young people's displays of alcohol content on social media is an area for future inquiry. For example, if parents see a reference to problem alcohol use on their child's Facebook profile, that reference may indicate that the child actually engages in problem drinking. Parent–child communication prompted by that social media reference could have an important impact. Preliminary work has explored communication strategies for these encounters and potential intervention opportunities (Moreno et al. 2012*a*; Park and Calamaro 2013; Whitehill et al. 2013). However, additional work is needed to understand how this knowledge can be translated into clinical practice or educational interventions appropriate to different settings, such as schools, clinics, or universities (George et al. 2013).

Third, research should explore the extent to which young people are exposed to advertising from alcohol manufacturers across social media sites. Regulations or new technology-based methods to avoid displaying such content to underage individuals may be possible and warranted. The same social-marketing approaches that may be used to promote alcohol on social media also can potentially be harnessed to promote abstention before age 21 and responsible use thereafter. In these ways, an improved understanding of the new landscape of social media could be used to reduce the negative consequences of alcohol use among youth.

In all future studies involving social media sites, attention to two factors will be critical. First, researchers must pay attention to privacy settings on the sites and the users' expectations for protection of their confidentiality. Previous work has illustrated that older adolescents are willing to interact with others regarding their displayed health risk behaviors on social media sites (Moreno et al. 2012*b*); however, differences may exist between social media sites with respect to users' expectations for privacy. Second, it is crucial to approach social media sites with the same ethical and regulatory rigor that is expected in offline studies involving human subjects. To this end, several guidelines have been published that identify best practices in study design and working with institutional research boards (Moreno et al. 2009, 2013*a*; Sixsmith and Murray 2001; Zimmer 2010).

Conclusion

Social media have a broad reach into the lives of many young people and therefore have the potential to strongly influence their decisions. The growing body of literature on social media and alcohol suggests that researchers can consider the role of social media in alcohol consumption in two ways. First, social media can serve as a source of information about the behavior of the individual user, as illustrated by studies that link online content to offline behavior (Moreno et al. 2011) or demonstrate links between online and offline alcohol consumption patterns (West at al. 2012). Second, social media can be a source of influence on behavior according to such behavioral models as Social Learning Theory (Bandura 1986), the Media Practice Model (Brown 2000), and new theoretical frameworks such as the Facebook Influence Model (Moreno et al. 2013*b*). The influence of alcohol advertising in social media is not yet fully understood. Future work is needed to broaden our understanding of alcohol content across social media sites and over time in an adolescent's development. Preliminary studies have begun to investigate possibilities for interventions using social media (Moreno et al. 2012*a*; Park and Calamaro 2013; Whitehill et al. 2013). Additional studies should integrate observational data, health behavior theory, and intervention possibilities to fully harness the tools social media may offer in the public health arena.

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Electronic Feedback in College Student Drinking Prevention and Intervention

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Alcohol consumption is prevalent among college students and can be associated with serious negative consequences. Several efficacious programs using one-on-one brief intervention techniques have been developed to target high-risk drinking by individual students, such as the Brief Alcohol Screening and Intervention for College Students (BASICS) (Dimeff et al. 1999). To reach a larger population (e.g., the incoming freshman class), researchers have adapted these interventions so that students can access them via the Internet or in some other electronic format. The purpose of this review is to discuss specific alcohol intervention programs that were (1) designed to be delivered remotely (e.g., via the Web or on an electronic device) without interaction with a provider and (2) were tested among college students using a randomized controlled trial design. Specific studies were drawn from earlier reviews as well as a comprehensive literature search. Although many programs have limited research support, and some findings are mixed, components that were directly translated from in-person BASICS to remote-delivery mediums (i.e., personalized feedback interventions [PFIs], personalized normative feedback [PNF] interventions), and broader programs that incorporate PFI/PNF, show promise in reducing alcohol use and/or negative consequences. However, more research is needed and suggestions for how the field can move these interventions forward are discussed.

Key words: Alcohol use, abuse, and dependence; alcohol consumption; alcohol use associated effects and consequences; problematic alcohol use; risky drinking; intervention; prevention; college students; undergraduate student; college freshman year; technology; electronic health technology; Internet; World Wide Web; brief intervention; personalized feedback intervention (PFI); personalized normative feedback (PNF); randomized controlled trial; literature search

Compared with young adults not in college, college students exhibit higher rates of both regular alcohol consumption (67.7 percent vs. 53.9 percent) and heavy episodic consumption[1] (37.4 percent vs. 29.5 percent) (Johnston et al. 2013) and are therefore at elevated risk for the myriad, and often costly, consequences related to alcohol misuse (Hingson et al. 2009; Perkins 2002). A variety of approaches to curtail high-risk drinking have been implemented over the years, including interventions aimed at the drinking behavior of individual students.

There has been a notable progression in individual-focused prevention efforts from purely educational programs, which typically emphasized potential life-altering consequences (e.g., grave injury, death) toward those that use alcohol-focused education to support alcohol skill use (e.g., refusal skills, protective behavioral strategies), placing primary focus on enhancing motivation and self-efficacy to act responsibly with respect to alcohol. The prototype for this latter approach is the Brief Alcohol Screening and Intervention for College Students (BASICS) (Dimeff et al. 1999), a brief motivational intervention (BMI) led by a facilitator trained in motivational interviewing (MI) (Miller and Rollnick 2013). In BASICS, each student participates in a one-on-one session to discuss personalized feedback related to alcohol use (i.e., the facilitator guides a discussion of the student's alcohol use and consequences, their normative perceptions of other students' drinking, their expectations about alcohol's effects, etc., which were assessed prior to the session and are summarized for the student on a printed feedback sheet), coupled with education and skills training. Although the shift toward programs such as BASICS predates the 2002 report from the National Institute on Alcohol Abuse and Alcoholism's (NIAAA's) Task Force on College Drinking (NIAAA 2002), the compelling evidence for skills-based, motivational enhancement approaches highlighted in the Task Force report spurred the field to generate new interventions based on components of

[1] Wechsler and colleagues (1995) define an occasion of heavy episodic consumption as five or more drinks for men and four or more drinks for women in a row. This definition was used most frequently across the studies reviewed here; although, the statistics from the Monitoring the Future study (Johnston et al. 2013) do not differentiate by gender, and only indicate the percentage of young adults and college students (both men and women) who consumed five or more drinks on a single occasion.

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efficacious in-person programs, such as BASICS, that could reach a larger segment of the student body.

The first step toward bringing a BASICS-style BMI to a larger population was to test the effects of written personalized feedback delivered on its own, without a facilitator trained in MI (i.e., participants would receive feedback via U.S. mail) (e.g., Agostinelli et al. 1995; Larimer et al., 2007). With this approach, the written feedback was expanded to incorporate narrative explanations and supplemental material to replicate the information previously provided verbally by a trained facilitator. The approach has since been adapted for delivery via the Web, which has lower environmental and financial costs than the U.S. mail (i.e., no paper/envelopes, postage) and has become yet more attractive as technology (e.g., smartphones, tablets) evolved into the primary means by which young adults engage with the world and receive information.

Electronic alcohol feedback prevention programs (i.e., those designed to be delivered remotely, using some form of technology, typically the Web) include personalized feedback interventions (PFIs) that deliver most or all of the components included in the original BASICS feedback as well as personalized normative feedback (PNF) interventions that only deliver the normative re-education component of the BASICS feedback (i.e., educating participants about drinking norms and commonly held misperceptions about alcohol use among their peers). These programs are now common and include commercial and noncommercial branded interventions and interventions that are not branded, per se; the specifics of which may be unique to a single or small series of outcome studies. Some of these programs originally were designed to be focused on education but have since been modified (e.g., increasing focus on personalized feedback). Additional programs include some level of personalized feedback but do not rise to the level of what would constitute a PFI or PNF intervention. Given the range of available programs, this article will review the extant outcome literature for alcohol-specific, individual-focused, intervention programs designed for electronic delivery that include some level of personalized feedback, most of which may be considered a PFI or PNF intervention, that have been the subject of peer-reviewed, randomized controlled trials (RCTs) among college student populations.

The articles reviewed below were drawn from prior comprehensive qualitative reviews conducted by Cronce and colleagues (Cronce and Larimer 2011; Larimer and Cronce 2002, 2007), covering the span from 1984 to 2010, supplemented by a literature search of PsycInfo and Medline using comparable search terms with the stipulation that interventions be electronic (Web-based or delivered via an electronic device) and designed for administration outside of a controlled setting (although not always tested remotely). This strategy identified 29 new studies that utilized an RCT design and tested an electronic intervention for alcohol use within a sample of college students, reporting effects on one or more behavioral alcohol outcomes. These 29 studies are summarized in the table. Nearly all interventions were designed for delivery via the Web on a computer; therefore, unless otherwise stated, the reader should assume this is the method of intervention delivery. Effects on nonbehavioral outcomes, effects on use or consequences related to other drugs, comprehensive information on moderators and mediators of treatment effect, and full discussion of individual study limitations were considered beyond the scope of this review. Readers are referred to the original articles for more detailed information about a given study.

Branded Programs That Include PFI-Style Information

AlcoholEdu for College

AlcoholEdu for College incorporates personalized feedback regarding normative misperceptions and alcohol consumption, supplemented by education and skills training. Three studies reviewed by Cronce and Larimer (2011) (i.e., Croom et al. 2009; Hustad et al. 2010; Lovecchio et al. 2010) evaluated various versions of AlcoholEdu for College. Two additional publications reported on the effects of the intervention on alcohol use and consequences from a single multicampus study (Paschall et al. 2011*a,b*). Studies generally show reduced alcohol consumption and/or consequences (Hustad et al. 2010; Lovecchio et al. 2010; Paschall et al. 2011*a,b*) or a protective effect against increased alcohol use relative to assessment only (Lovecchio et al. 2010), at least in the short term (approximately 1 month). The largest study to date (Paschall et al. 2011*a,b*) utilized an intent-to-treat, campus-wide implementation strategy and randomly assigned 30 campuses to either an intervention or control group. Treatment effects were observed in the fall semester (following implementation in summer and early fall) that were no longer evident by spring. Although stronger effects were found among campuses with higher rates of intervention participation, the lack of endurance of effects requires further research, perhaps using a longitudinal versus panel design. Studies are not universally positive, however. Croom and colleagues (2009) found that AlcoholEdu participants reported less participation in drinking games but no changes in consumption or consequences.

AlcoholEdu for Sanctions

Whereas AlcoholEdu for College is advertised as a population-level prevention program for use with freshmen or the entire student body, AlcoholEdu for Sanctions specifically targets students who have been mandated to receive an alcohol intervention following a campus alcohol policy violation. The overall content of the program is similar to the original but emphasizes the prevention of future consequences and policy violations. One study reviewed by Cronce and colleagues (2011) (Carey et al. 2011) compared

Table Summary of Methodologies and Outcomes for Previously Unreviewed Studies Included in the Current Review

Authors Year	Group Studied	Intervention Condition	Behavioral Alcohol Assessment/Outcome Measures	Follow-up Assessment	Conclusions/Results For Electronic Intervention Condition(s)
Alfonso et al. 2013	Undergraduate students who were mandated to an alcohol intervention for violating university alcohol policies ($N = 173$).	Brief Alcohol Screening and Intervention for College Students (BASICS) (individual in-person brief motivational intervention [BMI]); CHOICES (group in-person); e-CheckUpToGo (individual personalized feedback intervention [PFI]).	Alcohol Timeline Followback; BAC; Rutgers Alcohol Problem Index.	3 months	e-CheckUpToGo was associated with significant within-person reductions in alcohol-related harms, which were similar to those observed for the BASICS condition. No reductions were evident on indices of alcohol use for those receiving e-CheckUpToGo.
Bewick et al. 2010	University students (ages 18–67; 95 percent undergraduates) reporting consumption of alcohol at least once every 6 months ($N = 1,112$); 57 percent of the sample scored 8 or higher on the AUDIT.	Immediate (weeks 1 through 7) vs. delayed (weeks 8 through 15) access to the Unitcheck electronic intervention vs. assessment only control.	Retrospective weekly drinking diary, AUDIT.	4 follow-up assessments across the 24-week study	Significant reductions in drinks per drinking occasion were evident in the delayed intervention and assessment-only conditions, with no effect in the immediate intervention condition. Those assigned to either intervention condition that completed more than two of the five total assessments showed greater reductions in drinking than those in the control condition.
Bingham et al. 2010	Freshmen college students who were living in dormitory housing ($N = 1,137$); sample divided into non-, low-, and high-risk drinkers for analyses. High-risk defined as consumption of an average of more than 14 (male) or 7 (female) drinks per week or 5 (male) or 4 (female) drinks in a row at least 2 times during the past 3 months. Nondrinkers reported no alcohol consumption in the 6 months preceding baseline.	Four sessions of online *Michigan Prevention and Alcohol Safety for Students* (M-PASS) program vs. assessment-only control.	Daily drinking questionnaire, 28-day Timeline Followback (TLFB), Young Adult Alcohol Problems Screening Test (YAAPST).	Posttest at end of intervention (9 weeks)	Among those assigned to M-PASS relative to control: high-risk male drinkers reported fewer episodes of heavy drinking; high-risk female drinkers reported lower total drinks on TLFB; low-risk female drinkers report fewer drinks per drinking day.
Bingham et al. 2011	3-month followup of sample reported in Bingham et al. (2010).	See Bingham et al. (2010).	See Bingham et al. (2010)	3 months after intervention end	Among those assigned to M-PASS relative to control: male and female high-risk drinkers reported fewer episodes of heavy episodic consumption and high-risk female drinkers also reported fewer alcohol-related consequences. Further, M-PASS showed protective effect among nondrinking women in terms of total drinks consumed.
Bryant et al. 2013	Students enrolled in first-year psychology courses ($N = 191$).	E-mailed PFI vs. e-mailed educational information about the risks of alcohol consumption.	AUDIT, Daily Drinking Questionnaire, Rutgers Alcohol Problem Index.	6 weeks	Relative to alcohol education, e-mailed PFI was associated with fewer drinks per week and fewer days drunk in the past 30 days.

Table Summary of Methodologies and Outcomes for Previously Unreviewed Studies Included in the Current Review *(continued)*

Authors Year	Group Studied	Intervention Condition	Behavioral Alcohol Assessment/Outcome Measures	Follow-up Assessment	Conclusions/Results For Electronic Intervention Condition(s)
Carey et al. 2013	College students who were mandated to an alcohol intervention for first-time campus alcohol policy violations ($N = 288$).	BMI or Alcohol 101+ program: self-chosen ($N = 147$) vs. randomly assigned ($N = 141$).	Daily Drinking Questionnaire; AUDIT; Brief Young Adult Alcohol Consequences Questionnaire.	1 and 2 months	Reductions in alcohol use and consequences were evident among those receiving the BMI relative to Alcohol 101+ at the 2-month followup. The absolute efficacy of Alcohol 101+ cannot be determined due to the absence of an assessment control condition; however, those who were randomly assigned to Alcohol 101+ showed greater reductions in drinks per drinking day and drinks per week relative to those who chose Alcohol 101+.
Donovan et al. 2012	High-school seniors and their parents ($N = 279$ parent–teen pairs, of which $N = 150$ who reported drinking and were included in analyses regarding alcohol use).	MyStudentBody-Parent (MSB-P) online intervention vs. attention control (e-mailed alcohol education newsletters).	Single question assessing number of heavy-drinking episodes in the past 30 days using 5/4 gender-specific criteria within 2-hour time frame on a given occasion.	1 week postintervention, 3 and 6 months	No treatment effect on proportion of teens reporting episodes of heavy drinking.
Doumas et al. 2010	First-year NCAA Division 1 intercollegiate athletes ($N = 106$); sample divided into low- and high-risk drinkers for analyses. High-risk defined as reporting one or more occasions of heavy drinking in the past 3 months using the 5/4 gender-specific criteria.	e-CheckUpToGo vs. Web-based alcohol education program.	Daily Drinking Questionnaire.	3 months	Relative to control, high-risk drinkers in the e-CheckUpToGo condition significantly reduced their weekly drinking, peak drinking quantity and frequency of drinking to intoxication. There were no differences among low-risk drinkers.
Doumas et al. 2011*a*	Freshmen college students randomly assigned as intact orientation groups ($N = 82$); sample divided into low- and high-risk drinkers for analyses. High-risk defined as reporting one or more occasions of heavy drinking in the past 3 months using the 5/4 gender-specific criteria.	e-CheckUpToGo vs. assessment-only control.	Daily Drinking Questionnaire; Rutgers Alcohol Problem Index; individual items assessing peak alcohol consumption and frequency of drinking to intoxication.	3 months	Relative to control, high-risk drinkers in the e-CheckUpToGo condition significantly reduced their peak drinking quantity and frequency of drinking to intoxication. However, only seven participants were in the high-risk e-CheckUpToGo condition.
Doumas et al. 2011*b*	Students mandated to university counseling services for violating university alcohol policies ($N = 37$).	Online e-CheckUpToGo feedback only (PFI) vs. counselor-facilitated review of e-CheckUpToGo feedback (BMI).	Daily Drinking Questionnaire; Rutgers Alcohol Problem Index; individual items assessing peak alcohol consumption and frequency of drinking to intoxication.	30 days	Participants in both conditions showed significant within-person reductions in weekly and peak drinking quantity, frequency of drinking to intoxication, and alcohol-related consequences. No significant differences were found between the groups.

Table Summary of Methodologies and Outcomes for Previously Unreviewed Studies Included in the Current Review *(continued)*

Authors Year	Group Studied	Intervention Condition	Behavioral Alcohol Assessment/Outcome Measures	Follow-up Assessment	Conclusions/Results For Electronic Intervention Condition(s)
Doumas et al. 2011*c*	8-month followup of sample reported in Doumas et al. (2011*b*) ($N = 83$).	See Doumas et al. (2011*b*).	See Doumas et al. (2011*b*).	8 months	Relative to those in the e-CheckUp-ToGo PFI condition, participants in the BMI condition showed significant reductions in weekly drinking quantity and frequency of heavy episodic drinking. Participants in the PFI condition showed increases on these drinking indices.
Ekman et al. 2011	Sophomore students from a single Swedish university who consumed 180/120 (men/women) grams of alcohol or more per week in the past 3 months and/or consumed 60/48 (men/women) grams of alcohol or more on two or more occasions in the past month ($N = 158$).	Personalized normative feedback (PNF) with harm reduction tips compared with a minimal feedback control (comparing the student's drinking to national safe drinking guidelines).	Items assessing average weekly alcohol consumption, frequency of heavy episodic drinking and peak BAC; specific measures used were not indicated.	3 and 6 months	Significant within-person reductions in weekly consumption in the PNF group, and significant within-person reductions in number of heavy drinking episodes in both conditions at both followups. No significant between-group differences for alcohol-related outcomes at either time point.
Hagger et al. 2012	Undergraduate students from a single university in the United Kingdom ($N = 238$).	Web-based instructions: 2 (mental simulation of achieving goal of keeping drinking within safe limits vs. no mental simulation) × 2 (intention to implement reduction in drinking vs. no implementation intention) design.	Items assessing number of alcohol units consumed and number of episodes of heavy drinking in the past 4 weeks using criteria applicable in the United Kingdom; specific measures used were not indicated.	1 month	Receipt of the mental simulation instructions without the implementation intention instructions was associated with reductions in number of units consumed and heavy episodic drinking.
Hendershot et al. 2010	College students of northeast Asian descent ($N = 200$).	Web-based ALDH2 genotype-specific feedback (ALDH2*1/*1, ALDH2*1/*2, or ALDH2*2/*2) vs. attention control.	Daily Drinking Questionnaire.	30 days	Participants heterozygous for the ALDH 2*2 allele (i.e., ALDH2*1/*2) who received genetic-risk feedback personalized to their genotype showed reductions in quantity and frequency of drinking relative to control.
Hester et al. 2012	College students who reported one or more occasion of heavy episodic drinking in the past 2 weeks using the 5/4 gender-specific criteria with an associated blood alcohol content [BAC] of .08%. (Two trials: $N = 130$ and $N = 81$).	College Drinkers Check-up (CDCU). In experiment 1, CDCU vs. assessment-only control; in experiment 2: CDCU vs. a delayed-assessment control group.	AUDIT, Brief Drinker's Profile, 19 items from the CORE Institute's alcohol survey related to negative consequences.	Experiment 1: 1 and 12 months; Experiment 2: 1 month	Experiment 1: Adjusting for multiple comparisons, reductions in peak BAC on two heavier occasions in the past month were evident at 1-month followup among those assigned to CDCU, but the effect was absent at 12 months. Experiment 2: CDCU associated with significant reductions in drinks per week, typical peak BAC, and average number of drinks and BAC on two heavier occasions in the past month.

Table Summary of Methodologies and Outcomes for Previously Unreviewed Studies Included in the Current Review *(continued)*

Authors Year	Group Studied	Intervention Condition	Behavioral Alcohol Assessment/Outcome Measures	Follow-up Assessment	Conclusions/Results For Electronic Intervention Condition(s)
Kypri et al. 2008	Students at a New Zealand student health service scoring 8 or higher on the AUDIT (*N* = 429).	Single-dose PFI vs. two-dose PFI vs. education-only control.	AUDIT, additional items assessing frequency of drinking, typical quantity per occasion, total volume, frequency of heavy drinking episodes (120/80 g, men/women), consequences of heavy drinking; specific measures used were not indicated.	1, 6, and 12 months	Reductions in frequency of drinking, total consumption, and academic consequences at 6 months in both PFI conditions relative to control. Additional reductions in frequency of drinking, typical quantity, and frequency of heavy episodic consumption at 6 months in the multidose PFI condition. Reductions in total consumption and academic problems were still evident at 12 months in the single dose PFI condition. Reductions in academic problems were also still evident at 12 months in the multidose condition, and effects on nonacademic consequences emerged. Reductions in AUDIT scores (alcohol problems) were evident in both PFI groups at 12 months.
Kypri et al. 2009	Undergraduates at a single Australian university who scored 8 or higher on the AUDIT and who exceeded Australian gender-specific standards for one or more episodes of heavy episodic drinking in the past 4 weeks (*N* = 1,904 at 1-month followup; 1,578 at 6 months).	Two-dose PFI vs. assessment only control.	AUDIT, Alcohol Problems Scale (APS), Academic Role Expectation and Alcohol Scale (AREAS), additional items assessing frequency and quantity of drinking, and heavy-drinking episodes.	1 and 6 months	Relative to control, participants in the PFI condition reported significant reductions in frequency and quantity of drinking (drinks per occasion and total consumption) at 1-month followup; effects on frequency of drinking and total consumption were maintained at 6 months.
Kypri et al. 2014	Non-Maori students at seven New Zealand universities who scored 4 or higher on the AUDIT-C (*N* = 2,850).	PFI including screening for, and feedback regarding, alcohol dependence vs. assessment only.	AUDIT-C, AREAS, additional items assessing alcohol use; for intervention participants only: AUDIT, Leeds Dependence Questionnaire.	5 months	PFI with dependence screening and feedback resulted in fewer drinks per drinking occasion at followup; however, analyses accounting for attrition call this finding into question. No effects evident on five other indices of alcohol use.
LaBrie et al. 2013	Heavy-drinking Caucasian and Asian undergraduates at two West Coast universities (*N* = 1,663).	Web-based PFI vs. eight Web-based PNF conditions differing on level of specificity of student-normative referent groups: typical same-campus student or a same-campus student at one (either gender, race, or Greek affiliation), or a combination of two, or all three levels of specificity vs. non-alcohol normative feedback control.	Daily Drinking Questionnaire, Quantity/Frequency Index, Rutgers Alcohol Problem Index.	1, 3, 6, and 12 months	Both the PFI and PNF groups reported significant reductions in indices of alcohol use relative to control, with participation in any PNF group also associated with significant reductions in alcohol-related negative consequences. PFI and PNF were no different than one another across alcohol use and consequence outcomes. Comparison among PNF conditions supports the use of the "typical student" normative referent.

Table Summary of Methodologies and Outcomes for Previously Unreviewed Studies Included in the Current Review *(continued)*

Authors Year	Group Studied	Intervention Condition	Behavioral Alcohol Assessment/Outcome Measures	Follow-up Assessment	Conclusions/Results For Electronic Intervention Condition(s)
Lee et al. 2014	Students intending to go on a spring break (SB) trip with friends as well as to engage in heavy episodic drinking (using the 5/4 gender-specific criteria) on at least 1 day of SB ($N = 783$; $N = 507$ who actually went on a SB trip).	Standard BASICS vs. SB-focused BASICS vs. SB-focused BASICS with a friend vs. SB-focused PFI vs. SB-focused PFI with a friend vs. attention control.	Modified Daily Drinking Questionnaire to assess SB drinking intentions (baseline) and actual consumption (followup), 12 items modified from the Young Adult Alcohol Problems Screening Test and the Young Adult Alcohol Consequences Questionnaire to measure anticipated (baseline) and actual (followup) alcohol-related consequences.	1 week after SB	Neither of the PFI conditions (with or without a friend) resulted in reductions in alcohol use or consequences. Only in-person SB-focused BASICS without a friend reduced drinking versus attention control.
Lewis et al. 2014	College students who reported being sexually active within the past year, typically with a member of the opposite sex, and who also reported at least one occasion of heavy episodic drinking in the past month using the 5/4 gender-specific criteria ($N = 480$).	Alcohol-only PNF (PNF-A), alcohol-related risky sexual behavior (RSB) only PNF (PNF-RSB), combined alcohol and alcohol-related RSB PNF (PNF-C), or assessment-only control.	Daily Drinking Questionnaire, Quantity/Frequency Index, Brief Young Adult Alcohol Consequences Questionnaire, additional individual items assessing risky sexual behavior and normative perceptions of sexual behavior adapted from prior work by the first author.	3 and 6 months	Compared with control, PNF-C and PNF-A were associated with reductions in drinking quantity and frequency at 3 months with most effects maintained at 6 months. PNF-C and PNF-RSB were effective in reducing frequency of drinking prior to sex at 3- but not 6-month followup. None of the interventions reduced alcohol-related negative consequences.
Martens et al. 2010	Intercollegiate college athletes ($N = 263$) from three colleges in the Northwest, Midwest, and Northeast.	PFI targeted to college athletes vs. standard PFI targeted to college students in general vs. alcohol education control.	Daily Drinking Questionnaire, Brief Young Adult Alcohol Consequences Questionnaire.	1 and 6 months	Those receiving the targeted PFI who were currently in their athletic season ($N = 57$) or who were heavier drinkers at followup ($N = 61$) reported fewer drinks per week and lower peak BAC, respectively, at 1 month. At 6 months, the effect of the targeted PFI on peak BAC was evident across all participants in that condition, and the standard PFI also showed reductions in peak BAC among heavier drinkers $N = 57$).
Mason et al. 2014	Undergraduates enrolled in psychology courses at a single Southeastern university who scored 8 or higher on the AUDIT ($N = 18$).	Automated personalized text messaging (four to six messages for 4 days that required a brief response) vs. assessment-only control.	AUDIT, additional items assessing quantity and frequency of alcohol use; specific measures used not specified.	1 month	No effects on alcohol use or problems.
Moreira et al. 2012	Freshmen and sophomore college students from 22 universities in the United Kingdom ($N = 876$ at 6 months, 1,050 at 12 months).	E-mailed PNF vs. repeated assessment-only control vs. posttest-only (at 12-month followup) control.	AUDIT, individual items developed by the authors assessing alcohol quantity, frequency and alcohol-related consequences.	6 and 12 months	Compared with repeated-assessment-only control, participants in the PNF group reported less weekly drinking at 6 months (looking at the full sample and a high-risk subsample), but this effect was absent at 12 months. No other effects of the intervention on alcohol use or consequences were evident.

Table Summary of Methodologies and Outcomes for Previously Unreviewed Studies Included in the Current Review *(continued)*

Authors Year	Group Studied	Intervention Condition	Behavioral Alcohol Assessment/Outcome Measures	Follow-up Assessment	Conclusions/Results For Electronic Intervention Condition(s)
Murphy et al. 2010, study 2	College students reporting at least one occasion of heavy episodic drinking in the past month using the 5/4 gender-specific criteria ($N = 118$).	BASICS vs. e-CheckUpToGo vs. assessment only.	Daily Drinking Questionnaire, individual item assessing number of heavy drinking episodes in the past month.	1 month	Participants assigned to e-CheckUpToGo showed within-person reductions in weekly drinking quantity ($d = 0.42$) and frequency of heavy episodic drinking ($d = 0.39$). The e-CheckUpToGo condition was not significantly different than BASICS in terms of reductions in heavy episodic drinking; however, it was also no different than assessment only on this variable or weekly drinking.
Neighbors et al. 2010	Freshmen reporting at least one occasion of heavy episodic drinking in the past month using the 5/4 gender-specific criteria ($N = 818$).	One- vs. four-dose gender-specific PNF vs. one- vs. four-dose gender-neutral PNF vs. attention control.	Daily Drinking Questionnaire, Alcohol Consumption Index, Rutgers Alcohol Problem Index.	6, 12, 18, and 24 months	Biannually administered gender-specific PNF was associated with decreased weekly drinking for men and women, and with fewer-alcohol related consequences for women only. No effects were evident for either of the single-dose PNF conditions or the biannual (four-dose) gender-neutral PNF.
Neighbors et al. 2012	Students intending to engage in heavy episodic drinking (using the 5/4 gender-specific criteria) on their 21st birthday ($N = 599$).	Standard BASICS vs. 21st birthday–focused BASICS vs. 21st birthday–focused BASICS with friend vs. 21st birthday–focused PFI vs. 21st birthday–focused PFI with friend vs. an attention control.	Modified Daily Drinking Questionnaire to measure 21st birthday drinking intentions (baseline) and actual consumption (followup), modified Young Adult Alcohol Problems Screening Test to measure anticipated (baseline) and actual (followup) alcohol-related consequences.	1 week after 21st birthday	21st birthday–focused PFI (without friend) was associated with lower BACs on participants' 21st birthday compared with control, similar to standard BASICS, but had no effect on total consumption or consequences. 21st birthday–focused PFI with friend reduced alcohol-related consequences relative to control, similar to all three BASICS conditions but did not reduce consumption or BAC.
Palfai et al. 2011	Introductory psychology students reporting two or more occasions of heavy episodic drinking in the past month using the 5/4 gender-specific criteria or who had an AUDIT score of 8 or higher ($N = 119$).	PFI vs. attention control.	Daily Drinking Questionnaire, Young Adult Alcohol Problems Screening Test.	1 month	Those with high (vs. low) levels of alcohol-related consequences at baseline who were assigned to the PFI showed significantly greater reductions in weekly drinking quantity and number of heavy-drinking episodes relative to control participants.
Paschall et al. 2011*a*	Multicampus study ($N = 30$ campuses, 5,074 college freshmen).	AlcoholEdu for College vs. control.	Individual items assessing past-30-day alcohol use, average number of drinks per occasion, and heavy episodic consumption.	N/A (fall and spring assessments were cross-sectional, not longitudinal)	Relative to control campuses, students at colleges assigned to AlcoholEdu for College reported reductions in past 30-day alcohol use and frequency of heavy episodic consumption in the fall; however, these effects were absent at the subsequent spring assessment.

Table Summary of Methodologies and Outcomes for Previously Unreviewed Studies Included in the Current Review *(continued)*

Authors Year	Group Studied	Intervention Condition	Behavioral Alcohol Assessment/Outcome Measures	Follow-up Assessment	Conclusions/Results For Electronic Intervention Condition(s)
Paschall et al. 2011*b*	Additional findings from Paschall et al. (2011*a*).	See Paschall et al. (2011*a*).	Rutgers Alcohol Problem Index.	See Paschall et al. (2011*a*)	Relative to control campuses, students at colleges assigned to AlcoholEdu for College reported reductions in alcohol consequences in the fall; however, these effects were absent at the subsequent spring assessment.
Patrick et al. 2014	Undergraduates (ages 18–21) who planned to go on a SB trip with their friends ($N = 263$).	Combined SB alcohol use and SB alcohol-related RSB PNF vs. assessment-only control.	Individual items assessing anticipated and actual alcohol use, sexual behavior, and associated consequences.	1 week after SB	No significant differences between PNF and control on alcohol use, risky sexual behavior or related consequences.
Schuckit et al. 2012	Freshmen who have never met criteria for DSM–IV alcohol or drug dependence, who reported any drinking in the past 6 months and who reported a low or high subjective level of response (LR) to alcohol ($N = 64$).	Prevention videos tailored to a low LR to alcohol vs. non-tailored prevention videos.	Individual items assessing alcohol use and associated consequences (drawn from the Rutgers Alcohol Problem Index).	Immediate posttest and 4 weeks following end of the intervention	Although all participants showed significant decreases in typical and peak drinks per occasion, participants with a low LR who were assigned to the tailored group showed greater reductions than those assigned to the nontailored group. Additionally, in terms of typical drinks per occasion, those with high LR assigned to the nontailored group showed greater reductions than those in the tailored group.

AlcoholEdu for Sanctions with a waitlist control group and at the 1-month followup found reductions in alcohol use, relative to the control group, for men only. Within-person reductions in alcohol use were reported in women in the intervention group, but no differences were found between women in the intervention and control groups. Likewise, within-person reductions in alcohol consequences were evident for men and women, but these reductions did not differ relative to the control group. No additional studies were identified, indicating a need for more research to establish efficacy.

Check Your Drinking (CYD)

All iterations of CYD have included a brief online assessment followed by presentation of personalized feedback. Two studies reviewed by Cronce and Larimer (2011) (Doumas and Haustveit 2008; Doumas et al. 2009) evaluated the efficacy of the original beta version of CYD, showing reductions in both alcohol consumption among mandated students and high-risk-drinking intercollegiate athletes at the 1- and 3-month followup, respectively. Although the original beta version still is available, the program now is in its third iteration (version 3.0). Whereas studies have been conducted in the general adult population, to date, CYD 3.0 does not seem to have been specifically evaluated among college students. Therefore, research is needed to establish the efficacy of the most current iteration in college populations.

College Drinker's Check-up (CDCU)

CDCU is a Web-based adaptation for college students of the well-established in-person intervention known as the Drinker's Check-up, originally developed for heavy-drinking adults. Like its predecessor, the CDCU begins with a screening instrument and incorporates decisional balance exercises (i.e., assessing and considering pros and cons of drinking) along with personalized feedback. A single two-trial study (Hester et al. 2012) has evaluated CDCU. In the first trial, reductions in peak blood alcohol concentration (BAC) were significant (correcting for multiple comparisons) at 1 month compared with repeated assessment but were absent at 12 months. The second trial, comparing CDCU to postassessment only (versus repeated assessment) found robust reductions across peak and typical drinking outcomes from baseline to 1 month. Although preliminary evidence suggests that this program may be efficacious, limited evidence, in addition to the sole finding of reduced peak BAC compared with repeated assessment, points to the need for further evaluation before the program should be widely adopted.

e-CheckUpToGo

E-CheckUpToGo, called e-CHUG in earlier versions, incorporates assessment, personalized feedback targeting normative misperceptions and other alcohol behaviors, education, and skills training. Three of the four previously reviewed studies on this approach demonstrated at least short-term positive effects on alcohol use (Doumas and Andersen 2009; Hustad et al. 2010; Walters et al. 2007) and alcohol-related consequences (Doumas and Andersen 2009). Five new studies have been published since the 2011 review by Cronce and Larimer, three of which show reductions in various indices of alcohol use (Doumas et al. 2010, 2011*a*) and/or consequences (Alfonso et al. 2013) relative to control subjects across follow-up periods ranging from 1 to 6 months. One study (Murphy et al. 2010) demonstrated no between-group differences at 1 month compared with assessment only, although the study did show within-group differences for e-CheckUpToGo. Another study showed successes compared with an in-person BMI at 1 month that were no longer present at the 8-month followup, with increased drinking evident in the e-CheckUpToGo group (Doumas et al. 2011*b*,*c*). Absence of an assessment-only control in this study leaves overall efficacy unclear. Although e-CheckUpToGo has been tested across an array of high-risk populations (e.g., mandated students, athletes, and freshmen), research on any one college population is relatively limited and would benefit from replication, especially given variation in specific effects on alcohol outcomes across studies.

MyStudentBody (MSB) and MyStudentBody-Parent (MSB-P)

MSB includes general education and skills training, along with assessment and personalized feedback discussing alcohol behavior, beliefs, and risks. One previously reviewed study (Chiauzzi et al. 2005) evaluated MSB among binge-drinking college students. Participants randomly assigned to MSB showed reductions in peak drinks per drinking day and composite drinking index scores at 1 month but were no different than an alcohol education control group at 3 months. Female, but not male, MSB participants showed reduced consumption on special occasions and fewer alcohol-related negative consequences relative to control subjects at followup. Additional research is needed to evaluate efficacy.

More recently, Donovan and colleagues (2012) examined MSB-P, a modification of MSB delivered to parents (only) that encourages parent–teen communications about alcohol. Parent–teen dyads were randomly assigned to either MSB-P or an attention control (i.e., receipt of an equal amount of material that is not expected to produce change, in this case, an alcohol education e-mail newsletter). Parents received the intervention 4 weeks prior to the start of their child's freshman year of college. Assessments through 6 months postintervention found no impact on students' binge drinking, which was the single alcohol use outcome variable.

Unitcheck

Unitcheck provides personalized feedback on alcohol consumption as well as related education and advice. One previously reviewed study (Bewick et al. 2008) demonstrated that drinks per drinking occasion were reduced at 12 weeks postintervention compared with assessment only. Subsequently, Bewick and colleagues (2010) randomly assigned students reporting alcohol use in the past 6 months to immediate access to the intervention (weeks 1 to 7), delayed access (weeks 8 to 15), or assessment only. Results were mixed. Reductions in drinks per drinking occasion occurred for the delayed and assessment-only conditions but not in the immediate condition. Across conditions, participants who completed a minimum of two of five assessments reduced drinking with additional reduction for those assigned to the intervention arms. This study demonstrated that repeated assessment alone may be effective at reducing alcohol consumption, and this may be enhanced by participation in an intervention such as Unitcheck. As with many programs, more research is needed.

Unbranded PFI-style and Personalized Normative Feedback (PNF) Programs

A number of studies have examined the effects of unbranded PFIs and/or single-component PNF interventions, the features of which differ, and any one version may only be represented by a single study. Two previously reviewed studies evaluated unbranded electronic PFIs with generally positive findings. Compared with a control group, Kypri and colleagues (2004) showed reduction of alcohol use and consequences, and, comparing a minimal versus enhanced version of PFI, Saitz and colleagues (2007) found within-person reductions in alcohol use and problem severity among women and in problem severity, but not consumption, among men across active interventions. Evaluating a brief computer-based PNF, Neighbors and colleagues (2004) found reductions in drinking persisting up to 6 months.

Twelve subsequent studies have tested other unbranded PFIs or PNFs. Similar to Saitz and colleagues (2007), Kypri and colleagues (2008) compared two versions of a PFI (a single vs. multiple dose) but also included an education-only control condition. Students scoring 8 or more on a 10-question screening instrument (i.e., Alcohol Use Disorders Identification Test [AUDIT]) were recruited from primary care. Relative to a control group, a single dose of a PFI resulted in lower frequency of drinking at 6-month followup, lower total consumption and academic consequences at both 6- and 12-month followup and reduced alcohol problems at 12 months. The multidose condition resulted in decreased typical quantity and frequency of drinking, lower total consumption, and reduced frequency of heavy episodic drinking at the 6-month followup; reduced academic consequences at both the 6- and 12-month followup, and

reduced non-academic consequences and alcohol problems at the 12-month followup.

Kypri and colleagues (2009) compared a two-dose PFI to assessment-only among Australian college students who scored 8 or more on the AUDIT and engaged in at least one occasion of heavy episodic consumption over the previous 4 weeks. Participants received assessment and feedback at baseline and again 1 month later, including additional feedback on alcohol use and consequences that occurred after the initial feedback. Of outcomes examined at 1-month followup, participants receiving the two-dose PFI reported a lower frequency of drinking, fewer drinks per occasion, and lower total consumption relative to those who received assessment only. Only the effects on frequency of drinking and total consumption were maintained at the 6-month followup. Negative-consequence variables did not differ at either time point. Overall differences in alcohol consumption differed by condition, with the intervention group consuming 17 percent less alcohol compared with an 11 percent reduction by the control condition. The authors indicated that this was primarily driven by reductions in frequency of drinking rather than amount consumed per episode.

Kypri and colleagues (2014) compared a PFI to assessment only among students scoring 4 or more on the AUDIT-C[2] at seven New Zealand universities. At the 5-month followup, those randomly assigned to PFI reported fewer drinks per typical drinking occasion; however, this effect was reduced to non-significance in sensitivity analyses designed to detect effects of differential attrition. No effects on the five other drinking-related outcomes assessed were evident.

Palfai and colleagues (2011) randomly assigned college students scoring 8 or more on the AUDIT to PFI versus attention control. At the 1-month followup, participants who received the PFI reported drinking fewer drinks per week overall. Subsequent analyses indicated that this effect was driven by those students who had reported a greater number of alcohol consequences at baseline, with no effect of the intervention among students with a lower number of baseline consequences. A similar effect was shown for heavy episodic consumption, with reductions in episode frequency evident among those with greater baseline consequences and not for those with fewer baseline consequences.

Martens and colleagues (2010) compared two forms of PFI—one targeted to college athletes and the other aimed at college students in general (generic)—against an alcohol education control group among varsity and club-sport athletes. At 6 months, those in the targeted PFI condition reported lower peak BAC compared with the control group and the generic PFI, with increases in peak BAC evident in these latter two groups. However, for heavy drinkers, reductions in peak BAC were evident for both PFI conditions compared with the control group. No effects were found for other alcohol-related indices.

Bryant and colleagues (2013) randomly assigned students to receive either a PFI or educational information on the risks of alcohol via e-mail. Followup at 6 weeks postintervention revealed that those who had received the PFI reported fewer drinks per week and fewer days drunk in the past 30 days compared with those who received education only. However, it must be noted that about 40 percent of students were lost to followup, and these individuals reported significantly higher values on all alcohol outcome measures at baseline.

LaBrie and colleagues (2013) compared a full PFI to eight versions of a PNF intervention (a component of the full PFI) that varied the specificity of the normative reference group and a generic non–alcohol-focused normative feedback control group in Caucasian and Asian students reporting one or more occasions of heavy episodic consumption in the past month. PFI participants reported lower peak drinking and fewer drinking days compared with control subjects, with no effects on alcohol consequences. Those receiving any PNF reported lower average total consumption, lower peak drinking, fewer drinking days, and fewer alcohol consequences compared with control subjects. Comparisons of PNF conditions indicated that use of the "typical student" reference group is most effective.

Lewis and colleagues (2014) expanded targets of PNF to include alcohol-related risky sexual behaviors (RSB) in addition to alcohol-related behaviors. Students were stratified by gender and level of drinking and randomly assigned to an alcohol-only PNF, an alcohol-related RSB-only PNF, a combined alcohol and alcohol-related RSB PNF, or assessment only. The alcohol-only and the alcohol-related RSB-only PNFs each reduced their target behaviors and the combined intervention reduced both sets of outcomes relative to control subjects. None of the interventions reduced alcohol-related consequences. Results indicate that combining related treatment targets may be an effective strategy.

Ekman and colleagues (2011) compared a minimal feedback intervention, in which participants' own drinking was compared with safe-drinking guidelines, to PNF with harm reduction advice among students at a Swedish university. Retention rates at the 3- and 6-month followup were quite low (between 24 percent and 38 percent), and although some significant within-person reductions in alcohol use and risk were evident, given the small sample size, it was not surprising that no significant between-groups effects emerged.

Moreira and colleagues (2012) evaluated PNF against assessment-only and delayed (posttest–only) assessment in a sample of students drawn from multiple universities in the United Kingdom. Although retention was poor (50 percent) at the 6-month followup, a significant decrease in weekly drinking was evident in the PNF group compared with control subjects. However, this effect was absent at the 12-month followup, and no effects were observed on any of the other alcohol outcome measures.

Neighbors and colleagues (2010) tested gender-specific versus non–gender-specific PNF as a single- versus four-dose (biannual) intervention against an attention control group among heavy-drinking freshmen. At 6 months, those

[2] The AUDIT-C is a three-item alcohol screening test that is scored on a scale from 0 to 12.

in the four-dose, gender-specific PNF condition reported lower weekly drinking compared with the control group. Women, but not men, who received the four-dose, gender-specific PNF decreased their alcohol problems compared with control subjects. No differences were found on any outcome between the control group and the gender-specific single-dose PNF or non–gender-specific PNF groups.

Finally, Mason and colleagues (2014) randomly assigned students with hazardous drinking to either an assessment-only control condition or a very brief (four to six texts over 4 consecutive days) automated text intervention including personalized information on drinking frequency, social norms, social risk, and protective behavioral "boosts," if requested. The amount of personalized information contained in the intervention is most consistent with a PNF versus a PFI; however, the inclusion of skills training and the MI framework used for the texts go beyond a standard PNF. This was a small-scale proof-of-concept investigation to determine feasibility. Although there were no significant group differences on behavioral alcohol outcomes, this was not surprising given the very small sample size. The results did show changes in potential mediators of intervention efficacy (i.e., readiness to change), suggesting further research may be warranted.

Event-Specific Prevention (ESP)

Electronic interventions targeting general alcohol misuse have been adapted to proactively address alcohol use and consequences for specific events associated with extreme alcohol consumption (i.e., 21st birthdays, spring break [SB]). In an ESP study reviewed by Cronce and Larimer (2011), Neighbors and colleagues (2009) randomly assigned participants to receive an electronic card 2 days before their 21st birthday that contained a hyperlink to personalized feedback about their drinking intentions and anticipated BAC for their 21st birthday, associated normative information, education on BAC effects, and suggestions for protective behavioral strategies. The intervention (which is most consistent with PNF) reduced reported BAC levels on the day of participants' 21st birthdays compared with an assessment-only control condition. This effect was pronounced for those with baseline intentions to reach higher BACs.

Three subsequent ESP studies were identified. In the first, Neighbors and colleagues (2012) tested a 21st birthday–specific in-person BASICS, a Web-based 21st birthday PFI, a general in-person BASICS condition, and attention control. Two additional conditions tested augmented versions of the 21st birthday–specific interventions by incorporating a friend of the participant who was supplied with alcohol education and harm reduction tips for their friend's birthday celebration. Students with reported intention to "binge drink" on their upcoming 21st birthday were randomly assigned to one of the six conditions. Results were mixed. None of the interventions reduced the number of drinks consumed compared with the control group. The 21st birthday PFI without the friend component, but not with, resulted in lower BACs compared with control subjects, as did the general in-person BASICS. Unlike the 21st birthday PFI without the friend component, the 21st birthday PFI with the friend component reduced consequences relative to the control group, as did all three in-person conditions.

With a similar design to Neighbors and colleagues (2012), Lee and colleagues (2014) conducted a large RCT examining five different intervention conditions against an attention control with the goal of reducing drinking and negative drinking consequences over SB. Two of five interventions included a PFI that was designed specifically to address SB drinking; one with a friend component, one without. Neither SB-PFI, with or without a friend, nor the original in-person BASICS, was shown to be effective in reducing SB drinking. Only the in-person SB-BASICS intervention without a friend reduced drinking compared with control subjects. Of note, the same intervention with the friend component was not effective.

Lastly, Patrick and colleagues (2014) applied a PFI modified to address both alcohol-related behavior and alcohol-related RSB, similar to Lewis and colleagues (2014), as an ESP to target SB alcohol use. Students between the ages of 18 and 21 who planned to go on SB trips with friends were randomly assigned to PFI or assessment only. Although normative perceptions were reduced, there were no main effects on any of the primary alcohol-related behavioral outcomes.

Other Programs with Minimal Personalization

In addition to unbranded PFIs, other interventions have taken advantage of technology-based delivery methods that include some personalization but which cannot be considered a full PFI or PNF intervention. For example, Cronce and Larimer (2011) reviewed a study by Weitzel and colleagues (2007) that compared 2 weeks of repeated (daily) assessment on a handheld (HH) computer plus tailored feedback on avoiding alcohol consequences, based on baseline levels of reported self-efficacy and drinking outcome expectancies, to repeated assessment alone. Those who received the tailored feedback messages reported fewer drinks per drinking day on the HH device during the daily assessment period. However, no group differences in drinking outcomes were evident on the retrospective assessment for the same period completed at the 2-week followup.

Hendershot and colleagues (2010) tested an intervention that targeted the $ALDH_2$ genotype, found almost exclusively in individuals of northeast Asian descent, which can convey a protective effect against alcohol misuse. Students of 100 percent Chinese, Korean, or Japanese heritage underwent genotyping and were randomly assigned to personalized genetic feedback that included their $ALDH_2$ test results and information specific to their genotype ($ALDH_2$ 1/1, $ALDH_2$ 1/2, $ALDH_2$ 2/2), or attention-control feedback that provided normative information about nonalcohol behaviors. At the 1-month followup, only the group with one of two affected alleles ($ALDH_2$ 1/2) demonstrated a

reduction in alcohol-related measures (i.e., peak quantity, typical weekend quantity, drinking frequency). However, this is an encouraging result as this genotype is most at risk for alcohol-related cancers.

Schuckit and colleagues (2012) examined a prevention paradigm based on another genetically linked trait, subjective levels of response (LR) to alcohol (high vs. low). Freshman were randomly assigned to either (1) a low LR–based prevention group (LRB group), which watched four 45-minute Internet-based videos that included, in addition to prevention messages, information on how low LR to alcohol may promote heavy drinking; or (2) a non-LRB comparison group, which saw the same prevention messages without the LR framework. Self-reported usual and maximum drinks per drinking occasion decreased significantly for all participants regardless of LR status or condition. Low-LR students showed the greatest decreases in the LRB condition and high-LR students showed greater decreases in the non-LRB condition, demonstrating support for tailoring prevention messages to specific predisposing factors such as LR. Because the study design did not include an assessment-only control group, general efficacy information is unknown.

Hagger and colleagues (2012) randomly assigned students from the United Kingdom to one of four instruction conditions delivered using Web and e-mail: implementation intention only (setting specific intentions to reduce alcohol intake), mental simulation only (visualizing achieving goals), a combination of the two, and an assessment-only control. Only the students in the mental simulation–only condition reduced alcohol consumption and heavy episodic drinking occasions over the subsequent month compared with the control group. Students with the highest baseline use, however, had a greater reduction in alcohol consumption in the combined condition than any of the other conditions.

Alcohol 101+

Alcohol 101+, a Web-based modification of the earlier CD-ROM–based Alcohol 101 program, provides alcohol education and skills training using a "virtual campus," modeling potential drinking situations and discussing possible consequences and alternatives, with personalized BAC calculations provided. Three studies were identified, two of which (Carey et al. 2009, 2013) included Alcohol 101+ as a control condition, limiting the ability to evaluate efficacy. The third (Carey et al. 2011), previously reviewed by Cronce and Larimer (2011), compared Alcohol 101+ with a waitlist control group and found reductions in alcohol use for male mandated students compared with wait-listed students at 1 month. However, only within-person reductions (no between-groups effects) were found for female mandated students. In terms of alcohol consequences, women assigned to Alcohol 101+ actually fared worse compared with waitlist students, and there were no intervention effects for men at 1 month.

Michigan Prevention and Alcohol Safety for Students (M-PASS)

M-PASS comprises 4 10- to 15-minute online MI sessions delivered over 9 weeks. Sessions were tailored based on the participants' general drinking profiles, readiness to change and self-efficacy, and included some personalized information (i.e., drinking norms based on participant's demographics). One study has evaluated the efficacy of the M-PASS program, with findings from posttest (Bingham et al. 2010) and 3-month followup (Bingham et al. 2011) published separately. Treatment effects, relative to the control group, varied somewhat by gender, with lower binge drinking frequency among high-risk drinking men, fewer total drinks consumed over the past 28 days among high-risk drinking women, and fewer drinks per drinking day among low-risk drinking women at posttest. At 3 months, male high-risk participants in M-PASS continued to show lower frequency of heavy episodic consumption compared with control subjects; however, the effect would not have been significant if a correction for multiple comparisons was applied. Treatment effects for women differed at the 3-month followup relative to posttest, with lower frequency of heavy episodic consumption and fewer alcohol related consequences among high-risk women relative to control subjects. The availability of a single study and the variability of findings over time indicate that additional research is needed before strong conclusions regarding efficacy can be drawn.

Discussion

College student alcohol use remains a critical issue. Fortunately, there have been successful advances in prevention strategies targeting individuals to reduce the harms associated with college student drinking. It is important to stress that no one program or approach is sufficient to prevent or reduce high-risk drinking, and an overall strategic plan should incorporate multiple approaches targeting every level of intervention (i.e., universal, selective, and indicated). Whereas the amount and quality of research on any one program varies, the extant evidence suggests that electronic interventions may be one piece of an effective overall strategic plan.

Although the general PFI approach (grouping together commercially branded and unbranded programs) and PNF approach seem to be efficacious on the whole, data are insufficient to make general recommendations regarding the best program for adoption. Moreover, overall conclusions regarding the efficacy of electronic interventions globally, and any one program, must be tempered by the limitations of the individual studies (e.g., small sample sizes, poor retention) as well as the challenges and limitations imposed by rapidly changing technology (e.g., devices and Web browsers are not universal, requiring unique adaptations of interventions; innovations make hardware outdated within 1 year) and specifics of the campus environment and resources (e.g., availability of programming staff to monitor

compliance; ability to impose contingencies on students who do not complete the intervention, such as holding grades or preventing registration). Certainly, additional research is needed, and efforts to replicate existing findings are indicated. Of note, many of the programs reviewed have been subject to modifications over time, resulting in multiple iterations or versions. Colleges wishing to implement one of these programs should conduct due diligence before adoption to understand which variant they are considering and to determine the empirical support for that specific version, as efficacy research on one version may not apply to others. For commercially available programs, colleges can, and should, request articles supporting efficacy for the current version that would be adopted on their campus to evaluate the potential benefit of implementation.

In addition to program choice, campuses may wish to consider for whom such approaches should be made available (e.g., first-year students, athletes, Greek members, mandated students, etc., which can be informed by research efforts to determine for whom these approaches are most helpful) and must also critically consider potential limitations of electronic interventions. For example, research has shown that without incentives or penalties for noncompliance, students are unlikely to complete interventions of their own volition (see Paschall et al. 2011*a*,*b*). Likewise, without face-to-face interaction with a person who can assess and confirm the degree to which a student is paying attention (as would be the case in an intervention like BASICS), a potential limitation includes the degree to which students are engaged in, connected to, and even multi-tasking during the intervention. Additionally, given the high variability in length and content across different electronic interventions, the appropriate intervention "dose" given to any individual student to decrease his or her alcohol use (and the consequences he or she has experienced) needs to be more firmly established (as does the need for any "booster" sessions beyond the initial intervention to potentiate and/or sustain effects). Although the effect of electronic interventions on alcohol-related negative consequences does not seem to be as robust as in-person BMIs (as they are only evident in a minority of the studies detailed here), followup generally has been shorter in studies of PFIs and PNF interventions relative to BMIs and it may be that longer followups are needed to demonstrate an effect on consequences. Other factors also may be at work, such as differences across studies in assessment tools used to measure consequences. Thus, more research is needed to specifically address under what conditions electronic interventions produce reductions in negative consequences.

In terms of future research, there are several interesting and important questions that need to be addressed in order to maximize the potential of electronic interventions. Briefly, these include the study of:

- *Additional interventions.* Other available programs would benefit from more thorough empirical validation, such as Alcohol-Wise, an educational program that contains e-CheckUpToGo, or MyPlaybook, a program targeted toward athletes. Although preliminary findings have been presented at informal academic venues, no peer-reviewed published RCTs were identified for these programs.

- *Timing of the intervention.* Many campuses require first-year students to complete an alcohol intervention prior to matriculation. Although this may convey the seriousness with which a campus takes alcohol prevention and serve to get students on the "same page" regarding alcohol information, students may not yet have a sense of general college norms, what goes on at their school, or what pressure to drink is like. Research could explore what, if any, boosters might be needed once students arrive on campus and if there is an optimal time for intervention delivery.

- *Opportunities for reaching more advanced students.* Given the emphasis on entering/first-year students, how might electronic interventions systematically be offered to students in later years of study? For example, research by Neighbors and colleagues (2009, 2012) suggests that students turning 21 could be invited to participate in an ESP. However, when not required (as with entering students), how might we attract students to participate in such interventions?

- *Electronic PFIs as a referral option.* Alcohol screening in campus health and counseling centers helps identify students struggling with substance use and reduce the likelihood of students "slipping through the cracks." Hingson (2010) suggested that if schools implement such screenings, there would be an impact at the campus level through referral to empirically supported interventions. As primary care–based BMIs typically are in person, determining what circumstances and for whom referral to an electronic PFI (adjunct or standalone) would be effective should be examined.

- *Keeping abstainers in mind.* Studies have shown a protective effect of personalized feedback for those who do not drink. For example, in a mailed feedback intervention, Larimer and colleagues (2007) demonstrated that abstainers who received the feedback were twice as likely to be abstaining 1 year later compared with control participants. With increased risk for addiction associated with earlier onset of use, delaying the initiation of use can be of great public health importance. The role of electronic interventions in achieving this goal should be explored and abstainers considered as schools develop a strategic plan.

- *Duration/length and formatting of interventions.* How brief can a brief intervention be and still be effective? Without a facilitator present, how much information is necessary to have an impact? In addition, as more online information is viewed on smaller tablets and phones, the

ability to impact change in a time- and space-efficient way will increase in importance.

Conclusion

As reviewed here, the existing evidence gives us reason to be excited about the potential of electronic feedback interventions in reducing high-risk drinking and related harm among college students. That said, the field is still young and research must be done to establish the parameters of successful intervention, as well as the reliability, relative efficacy, and longevity of effects related to specific electronic programs. PFI-style programs have the most research support to date, but the increasing variety of style and content of PFIs, including among electronic programs with different iterations, makes it harder to group these programs together when discussing efficacy but also points to the potential for campuses to develop their own PFI based on features of programs with promising outcomes. Whereas this review summarizes the existing base of information on electronic alcohol feedback interventions, research is always advancing. Campuses wishing to adopt a given program are again advised to "do their homework" to ensure their expenditure of resources and dedication to one specific program is based on the most up-to-date and accurate information.

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The Burden of Alcohol Use

Excessive Alcohol Consumption and Related Consequences Among College Students

Aaron White, Ph.D., and Ralph Hingson, Sc.D.

Research shows that multiple factors influence college drinking, from an individual's genetic susceptibility to the positive and negative effects of alcohol, alcohol use during high school, campus norms related to drinking, expectations regarding the benefits and detrimental effects of drinking, penalties for underage drinking, parental attitudes about drinking while at college, whether one is member of a Greek organization or involved in athletics, and conditions within the larger community that determine how accessible and affordable alcohol is. Consequences of college drinking include missed classes and lower grades, injuries, sexual assaults, overdoses, memory blackouts, changes in brain function, lingering cognitive deficits, and death. This article examines recent findings about the causes and consequences of excessive drinking among college students relative to their non-college peers and many of the strategies used to collect and analyze relevant data, as well as the inherent hurdles and limitations of such strategies. **Key Words: Alcohol consumption; alcohol use, abuse, and dependence; alcohol burden; alcohol effects and consequences; harmful drinking; underage drinking; binge drinking; college student; risk factors; genetic factors; environmental factors; social norms; parental attitude; Greek organization; athletes; community environment; academic performance; injury; sexual assault; overdose; memory blackout; brain function; cognitive deficits; death; accessibility; availability; affordability; survey; data collection; data analysis.**

Since 1976, when the National Institute on Alcohol Abuse and Alcoholism (NIAAA) issued its first report on alcohol misuse by college students, research advances have transformed our understanding of excessive drinking on college campuses and the negative outcomes that follow from it. For instance, we now know that a broad array of factors influence whether a particular college student will choose to drink, the types of consequences they suffer from drinking, and how they respond to those consequences. We have learned that predisposing factors include an individual's genetic susceptibility to the positive and negative effects of alcohol, alcohol use during high school, campus norms related to drinking, expectations regarding the benefits and detrimental effects of drinking, penalties for underage drinking, parental attitudes about drinking while at college, whether one is member of a Greek organization or involved in athletics, and conditions within the larger community that determine how accessible and affordable alcohol is. Consequences include missed classes and lower grades, injuries, sexual assaults, overdoses, memory blackouts, changes in brain function, lingering cognitive deficits, and death.

This article reviews recent research findings about alcohol consumption by today's college students and the outcomes that follow. It examines what we know about the causes and consequences of excessive drinking among college students relative to their non-college peers and many of the strategies used to collect and analyze relevant data, as well as the inherent hurdles and limitations of such strategies.

Excessive Drinking At College

Currently, only two active national survey studies are able to characterize the drinking habits of college students in the United States. The National Survey on Drug Use and Health (NSDUH), an annual survey sponsored by the Substance Abuse and Mental Health Services Administration (SAMHSA), involves face-to-face interviews with approximately 67,500 persons ages 12 and older each year regarding use of alcohol and other drugs. Monitoring the Future (MTF) is an annual, paper-and-pencil national survey of alcohol and other drug use with a sample comprising nearly 50,000 students in 8th, l0th, and 12th grades drawn from roughly 420 public and private schools. Approximately 2,400 graduating seniors are resurveyed in subsequent years, allowing for the monitoring of trends in college drinking.

In addition, two prior surveys yielded data on college drinking that remain valuable and relevant. The National Epidemiologic Survey on Alcohol and Related Conditions (NESARC), sponsored by NIAAA, collected data on alcohol and other drug use from a sample of roughly 46,500 citizens 18 and older using face-to-face computer-assisted interviews. Two waves of data (2001 and 2004) were collected from the same sample, and data from an independent sample are scheduled to be collected in 2013. The Harvard College Alcohol Study (CAS), although no longer active, was a land-

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mark paper-and-pencil survey that provided national data (years 1993, 1997, 1999, and 2001) from roughly 15,000 students on more than 100 college campuses each year (Wechsler and Nelson 2008). Data from both NESARC and Harvard CAS remain useful for examining associations between patterns of drinking at college and the frequency and prevalence of alcohol-related consequences for both drinkers and nondrinkers.

Data from NSDUH and MTF suggest that roughly 65 percent of college students drink alcohol in a given month (see figure 1 for data from MTF), and Harvard CAS all suggest that a large percentage of college students who drink do so to excess. Excessive, or "binge," drinking is defined in NSDUH, MTF, and NESARC as consuming five or more drinks in an evening, although the instruments vary in the specified time frames given (i.e., once or more in the past month for NSDUH, past 2 weeks for MTF, and multiple time periods for NESARC) (Johnston et al. 2001*a*; SAMHSA 2011). The Harvard CAS was the first national study of college students to utilize a gender-specific definition of binge drinking (i.e., four or more drinks in an evening for females or five or more for males in the past 2 weeks) to equate the risk of alcohol-related harms (Wechsler et al. 1995). The Centers for Disease Control and Prevention (CDC) utilizes the same four or more/five or more gender-specific measures but specifies a 30-day time period (Chen et al. 2011). NIAAA uses the four or more/five or more gender-specific measure but specifies a time frame of 2 hours for consumption, as this would generate blood alcohol levels of roughly 0.08 percent, the legal limit for driving, for drinkers of average weight (NIAAA 2004).

According to NSDUH, the percentage of 18- to 22-year-old college students who reported drinking five or more drinks on an occasion in the previous 30 days remained relatively stable from 2002 (44 percent) to 2010 (44 percent) (SAMHSA 2011). Among 18- to 22-year-olds not enrolled in college, the percentage who engaged in binge drinking decreased significantly from 2002 (39 percent) to 2010 (36 percent) (see figure 2).

Looking at a longer time period, data from MTF suggest that there have been significant declines in the percentage of college students consuming five or more drinks in the previous 2 weeks, from 44 percent in 1980 to 36 percent in 2011 (Johnston et al. 2012) (see figure 3). This time frame includes the passage of the National Minimum Drinking Age Act of 1984, which effectively increased the drinking age from 18 to 21 in the United States.

Across the four waves of data collection in the Harvard CAS (1993, 1997, 1999, and 2001), rates of binge drinking remained relatively stable (44, 43, 45, and 44 percent, respectively) (Wechsler et al. 2002) (see figure 4). However, the number of non–binge drinkers decreased, whereas the number

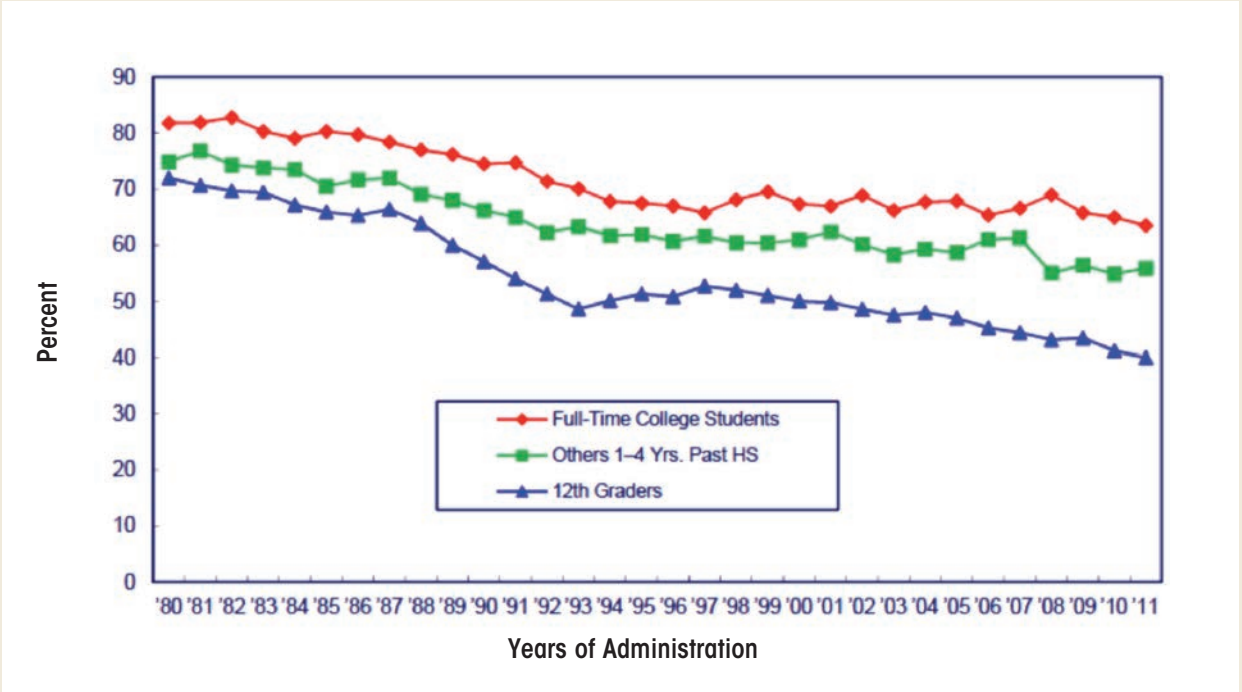

Figure 1 Alcohol: Trends in 30-day prevalence among college students vs. others 1 to 4 years beyond high school (twelfth graders included for comparision).

SOURCE: The Monitoring the Future study, the University of Michigan.
NOTE: Others refers to high school graduates 1 to 4 years beyond high school not currently enrolled full time in college.

of frequent binge drinkers (three or more binge-drinking episodes in a 2-week period) increased. Wechsler and colleagues (2002) reported that binge drinkers consumed 91 percent of all the alcohol consumed by college students during the study period. Frequent binge drinkers, a group comprising only 1 in 5 college students, accounted for 68 percent of all alcohol consumed (Wechsler and Nelson 2008).

Individual and Environmental Contributors to Excessive Drinking

Survey data indicate that males outpace females with regard to binge drinking. According to MTF, in 2011, 43 percent of male and 32 percent of female college students crossed the binge threshold in a given 2-week period. Further, 40 percent of students—more males (44 percent) than females (37 percent)—reported getting drunk in a given month. Research suggests that gender differences in alcohol use by college students have narrowed considerably over the years. In their landmark 1953 report on college drinking, Yale researchers Straus and Bacon indicated that, based on survey data from more than 15,000 students on 27 college campuses, 80 percent of males and 49 percent of females reported having been drunk at some point. Nearly 60 years later, in 2011, data from MTF indicated that 68 percent of males and 68 percent females reported having been drunk. These new, higher levels of drinking among females seem to be ingrained

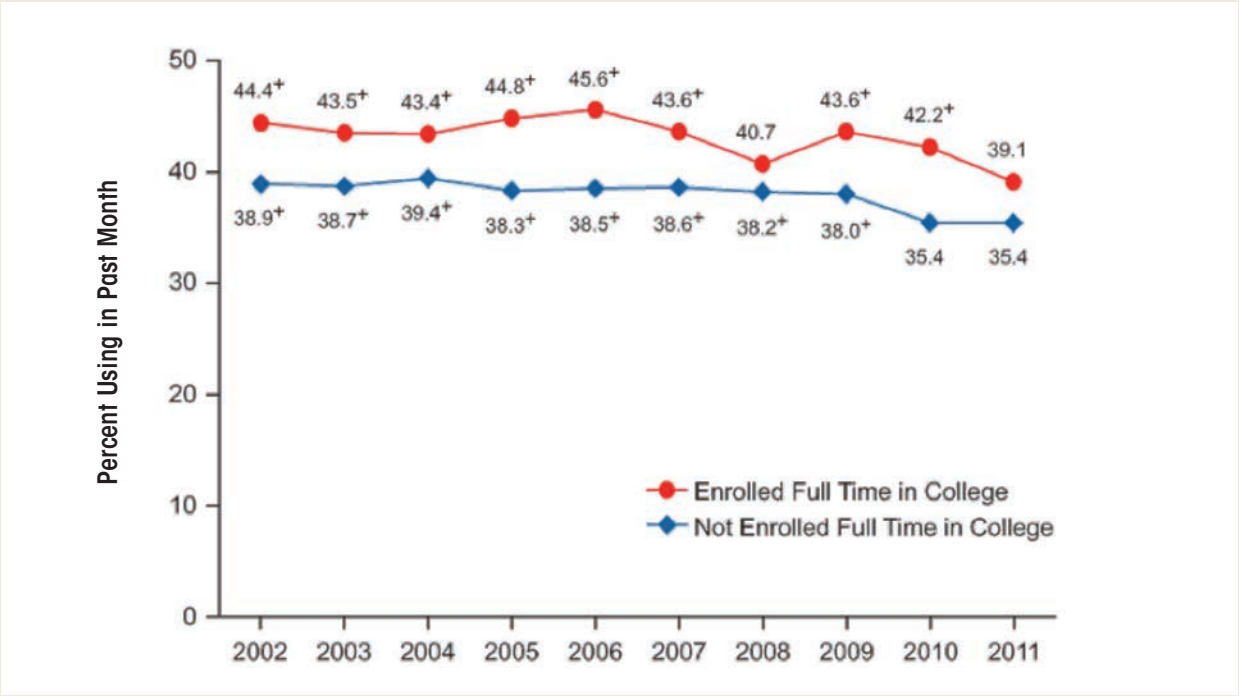

Figure 2 Binge alcohol use among adults aged 18 to 22, by college enrollment: 2002–2011. Survey years are shown on the horizontal axis, and the percentage using in the past month is shown on the vertical axis. For each college enrollment status (enrolled full time in college and not enrolled full time in college), there is a line showing use over the years 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, and 2011. Tests of statistical significance at the .05 level were performed between 2011 and each of the previous years listed; significant results are indicated where appropriate.

Among adults aged 18 to 22 enrolled full time in college, 44.4 percent were past-month binge alcohol users in 2002, 43.5 percent in 2003, 43.4 percent in 2004, 44.8 percent in 2005, 45.6 percent in 2006, 43.6 percent in 2007, 40.7 percent in 2008, 43.6 percent in 2009, 42.2 percent in 2010, and 39.1 percent in 2011. The differences between the 2011 estimate and the 2002, 2003, 2004, 2005, 2006, 2007, 2009, and 2010 estimates were statistically significant.

Among adults aged 18 to 22 not enrolled full time in college, 38.9 percent were past-month binge alcohol users in 2002, 38.7 percent in 2003, 39.4 percent in 2004, 38.3 percent in 2005, 38.5 percent in 2006, 38.6 percent in 2007, 38.2 percent in 2008, 38.0 percent in 2009, 35.4 percent in 2010, and 35.4 percent in 2011. The differences between the 2011 estimate and the 2002 through 2009 estimates were statistically significant.

SOURCE: Substance Abuse and Mental Health Services Administration. *Results From the 2011 National Survey on Drug Use and Health: Summary of National Findings,* NSDUH Series H–44, HHS Publication No. (SMA) 12–4713. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2012.

in the youth drinking culture. Whereas binge-drinking rates declined significantly among high-school seniors over the last decade, the effect was driven by a decline among males only. Binge-drinking rates among females remained relatively stable (Johnston et al. 2012) (see figure 5).

Beyond gender, survey studies of college drinking reveal a range of characteristics of both individual students and campus environments that influence the likelihood of binge drinking. Data from the Harvard CAS and other studies reveal that males, Caucasians, members of Greek organizations, students on campuses with lower percentages of minority and older students, athletes, students coping with psychological distress, those on campuses near a high density of alcohol outlets, students with access to cheap drink specials, a willingness to endure the consequences of alcohol misuse, and drinking at off-campus parties and bars all contribute to excessive drinking (Mallett et al. 2013; Wechsler and Kuo 2003; Yusko et al. 2008). Further, students living off campus and/or in Greek housing, those who drink to try to fit it, students with inflated beliefs about the proportion of other students who binge drink, and those with positive expectations about the results of drinking are more likely to drink excessively (Scott-Sheldon et al. 2012; Wechsler and Nelson 2008). Importantly, excessive drinking prior to college relative to other college-bound students is predictive of both excessive drinking at college and experiencing alcohol-related consequences (Varvil-Weld et al. 2013; White et al. 2002).

Strengths and Weaknesses of Binge-Drinking Measures

Several studies indicate that crossing commonly used binge-drinking thresholds increases a college student's risk of experiencing negative alcohol-related consequences. For instance, data from the Harvard CAS indicate that students who binge one or two times during a 2-week period are roughly three times as likely as non–binge drinkers to get behind in school work, do something regretful while drinking, experience a memory blackout, have unplanned sex, fail to use birth control during sex, damage property, get in trouble with police, drive after drinking, or get injured (Wechsler et al. 2000). The more often a student binges, the greater the risk of negative outcomes. Further, the more binge drinking that occurs on a campus, the more likely non–binge drinkers and abstainers are to experience secondhand consequences of alcohol use, such as having studying or sleep disrupted, being a victim of sexual assault, and having property damaged (Wechsler and Nelson 2008).

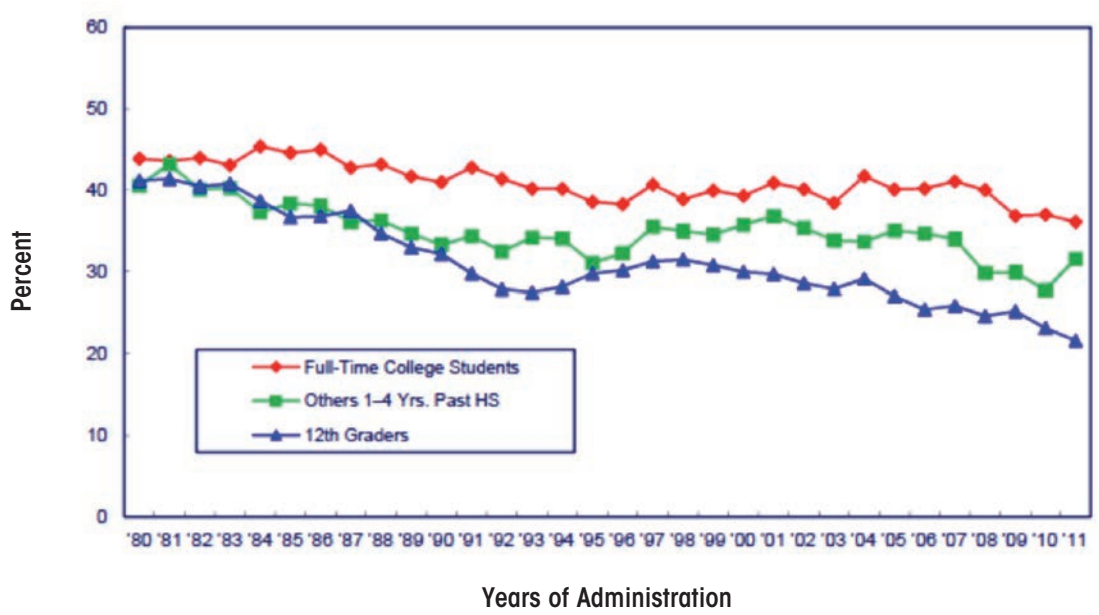

Figure 3 Alcohol: Trends in 2-week prevalence of consuming five or more drinks in a row among college students vs. others 1 to 4 years beyond high school (12th graders included for comparision).

SOURCE: The Monitoring the Future study, the University of Michigan.
NOTE: Others refers to high school graduates 1 to 4 years beyond high school not currently enrolled full time in college.

Because of the increased risk of consequences to self and others that occurs when a person drinks at or beyond the binge threshold, a great deal of emphasis is placed on tracking the percentage of college students that cross binge thresholds. Although this has proven extremely valuable, as Wechsler and Nelson (2001, p. 289) state, "Alcohol use is a complex behavior. No single measure will capture all the relevant aspects of alcohol use." One limitation of using a single threshold is that it removes data regarding just how heavily students actually drink (Alexander and Bowen 2004; Read et al. 2008) and assigns the same level of risk to all students who cross the thresholds regardless of how far beyond the threshold they go. This is an important consideration as recent studies suggest that plenty of college students who cross the binge threshold when they drink go far beyond it.

In a study of 10,424 first-semester college freshmen, more than one-half of all males and one-third of all females categorized as binge drinkers drank at levels two or more times the binge threshold (8 or more drinks for women and 10 or more drinks for men) at least once in the 2 weeks before the survey. Indeed, one in four binge-drinking males consumed 15 or more drinks at a time during that period (White et al. 2006). Naimi and colleagues (2010) reported that 18- 24-year-olds in the United States drink an average of 9.5 drinks per binge episode, nearly twice the standard binge threshold. Data from MTF also reveal that both college students and their non-college peers often drink at levels that exceed the binge threshold. On average, between 2005 and 2011, 7 percent of college females surveyed and 24 percent of college males consumed 10 or more drinks at least once in a 2-week period, compared with 7 percent of females and 18 percent of males not in college. Further, 2 percent of all college females surveyed and 10 percent of college males consumed 15 or more drinks in a 2-week period. Rates among non-college peers were similar, at 2 percent among females and 9 percent among males (Johnston et al. 2012). For a 140-pound female, consuming 15 drinks over a 6-hour period would produce an estimated blood alcohol level above 0.4 percent, a level known to have claimed, directly, several lives on college campuses in recent years. For a 160-pound male, drinking in this way would lead to a blood alcohol level above 0.3 percent, a potentially lethal level associated with memory blackouts and injury deaths.

Data from the Harvard CAS suggested that students who binge drink frequently (three or more times in a 2-week period) are at particularly high risk of negative alcohol-related outcomes. Compared with students who binge drink one or two times in a 2-week period, those who binge three or more times are twice as likely to experience alcohol-induced memory losses (27 percent vs. 54 percent, respectively), not use protection during sex (10 percent vs. 20 percent, respectively), engage in unplanned sex (22 percent vs. 42 percent, respectively), and get hurt or injured (11 percent vs. 27 percent, respectively), and are equally likely to need medical treatment for an overdose (1 percent vs. 1 percent). Whereas binge frequency is associated with an increased risk of negative outcomes, additional research indicates that there is a relationship between how often a student binges and the peak number of drinks he or she consumes. White and colleagues (2006) reported that 19 percent of frequent binge

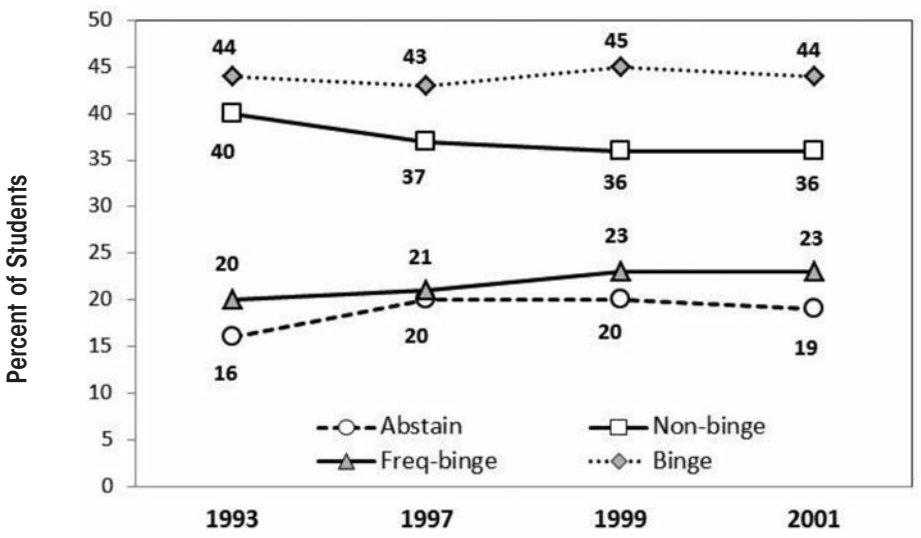

Figure 4 Drinking habits of college students from Harvard CAS.

SOURCE: Johnston, L.D.; O'Malley, P.M.; Bachman, J.G.; and Schulenberg, J.E. *Monitoring the Future National Survey Results on Drug Use, 1975–2011: Volume I: Secondary School Students.* Ann Arbor, MI: Institute for Social Research, The University of Michigan.

drinkers consume three or more times the binge threshold (12 or more drinks for females and 15 or more for males) at least once in a 2-week period compared with only 5 percent of infrequent binge drinkers. As a result of the association between frequency of binge drinking and peak levels of consumption, it is difficult to determine if the increase in risk that comes with frequent bingeing is a result of the number of binge episodes, per se, or the number of drinks consumed in an episode.

Importantly, although evidence suggests that many students drink at levels far beyond the binge threshold, additional research suggests that the majority of alcohol-related harms on college campuses result from drinking at levels near the standard four/five-drink measure. This is related to the well-known prevention paradox in which the majority of health problems, such as alcohol-related consequences, tend to occur among those considered to be at lower risk (Rose 1985). For a particular individual, the odds of experiencing alcohol-related harms increase as the level of consumption increases (Wechsler and Nelson 2001). However, at the population level, far fewer people drink in this manner. As a result, more total consequences occur among those who drink at relatively lower risk levels. For instance, based on data from roughly 9,000 college-student drinkers across 14 college campuses in California, Gruenewald and colleagues (2010) estimated that more than one-half of all alcohol-related consequences resulted from drinking occasions in which four or fewer drinks were consumed. Similarly, using national data from nearly 50,000 students surveyed across the four waves of the Harvard CAS, Weitzman and Nelson (2004) observed that roughly one-quarter to one-third of alcohol-related consequences, including getting injured, vandalizing property, having unprotected sex, and falling behind in school, occurred among students who usually consume three or four drinks per occasion. Such findings raise the possibility that a reduction in high peak levels of consumption might not necessarily result in large overall reductions in alcohol-related consequences on a campus. However, a reduction in high peak levels of drinking would certainly help save the lives of students who drink at these high levels.

In summary, while binge-drinking thresholds are useful for sorting students into categories based on levels of risk, a single threshold cannot adequately characterize the drinking habits of college students or the risks associated with alcohol use on college campuses (Read et al. 2008). It is not uncommon for college students to far exceed standard binge thresholds. Presently, only MTF tracks and reports the incidence of drinking beyond the binge threshold on college campuses. Such data are important as they allow for better tracking of changes in the drinking habits of students. For instance, it is possible that the number of students who drink at extreme levels could increase, whereas the overall percentage of students who binge drink declines or remains stable. Such a phenomenon might help explain why some consequences of excessive alcohol use, like overdoses requiring hospitalization, seem to be on the rise despite relatively stable levels of binge drinking on college campuses across several decades. Finally, although sorting students into binge drinking categories fails to capture high peak levels of consumption among students, a large proportion of harms actually occurs at or near the standard four or more/five or more threshold.

Do Students Know How to Define Standard Servings?

Despite concerns about the accuracy of self-report data for assessing levels of alcohol use among college students and the general population, such surveys remain the most common tool for assessing alcohol use. One major concern is whether students and other young adults are aware of what constitutes a single serving of alcohol. Research shows that college students and the general public tend to define and pour single servings of alcohol that are significantly larger than standard drinks, suggesting they might underestimate their true levels of consumption on surveys (Devos-Comby and Lange 2008; Kerr and Stockwell 2012). For instance, White and colleagues (2003, 2005) asked students to pour single servings of different types of alcohol beverages into cups of various sizes. Overall, students poured drinks that were too large. When asked to simply define standard drinks in terms of fluid ounces, students tended to overstate the number of ounces in a standard drink. The average number of ounces of liquor in student-defined mixed drinks was 4.5 ounces rather than the 1.5 ounces in actual standard drinks (White et al. 2005). When students were provided with feedback regarding discrepancies between their definitions of single servings and the actual sizes of standard drinks, they tended to revise their self-reported levels of consumption upward, leading to a significant increase in the number of students categorized as binge drinkers (White et al. 2005). Such findings suggest that students underreport their levels of consumption on surveys, raising the possibility that more students drink excessively than survey data indicate.

Although a lack of knowledge regarding standard serving sizes could lead students to underestimate, and thus underreport, how much they drink, field research suggests that the discrepancy between self-reported and actual levels of consumption might be smaller than expected from lab studies. For instance, Northcote and Livingston (2011) conducted a study in which they monitored the number of drinks consumed by research participants in bars and then asked them to report their consumption a few days later. Reports by study participants were consistent with the observations made by researchers for participants who had consumed less than eight total drinks. Only those who consumed eight drinks or more tended to underestimate their consumption. When comparing estimated blood alcohol concentrations (BAC) based on self-report to actual BAC readings in college students returning to campus from bars, actual BAC levels tended to be lower, rather than higher, than levels calculated using self-reported consumption (Kraus et al. 2005). Similarly, when actual BAC levels are compared with estimated BAC

levels in bar patrons, estimates are spread evenly between accurate, underestimates, and overestimates (Clapp et al. 2009).

In short, although self-reported drinking data might not be perfect, and college students lack awareness of how standard drink sizes are defined, research does not suggest that the discrepancies between self-reported and actual drinking levels are large enough to question the general findings of college drinking surveys.

Paper-and-Pencil, Face-To-Face, and Electronic Surveys: Does It Make a Difference?

National surveys of college drinking often utilize paper-and-pencil questionnaires (e.g., MTF and Harvard CAS) or face-to-face computer-assisted personal interviews (e.g., NSDUH and NESARC). It now is possible to collect survey data electronically via the Internet and also using handheld devices, such as smartphones and personal digital assistants. This raises questions about the comparability between traditional survey methods and electronic data collection.

Several studies comparing traditional (e.g., paper and pencil) and electronic means of data collection suggest that the approaches yield generally similar results from survey participants (Boyer et al. 2002; Jones and Pitt 1999; LaBrie et al. 2006; Lygidakis et al. 2010). For instance, in a comparison of Web-based and paper-and-pencil survey approaches, Knapp and Kirk (2003) found no differences in outcomes, suggesting that Web-based surveys do not diminish the accuracy or honesty of responses. Similarly, LaBrie and colleagues (2006) observed similar outcomes of self-reported alcohol consumption in a paper-and-pencil survey and an electronic survey. However, other studies suggest that students actually feel more comfortable answering personal questions truthfully when completing questionnaires electronically (Turner et al. 1998), which can lead to higher levels of self-reported substance use and other risky behaviors. Both Lygidakis and colleagues (2010) and Wang and colleagues (2005) indicate that adolescents completing electronic surveys reported higher levels of alcohol and other drug use compared with those completing paper-and-pencil versions.

Response rate is an important consideration, with higher response rates increasing the representativeness of the sample and limiting the likelihood that response biases will influence the outcomes. Two national paper-and-pencil surveys mentioned above, MTF and Harvard CAS, report response rates for college students of approximately 59 percent. For MTF, this response rate represents a retention rate, as the participants were followed up after high school. Response rates for the in-person computer-assisted personal interviews, NSDUH and NESARC, which assess college student drinking but are not limited to college students, are roughly 77 percent and 81 percent, respectively. Currently, there is no basis for assessing response rates for national Web-based assessments of college drinking. However, smaller studies suggest that response rates might be comparable, if not higher, than other approaches. McCabe and colleagues (2002) reported that, among 7,000 undergraduate students, one-half of whom were surveyed about alcohol and other drug use via the Internet and half surveyed via paper-and-

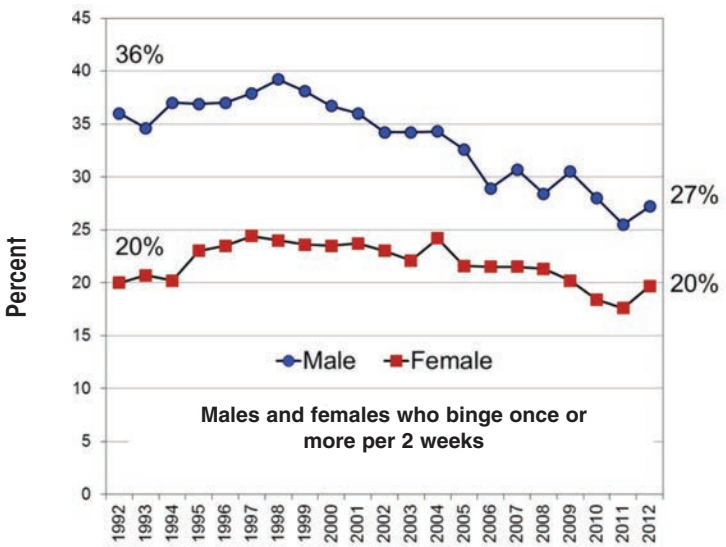

Figure 5 Percent of 12th-grade male and female students who reported drinking at least once in the prior 2 weeks.

SOURCE: Wechsler, H.; Lee, J.E.; Kuo, M., et al. Trends in college binge drinking during a period of increased prevention efforts: Findings from 4 Harvard School of Public Health College Alcohol Study surveys: 1993–2001. *Journal of American College Health* 50(5):203–217, 2002. PMID: 11990979

pencil surveys delivered through the mail, the response rates were 63 percent for the Web survey and 40 percent for the paper-and-pencil survey. Further, response rates for Web-based surveys can be improved by sending reminders via e-mail (van Gelder et al. 2010).

In summary, in recent years an increasing number of researchers have utilized electronic survey methods to collect college-drinking data. At present, evidence suggests that these methods can yield results quite similar to those obtained from traditional survey methods and that response rates might actually be higher.

Alcohol-Related Consequences Among College Students

Drinking to intoxication leads to widespread impairments in cognitive abilities, including decisionmaking and impulse control, and impairments in motor skills, such as balance and hand-eye coordination, thereby increasing the risk of injuries and various other harms. Indeed, research suggests that students who report "getting drunk" even just once in a typical week have a higher likelihood of being injured, experiencing falls that require medical treatment, causing injury in traffic crashes, being taken advantage of sexually, and injuring others in various ways (O'Brien et al. 2006). Students who drink with the objective of getting drunk are far more likely to experience a range of consequences, from hangovers to blackouts, than other students who drink (Boekeloo et al. 2011).

National estimates suggest that thousands of college students are injured, killed, or suffer other significant consequences each year as a result of drinking. However, researchers have questioned the manner in which such national estimates are calculated. In many cases, the lack of college identifiers in datasets means that the actual amount of annual alcohol-attributable harm that occurs among college students is unknown. Although the Harvard CAS collected data regarding the consequences of drinking, its final year of administration was 2001. Currently, assessing the damage done, on a national level, by college drinking requires estimating rates of consequences using a variety of data sources. Such assessments are complicated by the fact that outcomes considered to be negative consequences by researchers (e.g., blackouts and hangovers) are not always perceived as negative by students (Mallett et al. 2013). Further, college students often drink off campus, such as during spring breaks and summer vacations, meaning that many alcohol-related consequences experienced by college students are not necessarily associated with college itself. As such, our understanding of alcohol-related consequences among college students remains somewhat cloudy.

In one set of estimates, Hingson and colleagues (2002, 2005, 2009) utilized census data and national datasets regarding traffic crashes and other injury deaths to estimate the prevalence of various alcohol-related harms among all young people aged 18–24. Next, they attributed an amount of harm to college students equal to the proportion of all 18- to 24-year-olds who were enrolled full time in 4-year colleges (33 percent in 2005, the most recent year analyzed) (Hingson et al. 2009). Because college students drink more heavily than their non-college peers, it is possible this approach underestimated the magnitude of alcohol-related consequences on college campuses. Hingson and colleagues (2002, 2005, 2009) also used the percentage of college students who reported various alcohol-related behaviors (e.g., being assaulted by another drinking college student) in national surveys to derive national estimates of the total numbers of college students who experienced these consequences.

Based on the above strategies along with other sources of data, researchers have estimated the following rates and prevalence of alcohol-related harms involving college students:

- **Death:** It is possible that more than 1,800 college students between the ages of 18 and 24 die each year from alcohol-related unintentional injuries, including motor-vehicle crashes (Hingson et al. 2009).
- **Injury:** An estimated 599,000 students between the ages of 18 and 24 are unintentionally injured each year under the influence of alcohol (Hingson et al. 2009).
- **Physical Assault:** Approximately 646,000 students between the ages of 18 and 24 are assaulted each year by another student who has been drinking (Hingson et al. 2009).
- **Sexual Assault:** Perhaps greater than 97,000 students between the ages of 18 and 24 are victims of alcohol-related sexual assault or date rape each year (Hingson et al. 2009).
- **Unsafe Sex:** An estimated 400,000 students between the ages of 18 and 24 had unprotected sex and nearly 110,000 students between the ages of 18 and 24 report having been too intoxicated to know if they consented to having sex (Hingson et al. 2002).
- **Health Problems:** More than 150,000 students develop an alcohol-related health problem each year (Hingson et al. 2002).
- **Suicide Attempts:** Between 1.2 and 1.5 percent of college students indicate that they tried to commit suicide within the past year as a result of drinking or drug use (Presley et al. 1998).
- **Drunk Driving:** Roughly 2.7 million college students between the ages of 18 and 24 drive under the influence of alcohol each year (Hingson et al. 2009).
- **Memory Loss:** National estimates suggest that 10 percent of non–binge drinkers, 27 percent of occasional binge drinkers, and 54 percent of frequent binge drinkers reported at least one incident in the past year of blacking out, defined as having forgotten where they were or what

they did while drinking (Wechsler et al. 2000; White 2003).

- **Property Damage:** More than 25 percent of administrators from schools with relatively low drinking levels and more than 50 percent from schools with high drinking levels say their campuses have a "moderate" or "major" problem with alcohol-related property damage (Wechsler et al. 1995).

- **Police Involvement:** Approximately 5 percent of 4-year college students are involved with the police or campus security as a result of their drinking (Wechsler et al. 2002) and an estimated 110,000 students between the ages of 18 and 24 are arrested for an alcohol-related violation such as public drunkenness or driving under the influence (Hingson et al. 2002). A more recent national study reported that 8.5 percent of students were arrested or had other trouble with the police because of drinking (Presley and Pimentel 2006).

- **Alcohol Abuse and Dependence:** Roughly 20 percent of college students meet the criteria for an alcohol use disorder in a given year (8 percent alcohol abuse, 13 percent alcohol dependence). Rates among age mates not in college are comparable (17 percent any alcohol use disorder, 7 percent alcohol abuse, 10 percent alcohol dependence) (Blanco et al. 2008).

With regard to assessing the number of college students who die from alcohol each year, in addition to the lack of college identifiers in datasets, another barrier is the fact that levels of alcohol often are not measured in nontraffic fatalities. As such, attributable fractions, based on analyses of existing reports in which alcohol levels were measured postmortem, are used to estimate the number of deaths by various means that likely involved alcohol. The CDC often uses attributable fractions calculated by Smith and colleagues (1999) based upon a review of 331 medical-examiner studies. An updated approach is needed. The combination of including college identifiers in medical records and measuring alcohol levels in all deaths would allow for accurate assessments of the role of alcohol in the deaths of college students and their non-college peers.

Academic Performance

About 25 percent of college students report academic consequences of their drinking, including missing class, falling behind in class, doing poorly on exams or papers, and receiving lower grades overall (Engs et al. 1996; Presley et al. 1996*a*, *b*; Wechsler et al. 2002). Although some published research studies have not found a statistically significant association between binge drinking and academic performance (Gill 2002; Howland et al. 2010; Paschall and Freisthler 2003; Williams 2003; Wood et al. 1997), studies linking binge drinking to poorer academic performance outnumber the former studies two to one. Presley and Pimentel (2006) reported that in a national survey of college students, those who engaged in binge drinking and drank at least three times per week were 5.9 times more likely than those who drank but never binged to perform poorly on a test or project as a result of drinking (40.2 vs. 6.8 percent), 5.4 times more likely to have missed a class (64.4 vs. 11.9 percent), and 4.2 times more likely to have had memory loss (64.2 vs. 15.3 percent) (Thombs et al. 2009). Singleton and colleagues (2007, 2009), in separate prospective studies, found negative associations between heavy alcohol use and grade point average. Jennison (2004), based on a national prospective study, reported binge drinkers in college were more likely to drop out of college, work in less prestigious jobs, and experience alcohol dependence 10 years later. Wechsler and colleagues (2000) and Powell and colleagues (2004), based on the Harvard CAS, found frequent binge drinkers were six times more likely than non–binge drinkers to miss class and five times more likely to fall behind in school. White and colleagues (2002) observed that the number of blackouts, a consequence of heavy drinking, was negatively associated with grade point average (GPA). It is important to note that although data regarding GPA often are collected via self-report, the negative association between alcohol consumption and GPA holds even when official records are obtained (Singleton 2007). Collectively, the existing research suggests that heavy drinking is associated with poorer academic success in college.

Alcohol Blackouts

Excessive drinking can lead to a form of memory impairment known as a blackout. Blackouts are periods of amnesia during which a person actively engages in behaviors (e.g., walking, talking) but the brain is unable to create memories for the events. Blackouts are different from passing out, which means either falling asleep or becoming unconscious from excessive drinking. During blackouts, people are capable of participating in events ranging from the mundane, such as eating food, to the emotionally charged, such as fights and even sexual intercourse, with little or no recall (Goodwin 1995). Like milder alcohol–induced short-term memory impairments caused by one or two drinks, blackouts primarily are anterograde, meaning they involve problems with the formation and storage of new memories rather than problems recalling memories formed prior to intoxication. Further, short-term memory often is left partially intact. As such, during a blackout, an intoxicated person is able to discuss events that happened prior to the onset of the blackout and to hold new information in short-term storage long enough to have detailed conversations. They will not, however, be able to transfer new information into long-term storage, leaving holes in their memory. Because of the nature of

blackouts, it can be difficult or impossible to know when a drinker in the midst of one (Goodwin 1995).

There are two general types of blackouts based on the severity of the memory impairments. Fragmentary blackouts, sometimes referred to as gray outs or brown outs, are a form of amnesia in which memory for events is spotty but not completely absent. This form is the most common. En bloc blackouts, on the other hand, represent complete amnesia for events (Goodwin 1995).

Blackouts surprisingly are common among college students who drink alcohol. White and colleagues (2002) reported that one-half (51 percent) of roughly 800 college students who had ever consumed alcohol at any point in their lives reported experiencing at least one alcohol-induced blackout, defined as awakening in the morning not able to recall things one did or places one went while under the influence. The average number of total blackouts in those who experienced them was six. Of those who had consumed alcohol during the 2 weeks before the survey was administered, 9 percent reported blacking out. Based on data from 4,539 inbound college students during the summer between high-school graduation and the start of the freshmen year, 12 percent of males and females who drank in the previous 2 weeks experienced a blackout during that time (White and Swartzwelder 2009). Data from the Harvard CAS indicate that blackouts were experienced in a 30-day period by 25 percent of students in 1993 and 27 percent of students in 1997, 1999, and 2001 (Wechsler et al. 2002). A small study by White and colleagues (2004), in which 50 students with histories of blackouts were interviewed, suggests that fragmentary blackouts are far more common than en bloc blackouts. Roughly 80 percent of students described their last blackout as fragmentary.

Blackouts tend to occur following consumption of relatively large doses of alcohol and are more likely if one drinks quickly and on an empty stomach, both of which cause a rapid rise and high peak in BAC (Goodwin 1995; Perry et al. 2006). For this reason, pregaming, or prepartying, which typically involves fast-paced drinking prior to going out to an event, increases the risk of blacking out. Labrie and colleagues (2011) reported that 25 percent of 2,546 students who engaged in prepartying experienced at least one blackout in the previous month. Playing drinking games and drinking shots were risk factors. Further, skipping meals to restrict calories on drinking days is associated with an increased risk of blackouts and other consequences (Giles et al. 2009).

Because blackouts typically follow high peak levels of drinking, it is not surprising that they are predictive of other alcohol-related consequences. Mundt and colleagues (2012) examined past-year blackouts in a sample of more than 900 students in a randomized trial of a screening and brief intervention for problem alcohol use and found that blackouts predicted alcohol-related injuries over a subsequent 2-year period. Compared with students who had no history of blackouts, those who reported one to two blackouts at baseline were 1.5 times more likely to experience an alcohol-related injury, whereas those with six or more blackouts were 2.5 times more likely. In a follow-up report based on the same sample, Mundt and Zakletskaia (2012) estimated that among study participants, one in eight emergency-department (ED) visits for alcohol-related injuries involved a blackout. On a campus of 40,000 students, this would translate into roughly $500,000 in annual costs related to blackout-associated ED visits.

In the study of 50 students with blackout histories by White and colleagues (2004), estimated peak BACs during the night of the last blackout generally were similar for males (0.30 percent) and females (0.35 percent), although it is unlikely that self-reported alcohol consumption during nights in which blackouts occur is highly accurate. A study of amnesia in people arrested for either public intoxication, driving under the influence, or underage drinking found that the probability of a fragmentary or en bloc blackout was 50/50 at a BAC of 0.22 percent and the probability of an en bloc blackout, specifically, was 50/50 at a BAC of 0.31 percent, based on breath alcohol readings (Perry et al. 2006). In their study of blackouts in college students, Hartzler and Fromme (2003*a*) noted a steep increase in the likelihood of blackouts above a BAC of 0.25 percent, calculated from self-reported consumption. Thus, from existing research, it seems that the odds of blacking out increase as BAC levels climb and that blackouts become quite common at BAC levels approaching or exceeding 0.30 percent. As such, the high prevalence of blackouts in college students points to the magnitude of excessive consumption that occurs in the college environment. It should be noted, however, that BAC levels calculated based on self-reported consumption are unlikely to be accurate given the presence of partial or complete amnesia during the drinking occasion.

It seems that some people are more sensitive to the effects of alcohol on memory than others and are therefore at increased risk of experiencing blackouts. Wetherill and Fromme (2011) examined the effects of alcohol on contextual memory in college students with and without a history of blackouts. Performance on a task was similar while the groups were sober, but students with a history of blackouts performed more poorly when intoxicated than those without a history of blackouts. Similarly, Hartzler and Fromme (2003*b*) reported that when mildly intoxicated, study participants with a history of blackouts performed more poorly on a narrative recall task than those without a history of blackouts. When performing a memory task while sober, brain activity measured with functional magnetic resonance imaging is similar in people with a history of blackouts and those without such a history (Wetherill et al. 2012). However, when intoxicated, those with a history of blackouts exhibit lower levels of activity in several regions of the frontal lobes compared with subjects without a history of blackouts.

Thus, studies suggest that there are differences in the effects of alcohol on memory and brain function between those who experience blackouts and those who do not. Research by Nelson and colleagues (2004), using data from monozygotic twins, suggests that there could be a significant

genetic component to these differences. Controlling for frequency of intoxication, the researchers found that if one twin experienced blackouts, the other was more likely than chance to experience them as well. Further, Asian-American students with the aldehyde dehydrogenase ALDH2*2 allele[1] are less likely to experience blackouts than those without it, even after adjusting for maximum number of drinks consumed in a day (Lucsak et al. 2006).

Several challenges hinder the assessment of blackouts and the events that transpire during them. Blackouts represent periods of amnesia. As such, it is difficult to imagine that self-reported drinking levels are highly accurate for nights when blackouts occur. Further, in order for a person to know what transpired during a blackout, and sometimes to be aware that a blackout occurred at all, they need to be told by other individuals. Often, the information provided by these other individuals is unreliable as they were intoxicated themselves (Nash and Takarangi 2011). Thus, it is quite likely that self-reported rates and frequencies of blackouts, drinking levels during nights in which blackouts occur, and the rates of various types of consequences that occur during them, are underestimated.

Alcohol Overdoses

When consumed in large quantities during a single occasion, such as a binge episode, alcohol can cause death directly by suppressing brain stem nuclei that control vital reflexes, like breathing and gagging to clear the airway (Miller and Gold 1991). Even a single session of binge drinking causes inflammation and transient damage to the heart (Zagrosek et al. 2010). The acute toxic effects of alcohol in the body can manifest in symptoms of alcohol poisoning, which include vomiting, slow and irregular breathing, hypothermia, mental confusion, stupor, and death (NIAAA 2007*b*; Oster-Aaland et al. 2009). Using data from the Global Burden of Disease Study, the World Health Organization (WHO) estimated that, in 2002, alcohol poisoning caused 65,700 deaths worldwide, with 2,700 poisoning deaths occurring in the United States (WHO 2009). New stories about alcohol overdoses among college students and their non-college peers have become increasingly common, a fact that is perhaps not surprising given the tendency toward excessive drinking in this age-group.

To investigate the prevalence of hospitalizations for alcohol overdoses—which stem from excessive intoxication or poisoning—among college-aged young people in the United States, White and colleagues (2011) examined rates of inpatient hospitalizations for 18- to 24-year-olds between 1999 and 2008 using data from the Nationwide Inpatient Sample, which contains hospital discharge records from roughly 20 percent of all hospitals in the country. Hospitalizations for alcohol overdoses without any other drugs involved increased 25 percent among 18- to 24-year-olds from 1999 to 2008, highlighting the risks involved in heavy drinking. In total, nearly 30,000 young people in this age-group, more males (19,847) than females (9,525) were hospitalized for alcohol overdoses with no other drugs involved in 2008. Hospitalizations for overdoses involving other drugs but not alcohol increased 55 percent over the same time period, while those involving alcohol and drugs in combination rose 76 percent. In total, there were 59,000 hospitalizations in 2008 among 18- to 24-year-olds for alcohol overdoses only or in combination with other drugs. Given that 33 percent of people in this age-group were full-time college students at 4-year colleges in 2008, a conservative estimate would suggest approximately 20,000 hospitalizations for alcohol overdoses alone or in combination with other drugs involved college students, although the exact number is not known.

Data from the Drug Abuse Warning Network (DAWN) indicate that ED visits for alcohol-related events increased in a similar fashion as those observed for inpatient hospitalizations. Among those ages 18 to 20, ED visits for alcohol-related events with no other drugs increased 19 percent, from 67,382 cases in 2005 to 82,786 cases in 2009. Visits related to combined use of alcohol and other drugs increased 27 percent, from 27,784 cases in 2005 to 38,067 cases in 2009. In 2009, 12 percent of ED visits related to alcohol involved use of alcohol in combination with other drugs (SAMHSA 2011).

Alcohol interacts with a wide variety of illicit and prescription drugs, including opioids and related narcotic analgesics, sedatives, and tranquilizers (NIAAA 2007*a*; Tanaka 2002). Importantly, BAC required for fatal overdoses are lower when alcohol is combined with prescription drugs. An analysis of 1,006 fatal poisonings attributed to alcohol alone or in combination with other drugs revealed that the median postmortem BACs in those who overdosed on alcohol alone was 0.33 percent, compared with 0.13 percent to 0.17 percent among those who overdosed on a combination of alcohol and prescription drugs (Koski et al. 2003, 2005). The combined use of alcohol and other drugs peaks in the 18- to 24-year-old age range (McCabe et al. 2006), suggesting that college-aged young adults are at particularly high risk of suffering consequences from alcohol-and-other-drug combinations.

The above findings reflect the fact that heavy consumption of alcohol quickly can become a medical emergency. One does not need to get behind the wheel of a car after drinking or jump off a balcony into a swimming pool on a dare to risk serious harm. Simply drinking too much alcohol is enough to require hospitalization and potentially cause death. Further, combining alcohol with other drugs can increase the risk of requiring medical intervention substantially. Thus, efforts to minimize the consequences of alcohol-related harms on college campuses should not lose sight of the fact that alcohol often is combined with other drugs and, when this is the case, the risks can be greater than when alcohol or drugs are used alone.

[1] The ALDH2*2 allele results in decreased action by the enzyme acetaldehyde dehydrogenase, which is responsible for the breakdown of acetaldehyde. The accumulation of acetaldehyde after drinking alcohol leads to symptoms of acetaldehyde poisoning, such as facial flushing and increased heart and respiration rates.

Measuring the true scope of medical treatment for alcohol overdoses among college students is difficult for several reasons. First, in datasets such as the Nationwide Emergency Department Sample (NEDS) and the Nationwide Inpatient Sample (NIS), no college identifiers are included to indicate whether a young person treated for an alcohol overdose is enrolled in college. Many schools do not track or report the number of students treated for an alcohol overdose, and many students drink excessively when away from campus. Further, schools that implement Good Samaritan or Amnesty policies, which allow students to get help for overly intoxicated peers without fear of sanctions, could create the false impression that overdoses are on the rise. For instance, after Cornell University implemented an amnesty policy, they witnessed an increase in calls to residence assistants and 911 for help dealing with an intoxicated friend (Lewis and Marchell 2006). Given the dangerous nature of alcohol overdoses, with or without other drugs involved, it is important to improve the tracking of these events at colleges and in the larger community.

Sexual Assault

Sexual assault is a pervasive problem on college campuses, and alcohol plays a central role in it. A study of roughly 5,500 college females on two campuses revealed that nearly 20 percent experienced some form of sexual assault while at college (Krebs et al. 2009). Data from the Harvard CAS suggested that 5 percent of women surveyed were raped while at college (Mohler-Kuo et al. 2004). In a national sample of students who completed the Core Alcohol and Drug Survey in 2005, 82 percent of students who experienced unwanted sexual intercourse were intoxicated at the time. Similarly, nearly three-quarters (72 percent) of respondents to the Harvard CAS study who reported being raped were intoxicated at the time. In many cases, rape victims are incapacitated by alcohol. In one study, 3.4 percent of rape victims reported being so intoxicated they were unable to consent (Mohler-Kuo et al. 2004). In a study of 1,238 college students on three campuses over a 3-year period, 6 percent of students reported being raped while incapacitated by alcohol (Kaysen et al. 2006).

Research suggests that the involvement of alcohol increases the risk of being victimized in several ways, such as by impairing perceptions that one is in danger and by reducing the ability to respond effectively to sexual aggression (Abbey 2002; McCauley et al. 2010; Testa and Livingston 2009). Further, alcohol might increase the chances that a male will commit a sexual assault by leading them to misinterpret a female's friendly gestures or flirtation as interest in sex and by increasing sexual aggression (Abbey 2002). When asked to read a story about a potential date rape involving intoxicated college students, both male and female subjects who are intoxicated were more likely to view the female as sexually aroused and the male as acting appropriately (Abbey et al. 2003).

It is widely held that sexual assaults, with and without alcohol involvement, are underreported on college campuses. Title IX of the Education Amendments Act of 1972, a Federal civil rights law, requires universities to address sexual harassment and sexual violence. However, universities vary with regard to how they handle such cases, and a student's perception of safety and protection can influence the likelihood of reporting a sexual assault. Indeed, many universities have indicated changes in rates of reports of assaults consistent with changes in campus policies regarding how such cases are handled. As such, although it is clear that alcohol often is involved in sexual assaults on college campuses, questions about the frequency and nature of such assaults remain.

Spring Break and 21st Birthday Celebrations—Event-Specific Drinking Occasions

More college students drink, and drink more heavily, during specific celebratory events, such as spring break and 21st birthday celebrations, than during a typical week. Spring break is a roughly weeklong recess from school that takes place in the spring at colleges throughout the United States. While some students continue to work, travel home, or simply relax, others use the opportunity to travel to beaches and other party destinations. During spring break, approximately 42 percent of students get drunk on at least 1 day, 11 percent drink to the point of blacking out or passing out, 32 percent report hangovers, and 2 percent get into trouble with the police (Litt et al. 2013). Students with a history of binge drinking and those intending to get drunk tend to drink the heaviest (Patrick et al. 2013), suggesting that prevention efforts aimed at altering students' intentions to get drunk while on spring break might lead to a reduction in peak drinking and the consequences that follow (Mallett et al. 2013). Interestingly, students who typically are light drinkers are more likely than those who typically are binge drinkers to experience consequences from excessive drinking during spring break (Lee et al. 2009).

In addition to spring break, 21st birthday celebrations are another event-specific opportunity for students to drink excessively. An estimated 4 out of 5 college students drink alcohol to celebrate their 21st birthdays (Rutledge et al., 2008) and many students drink more than they plan. Of 150 male and female college students surveyed about their intentions to drink during their upcoming 21st birthday celebrations, 68 percent consumed more than they anticipated while only 21 percent drank less and 11 percent were accurate. On average, males intended to consume 8.5 drinks but consumed 12.5, while females expected to drink 7 but had 9 (Brister et al., 2010). As with spring-break drinking, students with a history of binge drinking and those who intended to drink heavily on their 21st birthday consumed the most (Brister et al., 2011). In one study, roughly 12 percent of students reported consuming 21 or more drinks while celebrating, and one-third of females (35 percent) and nearly half of males (49 percent) reached estimated BACs

above 0.25 percent (Rutledge et al., 2008). Such high levels of consumption substantially increase the odds of sexual assaults, fights, injuries, and death (Mallett et al., 2013). Research indicates that brief interventions conducted in the week leading up to the 21st birthday celebration can reduce levels of consumption and associated consequences, suggesting that the risks of experiencing alcohol related consequences stemming from 21st birthday celebrations could be partially mitigated through specifically timed prevention efforts (Neighbors et al. 2009, 2012).

Summary

We have learned a considerable amount about the drinking habits of college students and the consequences that follow since NIAAA first reported on the matter in 1976. Surprisingly, drinking levels have remained relatively stable on and around college campuses over the last 30 years, with roughly two out of five male and female students engaging in excessive, or binge, drinking. Excessive drinking results in a wide range of consequences, including injuries, assaults, car crashes, memory blackouts, lower grades, sexual assaults, overdoses and death. Further, secondhand effects from excessive drinking place non–binge-drinking students at higher risk of injury, sexual assaults, and having their studying disrupted.

Estimates of the rates of alcohol use and related consequences are imperfect. Lack of knowledge of standard drink sizes and the effects of alcohol on memory formation all complicate the collection of accurate data from traditional self-report surveys. Underreporting of sexual assaults leads to difficulty in estimating the true extent of the problem. Lack of college identifiers in mortality records and the fact that alcohol levels are tested too infrequently in non–traffic-related deaths leaves uncertainty regarding the actual number of college students who die each year from alcohol-related causes. Similarly, college identifiers are not present in most crime reports and hospital reports.

Although it is beyond the scope of this review to examine efforts to prevent excessive drinking on college campuses, it should be noted that important strides have been made in this area (Carey et al. 2012). In addition, data from MTF suggest that levels of binge drinking are decreasing among 12th graders, particularly males. Hopefully, as our understanding of the nature of the problem continues to improve with better measurement strategies, improvements in prevention approaches combined with declines in precollege drinking will lead to reductions in both the levels of alcohol consumption by college students and the negative consequences that result. ■

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Prevalence and Predictors of Adolescent Alcohol Use and Binge Drinking in the United States

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Because alcohol use typically is initiated during adolescence and young adulthood and may have long-term consequences, the Monitoring the Future (MTF) study annually assesses various measures of alcohol use among 8th-, 10th-, and 12th-grade students. These analyses have found that although alcohol use among these age groups overall has been declining since 1975, levels remain high. Thus, in 2011 about one-quarter of 8th graders, one-half of 10th graders, and almost two-thirds of 12th graders reported drinking alcohol in the month preceding the interview. Binge drinking (i.e., consumption of five or more drinks in a row) was also prevalent. Specific rates of drinking, binge drinking, and getting drunk varied among different student subgroups based on gender and race/ethnicity. The MTF study has also identified numerous factors that influence the risk of alcohol use among adolescents, including parents and peers, school and work, religiosity and community attachment, exercise and sports participation, externalizing behavior and other drug use, risk taking and sensation seeking, well-being, and drinking attitudes and reasons for alcohol use. Drinking during adolescence can have long-term effects on a person's life trajectory. Therefore, these findings have broad implications for prevention and intervention efforts with this population.
Key words: Underage drinking; binge drinking; adolescent; high school student; young adult; prevalence; predictors; causes of alcohol and other drug use; risk factors; school risk factors; environmental risk factors; family risk factors; peer risk factors; gender differences; racial/ethnic differences; Monitoring the Future (MTF) Study; United States

In the United States, alcohol use typically begins and escalates during adolescence and young adulthood. To describe the historical and developmental trends in substance use in this age group, the Monitoring the Future (MTF) study (Johnston et al. 2012) was designed in 1975. Since then, this ongoing national-cohort sequential longitudinal study assessing the epidemiology and etiology of substance use among adolescents and adults has been funded by the National Institute on Drug Abuse (NIDA). This article summarizes findings from the MTF study regarding the prevalence and predictors of alcohol use during adolescence.

The Prevalence of Drinking and Historical Changes

As is true for adults, alcohol is the most commonly abused substance among American youth. The MTF study has been documenting the prevalence and trends in alcohol use frequency and binge drinking (i.e., consumption of five or more drinks in a row) for the past several decades in annual, national samples of American 8th-, 10th-, and 12th-grade students. Using these data, Patrick and Schulenberg (2010) found that very few 8th- and 10th-grade students who reported having ever used alcohol had not used alcohol in the past year, suggesting that most of the alcohol use reported is relatively recent. Therefore, this article focuses on alcohol use in the past 12 months and the past 30 days, as well as self-reported drunkenness in the past 30 days and binge drinking in the past 2 weeks. The prevalence figures for these variables for 2011 are summarized in table 1, broken down by grade level, gender, and racial/ethnic subgroups (for more information, see Johnston et al. 2012).

In 2011, 27 percent of 8th graders, 50 percent of 10th graders, and 64 percent of 12th graders reported having used alcohol in the past 12 months. The corresponding rates for alcohol use in the past 30 days were 13 percent, 27 percent, and 40 percent, respectively. Furthermore, 4 percent of 8th graders, 14 percent of 10th graders, and 25 percent of 12th graders reported having been drunk within the past month. Finally, binge drinking in the past 2 weeks was reported by 6 percent of 8th graders, 15 percent of 10th graders, and 22 percent of 12th graders.

Interestingly, it is more common for students to report binge drinking 2 or more times in the past 2 weeks than to report binge drinking only once in the past 2 weeks; thus, 61 percent of 8th graders and 62 percent of 10th graders who had engaged in binge drinking in the previous 2 weeks did so on multiple occasions (Patrick and Schulenberg 2010). This observation suggests a fast shift to frequent heavier drinking for many young people. In addition, the surveys indicate that extreme binge drinking (i.e., consumption of 10 or more or 15 or more drinks in a row) is a problem among 12th graders (this variable was not assessed among 8th and 10th graders). Thus, 10.5 percent of high school seniors reported consuming 10 or more drinks in a row, and 5.6 percent reported consuming 15 or more drinks in a row in the past 2 weeks (Patrick et al. 2013).

Alcohol use differs not only by age but also by demographic subgroups, including gender and race/ethnicity

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(see table 1). In 8th grade, girls tend to have somewhat higher rates of alcohol use (i.e., 13 percent in the past 30 days) than do boys (12 percent). Among older students, however, this ratio is reversed, with 38 percent of female and 42 percent of male 12th graders reporting alcohol use in the past 30 days. This gender difference continues into adulthood, with men consistently using alcohol at higher rates compared with women (Johnston et al. 2012; Wilsnack et al. 2000). A similar interaction seems to exist between grade and race/ethnicity (Wallace et al. 2003). Thus, among 8th graders, Hispanic youth tend to report a greater prevalence of alcohol consumption in the last 12 months (36 percent) or last 30 days (18 percent), as well as of being drunk in the last 30 days (6 percent) and binge drinking in the past 2 weeks (10 percent) than do both White and African American youth. By 12th grade, however, White adolescents have the highest prevalence levels of the three racial/ethnic groups on all alcohol use measures, African American adolescents have the lowest levels, and Hispanics have intermediate levels. For example, for binge-drinking, prevalence rates among 12th graders are 26 percent for Whites, 11 percent for African Americans, and 21 percent for Hispanics. Some, but not all, of these race/ethnicity differences in alcohol use among 12th graders are attributable to differential high-school dropout rates among the different groups. Thus, dropout rates tend to be higher among racial/ethnic minority youth, and alcohol and other drug (AOD) use tends to be higher among school dropouts than among those staying in school (Bachman et al. 2008).

Table 1 Prevalence of Alcohol Use (%) by Demographic Subgroups in 8th, 10th, and 12th Graders, 2011

	Any Use in Past 12 Months	Any Use in Past 30 Days	Been Drunk in Past 30 Days	5+ Drinks in a Row in Past 2 Weeks
8th Graders				
Total	26.9	12.7	4.4	6.4
Gender				
Boys	26.2	12.1	4.4	6.1
Girls	27.1	12.8	4.2	6.5
Race/Ethnicity*				
White	26.2	12.3	4.7	6.2
African American	26.2	11.6	2.9	5.1
Hispanic	36.0	18.0	5.6	10.4
10th Graders				
Total	49.8	27.2	13.7	14.7
Gender				
Boys	49.1	28.2	14.9	16.5
Girls	50.3	26.0	12.4	12.7
Race/Ethnicity				
White	52.1	29.1	15.6	16.1
African American	43.6	20.8	8.3	9.4
Hispanic	54.8	31.8	13.8	19.7
12th Graders				
Total	63.5	40.0	25.0	21.6
Gender				
Boys	63.3	42.1	27.5	25.5
Girls	63.5	37.5	22.0	17.6
Race/Ethnicity				
White	66.8	43.8	29.9	25.9
African American	55.2	30.1	14.2	11.3
Hispanic	65.3	39.7	20.0	20.8

*To derive percentages for each racial subgroup, data for the specified year and the previous year were combined to increase subgroup sample sizes and thus provide more stable estimates.
NOTE: For 8th graders, the approximate weighted *N* is 16,000. For 10th graders, the approximate weighted *N* is 14,900. For 12th graders, the approximate weighted *N* is 14,100.
SOURCE: The *Monitoring the Future study,* the University of Michigan.

Overall, alcohol use among adolescents and young adults has been declining to the lowest levels in recent decades, as shown by the trends in self-reported alcohol use in the past 12 months and drunkenness in the past 30 days (see figure 1) (Johnston et al. 2012; Patrick and Schulenberg 2010). Similar trends have been observed for alcohol use in the past 30 days and binge drinking in the past 2 weeks. These historical shifts in AOD use can be attributed to multiple influences. For example, changes in the minimum legal drinking age (e.g., Wagenaar et al. 2001) as well as in perceived social norms (e.g., Keyes et al. 2012) have been shown to contribute to changes in alcohol use. Of particular interest are historical shifts that relate to changes in developmental trajectories. Latent growth modeling analyses with multicohort data have demonstrated that, compared with earlier cohorts, more recent cohorts exhibit lower initial levels of binge drinking but more rapid increases from age 18 to young adulthood (Jager et al. 2013). This acceleration of alcohol use helps explain the findings that use among adolescents has been decreasing at faster rates than among young adults in recent decades.

Predictors of Alcohol Use Among Adolescents

Despite the changes in alcohol use that have occurred over the past three decades, the relevant risk and protective factors tend to remain very stable across historic time, age, gender, and race/ethnicity (e.g., Brown et al. 2001; Donovan et al. 1999; Patrick and Schulenberg 2010). Like many other large-scale studies on adolescent AOD use, the MTF study has cast a wide net in terms of risk and protective factors, correlates, and consequences of substance use. Not only is this approach well suited to placing alcohol use within the larger context of adolescent development, it makes good use of the MTF large-scale survey approach that emphasizes breadth of measurement. Conceptually, the analyses drew from broad multidomain models when examining causes, correlates, and outcomes of adolescent alcohol use (e.g., Brown et al. 2009; Chassin et al. 2009; Maggs and Schulenberg 2005). This section summarizes MTF study findings concerning several domains of predictors of AOD use during adolescence, after considering methodological issues when examining causes and consequences of adolescent alcohol use.

Methodological Issues in Understanding Risk Factors for and Consequences of Adolescent Alcohol Use

When considering the correlates of AOD use, any attempt to discern whether these correlates are causes or consequences of substance use is hampered by three factors:

- Firm conclusions about causal connections are difficult without randomly controlled experiments.

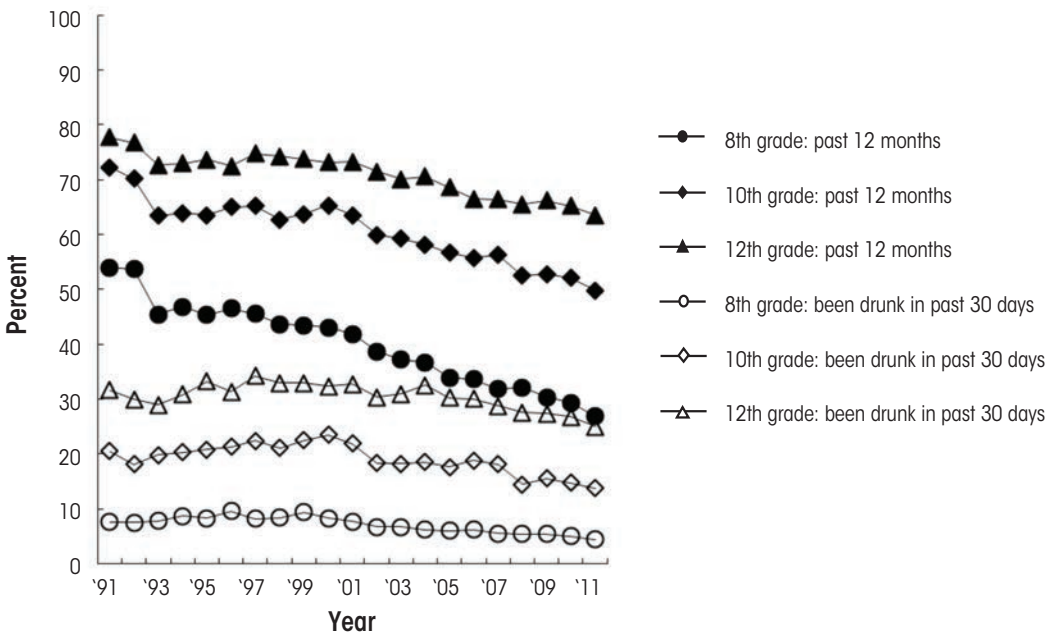

Figure Trends in alcohol use in the past 12 months and in having been drunk in the past 30 days for 8th, 10th, and 12th graders, 1991–2011.

- Alcohol use during adolescence typically is reciprocally related to risk factors across development, such that problems that contribute to alcohol use may get worse with continued alcohol use (e.g., Cairns and Cairns, 1994; Dodge et al. 2009; Schulenberg and Maslowsky 2009).

- Factors that are identified as causes or as consequences of alcohol use during adolescence in the total sample likely do not apply to all young people, given the heterogeneity in developmental course (Schulenberg 2006).

Cross-sectional studies, in which each individual is evaluated only once, typically provide little leverage for concluding whether a given construct is a cause, correlate, or consequence of alcohol use, emphasizing the importance of conceptual guidance, logic, and statistical controls. Furthermore, when adolescents report using multiple substances, it is difficult to determine whether they are using the drugs simultaneously or whether use of one substance leads to use of another. Longitudinal panel studies, in which the same individuals are followed over time, provide more leverage but still leave room for alternative interpretations. For example, these studies may suffer from selection effects—that is, a construct excluded from the analysis actually "causes" both drug use and assumed consequence of drug use, rendering the relationship between cause and consequence spurious. Some recent analytic strategies that have been used with longitudinal data, such as propensity score analyses (Bachman et al. 2011) and fixed effects analysis (Patrick et al. 2012*a*; Staff et al. 2009), allow for greater control of selection effects and thus better leverage on likely causal connections. Nevertheless, despite such statistical advances, experiments in which participants are randomly assigned to experimental groups remain the gold standard for demonstrating causal connections.

Finally, the use of self-report data may limit the usefulness of study findings because such data rely on participants to remember and accurately perceive their own level of substance use. Nevertheless, most studies like the MTF study rely on these measures, because they have been found to be valid and reliable (Bachman et al. 2011; O'Malley et al. 1983) and because it is very expensive and burdensome to collect physiological data (e.g., blood, urine, or hair) and/or information from multiple reporters (e.g., parents or peers) in large-scale studies.

Influence of Parents and Peers

One developmental transition characteristic of adolescence is the movement away from parents and increasing involvement with peers. Nonetheless, parents still play a pivotal role in adolescent experiences and in fact can sometimes counter the effects of other risk factors for AOD use. Like many other reports in the literature (e.g., Dishion and McMahon 1998; Kiesner et al. 2009), the MTF study found that parental supervision and monitoring relate to lower AOD use among 8th and 10th graders and together are one of the strongest predictors (Dever et al. 2012; Pilgrim et al. 2006). Of particular importance, this effect was equally important (i.e., invariant) across gender and race/ethnicity (Pilgrim et al. 2006). Furthermore, parental monitoring was especially protective against substance use for high-risk–taking adolescents (Dever et al. 2012).

The literature for decades has indicated that peer use is one of the strongest correlates of AOD use. This was confirmed in the MTF; thus, in an analysis of multiple predictors of binge drinking among 8th and 10th graders from 1991 to 2007, having friends who get drunk was the strongest risk factor, regardless of the grade level or cohort analyzed (Patrick and Schulenberg 2010). Moreover, friends' alcohol use in high school predicted both concurrent binge drinking and future trajectories of binge drinking (Schulenberg et al. 1996). Overall, the frequency of evenings out with friends (unsupervised by adults) was associated with more AOD use (Bachman et al. 2008; Brown et al. 2001; Patrick and Schulenberg 2010). Of course, a central issue when evaluating the role of peer use as a correlate and predictor of alcohol use is the extent to which friends actually influence an individual or the individual select friends who, like them, already drink. During adolescence and the transition to adulthood, both of these processes typically play a role (e.g., Patrick et al. 2012*b*).

Influence of School and Work

The broad domain of education also significantly relates to AOD use during adolescence (Crosnoe 2011). Studies consistently have found that grades, educational expectations, and school bonding are negatively correlated with AOD use, whereas school disengagement, school failure, school misbehavior, and skipping school are positively correlated with AOD use (Bachman et al. 2008; Bryant et al. 2003; Dever et al. 2012; Patrick and Schulenberg 2010; Pilgrim et al. 2006; Schulenberg et al. 1994). For example, in a longitudinal analysis examining 8th-grade predictors of concurrent and subsequent AOD use, school misbehavior and peer encouragement of misbehavior were positively associated with concurrent substance use and increased substance use over time. Conversely, school bonding, interest, and effort were negatively associated with concurrent and increased substance use, as were academic achievement and parental help with school (Bryant et al. 2003). Positive school attitudes were of particular importance and were especially influential as protective factors against substance use for low-achieving adolescents. The relationship between educational factors and AOD use is bidirectional, and it is clear that AOD use can contribute to educational difficulties. In general, however, it seems that based on MTF study longitudinal data and careful consideration of selection factors, the more common direction of influence is that school difficulties contribute to AOD use during adolescence (Bachman et al. 2008).

By the time they leave high school, most adolescents have worked part time during the school year. Although it has long been recognized that hours of work during adoles-

cence are positively related to use of AODs, conclusions about causal connections have remained elusive (Staff et al. 2009). Analysis of MTF study data found that when sociodemographic and educational characteristics are controlled for, the positive relationship between hours of work and AOD use diminishes, suggesting that selection effects exist. In other words, long hours of work and substance use have a common set of causes, particularly disengagement from school (Bachman and Schulenberg 1993; Bachman et al. 2011). The influence of selection effects is further supported by findings that simply wanting to work long hours is associated with heavier AOD use. This is true regardless of actual hours spent working, and especially among those who do not work (Bachman et al. 2003; Staff et al. 2010).

Religiosity and Community Attachment

Numerous studies found that religiosity tends to be negatively correlated with AOD use during adolescence (Brown et al. 2001; Wallace et al. 2003, 2007; Wray-Lake et al. 2012). This is true for both African American and White youth. In fact, religiosity does not explain race differences in substance use (Wallace et al. 2003). Religiosity tends to operate at both the individual and contextual levels, because highly religious adolescents attending highly religious schools have lower alcohol use compared with highly religious adolescents attending non–highly religious schools (Wallace et al. 2007). More broadly, community attachments, including religiosity as well as social trust and social responsibility, tend to be negatively correlated with AOD use during adolescence (Wray-Lake et al. 2012).

Exercise and Sports Participation

Whereas exercise correlates negatively with alcohol use, participating in team sports correlates positively with alcohol use during high school (Terry-McElrath et al. 2011). This is especially true for males (Dever et al. 2012).

Externalizing Behaviors and Other Drug Use

As part of a broader set of problem behaviors, it is not surprising that alcohol use is associated with externalizing behaviors as well as cigarette smoking and illicit drug use during adolescence. In the MTF study, externalizing behaviors overall, and aggressive behavior and theft/property damage in particular, correlated with AOD use during adolescence (Bachman et al. 2008; Brown et al. 2001; Maslowsky and Schulenberg, in press; Patrick and Schulenberg 2010). Disentangling causal connections is difficult, however, and it is likely that alcohol use both contributes to and is caused by externalizing behaviors (Osgood et al. 1988), particularly if these behaviors involve spending unsupervised time with peers (Osgood et al. 1996). Cigarette smoking and other illicit drug use also tend to be highly correlated with alcohol use during adolescence (Patrick and Schulenberg 2010).

Risk Taking and Sensation Seeking

The willingness to take risks and high levels of sensation seeking also both correlate with higher levels of AOD use (Dever et al. 2012; Patrick and Schulenberg 2010; Pilgrim et al. 2006; Schulenberg et al. 1996). Among 8th graders and 10th graders, the impact of risk taking on substance use (including alcohol) was partly mediated through school bonding (which negatively affected AOD use) and time with friends (which positively affected AOD use); these effects were largely invariant across race/ethnicity and gender (Pilgrim et al. 2006).

Well-Being

Self-esteem tends to be negatively correlated with AOD use and, correspondingly, self-derogation and depressive affect tend to be positively correlated with AOD use during adolescence (Maslowsky and Schulenberg, in press; Patrick and Schulenberg 2010; Schulenberg et al. 1996). When examining the relative contributions of conduct problems, depressive affect, and the interaction of conduct problems and depressive affect on AOD use, depressive affect is not as powerful a predictor as are conduct problems. However, the interaction of the two variables (i.e., high levels of both) is a relatively powerful predictor of alcohol use, especially for younger adolescents (Maslowsky and Schulenberg, in press).

Drinking Attitudes and Reasons for Using Alcohol

Attitudes regarding alcohol use and reasons for use are powerful correlates and predictors of drinking behavior. Indeed, disapproval of binge drinking is one of the strongest protective factors against heavy drinking (Patrick and Schulenberg 2010). A long-standing focus of the MTF study has been to show how, at the population level, changes in perceptions of risk about and disapproval of substance use precede changes in substance use (Bachman et al. 1998; Johnston et al. 2012; Keyes et al. 2011). A recent analysis assessed the effects of age, period (i.e., the year in which data were obtained), and cohort effects of population-based social norms regarding heavy alcohol use (i.e., level of disapproval of heavy use) on individual-level heavy drinking during adolescence. The study found that cohort effects predominated, indicating that being part of a birth cohort that reported higher disapproval of heavy drinking set the stage for lower alcohol use (Keyes et al. 2012).

Motivations or reasons for drinking also are associated with alcohol use behaviors and may serve as a marker for the development of problematic behavioral patterns. The reasons for alcohol use typically change across adolescence and into adulthood. MTF study investigators have assessed reasons for drinking using MTF study panel data following high-school seniors into young adulthood. (MTF survey questions regarding motivations are not included in the 8th- and 10th-grade surveys.) Of particular interest here, 12th-grade adolescents tend to report higher motivation for drinking to get drunk (as well as other social and coping reasons for

drinking) than do young adults. Conversely, 12th graders report lower motivations to use alcohol to relax, to sleep, and because it tastes good, all of which increase across the transition to adulthood (Patrick and Schulenberg 2011; Patrick et al. 2011). It is important to understand the reasons for alcohol use among adolescents, because the reasons for use reported in 12th grade, when adolescents are about 18, show long-term longitudinal associations with alcohol use and symptoms of alcohol use disorders decades later (Patrick et al. 2011; Schulenberg et al. 1996).

Long-Term Consequences of Alcohol Use

Attempting to discern long-term consequences of adolescent AOD use is fraught with conceptual and methodological complexities (e.g., Schulenberg et al. 2003), yet it is critical for understanding the development (i.e., etiology) of adult alcohol use disorders. Numerous studies have demonstrated that alcohol use in middle school and high school may be an important indicator of later problems. For example, although most students mature out of their heavy alcohol use (Schulenberg and Maggs 2002; Schulenberg and Patrick 2012; Schulenberg et al. 1996), substance use in high school is one of the strongest predictors of substance use in adulthood. Specifically, binge drinking in 12th grade predicts symptoms of alcohol use disorders 17 years later, at age 35 (Merline et al. 2004, 2008; Patrick et al. 2011). Furthermore, trajectories of binge drinking are predictive of alcohol use disorders during middle adulthood (Schulenberg and Patrick 2012), and continued substance use into young adulthood is associated with HIV-related risk behaviors (Patrick et al. 2012). Finally, binge drinking in high school predicts subsequent dropping out of college, although an increase in binge drinking during college is related to not dropping out (Schulenberg and Patrick 2012).

Implications for Prevention and Intervention

Studies on the etiology and epidemiology of alcohol use ought to go hand in hand in order to combine the broader approach of epidemiology with the more in-depth emphasis of etiology. As the discussion in this article has shown, there are both historical and developmental predictors related to adolescent AOD use that are changing over time. Understanding the scope of alcohol use during the middle-school and high-school years, and associated long-term problems, is an important step toward effectively intervening to reduce high-risk drinking and its negative consequences. The scope of the problem is underscored by the findings that more than one in five American high-school seniors in the class of 2011 reported binge drinking in the previous 2 weeks. The documented developmental increases in alcohol use across adolescence and young adulthood make this a particularly important time for intervention. In particular, the fast escalation among adolescents from binge drinking once to binge drinking multiple times within a given 2-week period (Patrick and Schulenberg 2010) highlights the importance of preventing early initiation as well as early escalation of AOD use.

Levels of alcohol use have been declining in recent decades, suggesting that past interventions, such as increasing the minimum legal drinking age to 21, have been effective. However, although it is worth recognizing that most adolescents manage to avoid heavy alcohol use and that such use is not an inevitable developmental progression, alcohol remains the most commonly used substance among adolescents, and its use is a leading cause of death and injury (U.S. Department of Health and Human Services 2007). To design effective programs and target prevention efforts toward students most likely to develop problematic levels of alcohol use, it is essential to identify characteristics of individuals at greatest risk. This effort is aided by the fact that the importance of risk and protective factors tends to remain very stable over time. As summarized above, demographic differences in drinking behavior point to important subgroups that should be targeted, including young men and White and Hispanic adolescents. Finally, the findings described here point to several risk and protective factors to consider when designing prevention and intervention programs, including parental involvement, peer influences, academic success, religiosity, externalizing and internalizing behaviors, alcohol attitudes, and self-reported reasons for drinking. ■

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The Burden of Alcohol Use

Focus on Children and Preadolescents

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The study of alcohol use by children ages 12 and younger has been very limited. This article summarizes information from U.S. national and statewide surveys on the prevalence of alcohol use among children in grades 6 and lower, data on health conditions wholly attributable to alcohol, the prevalence of children's treatment admissions for alcohol abuse, and their rates of presentation at emergency departments for acute alcohol intoxication. Factors hampering the estimation of alcohol burden in this population include the lack of ongoing national surveys of alcohol use and problems in children, the hand-me-down nature of alcohol assessments in this population, and the lack of studies to establish whether there is a causal relationship between childhood-onset drinking and morbidity and mortality in adolescence and later in life that would permit determination of alcohol-attributable fractions. This article concludes that although the alcohol burden in childhood is low, it may be augmented by both referred alcohol burden through parental drinking and alcohol abuse and by deferred alcohol burden from longer-term consequences of early use. **KEY WORDS: Alcohol consumption; alcohol use, abuse, and dependence; age of alcohol and other drug use onset; prevalence; alcohol burden; alcohol-attributable fractions; alcohol-related problems; alcohol intoxication; alcohol poisoning; childhood; child; preadolescent; youth; elementary school student; mortality; morbidity; survey; national surveillance data; health and disease; emergency care; treatment; underage drinking**

The burden of alcohol use usually is expressed as a function of the contribution of alcohol use in a population to morbidity and mortality in that population (Rehm et al. 2010). It is difficult to calculate the burden of alcohol use for middle-school and high-school adolescents (see Patrick and Schulenberg, p. 193 in this issue) and nearly impossible to do so for children and preadolescents. There are a number of reasons for this, most of which reflect the early stage of development of the research literature on alcohol use in this young population.

Factors Limiting Estimation of Alcohol Burden

The Absence of Recent National Surveillance Data

Chief among the factors inhibiting the estimation of alcohol burden in children and preadolescents is the absence of ongoing national surveillance data. The prevalence of child alcohol use can theoretically be estimated from either adolescents' retrospective recall of their alcohol use in childhood or from survey research with children.

Retrospective reports of the age at first drink, however, are not very reliable for this life stage. Typically, reported age of onset of alcohol use increases as a function of the age of the adolescents questioned (Bailey et al. 1992; Engels et al. 1997; Johnson et al. 1998; Labouvie et al. 1997; Parra et al. 2003). For example, in the most recent national data from the 2009 Youth Risk Behavior Survey (YRBS), 28.1 percent of 9th graders reported that they drank alcohol before age 13, compared with 14.2 percent of 12th graders (Eaton et al. 2010). These are not cohort effects but rather evidence of "forward telescoping," as shown by the fact that although the percentages at all grades have declined over time, a similar pattern can be seen in each of the previous YRBS surveys (1991–2007). This pattern also is evident in the 1993–2010 national data from the Monitoring the Future (MTF) surveys (see figures 6 to 20 in Johnston et al. 2011): in every year, less than one-half as many 12th graders as 8th graders report alcohol use initiation by grade 6. Thus, estimates based on retrospective recall are problematic as a summary of the prevalence of childhood drinking.

Direct surveys of children constitute a more appropriate approach for capturing normative data on child drinking. However, of the three major ongoing Federally sponsored national surveys in the United States—the annual MTF survey, the biennial YRBS, and the annual National Survey on Drug Use and Health (NSDUH)—only the NSDUH includes children who are age 12, and none includes children younger than 12. According to the 2010 NSDUH results (Tables 2.15B and 2.16B in Substance Abuse and Mental Health Services Administration [SAMHSA] 2011), 7.1 percent of 12-year-olds had ever had a drink of alcohol (i.e., a can of beer, a glass of wine, or a shot of liquor) in their life, 4.4 percent had a drink in the past year, 1.6 percent had a drink in the past month, and 0.4 percent had consumed five or more drinks on the same occasion.

Despite the absence of children in these ongoing Federal surveillance studies, preliminary information on the prevalence of alcohol use in children has nevertheless been compiled

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through a comprehensive search of internet sources to locate Nationwide and Statewide surveys of children in grades 6 and below (see Donovan 2007). Based on this review of the four Nationwide and seven Statewide datasets located, it is clear that a substantial number of children have had some exposure to alcohol. Data from the cross-national Health Behaviour of School-Aged Children Study (Nic Gabhainn and François 2000) indicate that in a 1998 national sample of 11-year-old U.S. students, 62 percent of boys and 58 percent of girls had ever tasted alcohol, 8 percent of boys and 7 percent of girls had consumed alcohol at least weekly, and 3 percent of both boys and girls had ever been drunk twice or more. According to the 1999 Partnership Attitude Tracking Study (sponsored by the Partnership for a Drug-Free America), which surveyed a national probability sample of nearly 2,400 U.S. elementary-school students, 9.8 percent of 4th graders, 16.1 percent of 5th graders, and 29.4 percent of 6th graders had had more than just a sip of alcohol in their life. In 2000–2001, the National Survey of Parents and Youth (NSPY) collected alcohol use information on 1,560 9- to 12-year-olds and found that 6.2 percent of 9-year-olds, 5.5 percent of 10-year-olds, 9.2 percent of 11-year-olds, and 15.5 percent of 12-year-olds had had more than a few sips of alcohol in their life. Data on alcohol use in the past year (rather than lifetime) are reported annually by Pride Surveys (see www.pridesurveys.com): according to the 2009–2010 summary of school-district surveys performed across the United States, 4.0 percent of 4th graders, 4.8 percent of 5th graders, and 8.3 percent of 6th graders had drunk alcohol in the past year. Both the Nationwide and Statewide datasets examined showed a decline in the prevalence of child drinking over the past 10 years or so. The datasets located for this review, however, generally are either outdated or nonrepresentative, and their limitations must be recognized in any attempt to estimate the burden of alcohol use in this population. The absence of any recent national survey of alcohol use among children argues for the need to institute ongoing Nationwide surveillance of this population.

It is nevertheless evident, however, that the percentage of children who have experience with alcohol decreases as the intensity of alcohol involvement increases (from a sip or taste to more than a few sips ever to use in the past year, past month, or past week), and that it differs as a function of grade, gender, and ethnicity (see Donovan 2007). Alcohol use rates increased with age, doubling between grades 4 and 6, with the largest jump in prevalence between grades 5 and 6. At each grade level, boys were more likely to have used alcohol than girls. African-American children were nearly as likely as white and Hispanic children to have used alcohol. About one-third as many children reported having had more than a sip of alcohol as reported having had only a sip. In general, around one-third of children who had ever used alcohol reported its use in the past year as well, and use in the past month occurred in only about one-third of those children who reported use in the past year.

There are few current Nationwide data sources on the prevalence of children's experience of problems attributed to alcohol use that could inform estimates of their wholly alcohol-attributable health conditions (i.e., alcohol dependence and acute intoxication). Several community-level studies suggest that rates of alcohol use disorders are close to zero prior to adolescence (Cohen et al. 1993; Giaconia et al. 1994; Sung et al. 2004). The low number of Nationwide admissions for treatment of alcohol abuse at ages 10–12 bears this out (see figures 14 and 15 in SAMHSA 2008). Patients under the age of 15 constitute just 0.5 percent of those admitted for treatment of alcohol abuse alone and 0.7 percent of those admitted primarily for treatment of alcohol abuse who also had abused another drug (Table 3.2a in SAMHSA 2008).

Likewise, in contrast to adolescents, children rarely present at hospital emergency departments for acute intoxication (alcohol poisoning). In 2009, the rate of visits to emergency departments for acute alcohol intoxication was 5.6 per 100,000 for U.S. children ages 0–5 and 1.0 per 100,000 for children ages 6–11 versus 310.8 per 100,000 for adolescents ages 12–17 (Drug Abuse Warning Network 2010). Of all calls to poison-control centers in the United States in 2009 involving children ages 5 or younger, 2.12 percent of cases involved ingestion of alcohol (Bronstein et al. 2010). This probably is an underestimate, as many children ingested products such as cold medicines, cologne, perfume, aftershave, and mouthwash that contain ethanol (see Vogel et al. 1995).

In summary, there are few surveillance studies of alcohol use and alcohol-related problems among children and preadolescents. The extant data indicate that although the rates of alcohol use are low in this population, substantial numbers of children do have experience with alcohol and the rates of wholly alcohol-attributable health conditions are very low in this population. No evidence has been generated regarding the influence of child drinking on other diseases or injuries within childhood.

Problems of Measurement

A second major limitation for estimating alcohol burden in this population is the widespread use of "hand-me-down" measures for the assessment of children's alcohol use. Measures originally developed for use with adults have been modified for use with college students; then modified for use with adolescents; and, finally, modified for assessment of children. Reliance on such hand-me-down assessments has resulted, for instance, in only limited research into sipping and tasting of alcohol despite the fact that this is the most common form of children's experience with alcohol (see Casswell 1996; Casswell et al. 1991; Donovan and Molina 2008; Johnson et al. 1997).

The hand-me-down nature of child and adolescent assessments is nowhere more evident than in the case of heavy episodic (binge) drinking, a major contributor to adult morbidity and mortality. In adults, binge drinking has been operationally defined as five or more drinks per occasion for

men and as four of more drinks per occasion for women (Wechsler et al. 1995); these levels of intake result in blood alcohol concentrations (BAC) of 0.08 percent (the legal definition of intoxication) if consumed within a 2-hour window. Using these definitions for children and adolescents is inappropriate, however, because they weigh less and thus have smaller volumes of total body water than adults. A recent analysis (Donovan 2009) modified the Widmark equation for estimating BAC so it would be more developmentally appropriate. This was done by incorporating formulas for estimating total body water that were derived from children and adolescents and by using ethanol elimination rates derived from child and adolescent presentations for acute alcohol intoxication at emergency departments. BAC estimates were calculated for intake of from one to five standard drinks for boys and girls separately at each age from 9 to 17 to determine how many drinks were required to result in an estimated mean BAC of 0.08 percent or higher. Data from more than 4,700 children and adolescents from the 1999–2002 National Health and Nutrition Examination Survey were analyzed. Girls and boys ages 9–13 had mean estimated BACs of 0.08 percent or higher at three or more drinks, as did girls ages 14–17. Boys ages 14 and 15 had mean estimated BACs of 0.08 percent or higher at four or more drinks, and boys ages 16 and 17 reached this level at five or more drinks. Table 1 summarizes the resulting recommendations for defining binge drinking for children and adolescents by age and gender. Only boys ages 16 or 17 met the adult definition.

In addition to the concern over hand-me-down assessments, there is a lack of consensus on the definition of the various levels of alcohol involvement for both children and adolescents. As is evident in the summary of survey studies above, drinker status was defined variously as consumption of more than a sip, more than a few sips, or a whole drink. This severely hinders the performance of meta-analyses across studies and the description of trends over time. Bacon (1976) noted a similar lack of consensus 35 years ago.

In general, evidence from both test–retest examinations and collateral reports suggests that children's self-reports of their alcohol use are as valid as adolescent self-reports (Dielman et al. 1995; Donovan et al. 2004). Given their typically low levels of intake and the opportunistic nature of their drinking, misreporting in child reports of their alcohol involvement is unlikely to reflect cognitive overload. More likely, difficulties stem from a lack of familiarity with alcohol beverage types (beer versus liquor, for example) and with estimation of drink volumes consumed. At least one recently developed inventory uses pictorial images to assess alcohol and drug use and their risk factors (see Andrews et al. 2003; Ridenour et al. 2009, 2011).

In addition to making child alcohol assessments more developmentally appropriate and user friendly, surveillance studies of child alcohol use need to be expanded to include questions on the intensity and patterning of their current alcohol use (e.g., frequency of use, usual and greatest intake, frequency of binge drinking, and contexts of use).

Table 1 Recommended Cut Points (Number of Drinks) for Developmentally Appropriate Definition of Binge Drinking in Children and Adolescents (Donovan 2009)

Age	Boys	Girls
9–13	3+	3+
14–15	4+	3+
16–17	5+	3+

Barriers to Collecting Child Data

Although monitoring the Nationwide prevalence of children's alcohol use would constitute a step in the right direction, increased research also is needed. It is possible that so few studies have been conducted in this area because of the perception of several barriers to such research (see Donovan 2007). One perceived barrier is that few children drink, so there is little variation to explain. A second is the difficulty of gaining school-district approval to access elementary school populations, necessitating the use of targeted-age directory sampling or household enumeration sampling methods. A third barrier sometimes raised is the misapprehension that parents will be reluctant to consent to their children's participation in alcohol research.

Referred Childhood Alcohol Burden Through Parent Drinking

Parents contribute to the alcohol burden of their children in a variety of ways. First, they model drinking behavior for good or for ill. National surveys show that the majority (87.9 percent) of adults in the United States ages 26 and older have ever drank, 69.0 percent drank in the past year, and 54.9 percent drank in the past month (Table 2.37B in SAMHSA 2011). Children learn about alcohol and its effects and usages from observing their parents drinking or from hearing their parents talk about their drinking, as well as from their exposure to drinking in the larger social environment (e.g., relatives, peers and their families, neighborhood events, alcohol commercials on TV and radio, magazine ads, Internet Web sites, social media, and drinking in movies and even in animated feature films) (see Zucker et al. 2008, 2009). Children whose parents drink are more likely to initiate early use (Donovan and Molina 2008, 2011; Hawkins et al. 1997).

Second, parents actively teach their children about alcohol. Children are first introduced to alcohol use by parents or other relatives in a family context (see Jackson 1997; Jahoda and Cramond 1972; Johnson et al. 1997). Such precocious socialization into alcohol use can reflect either Old World cultural beliefs regarding the role of alcohol as food or as a necessary adjunct for celebrations or the belief that introducing

children to alcohol use as part of family dinners or events serves to inoculate them from later involvement in problem drinking. Research has not yet established, however, whether learning to drink in a family context actually serves to protect children from developing later alcohol problems. The relevant longitudinal research (Dielman et al. 1989; McMorris et al. 2011; van der Vorst et al. 2010) suggests that this is not the case: prior supervised drinking increases the likelihood of unsupervised drinking and more negative consequences later on. In addition, children who were permitted to drink alcohol at home have been found to show increased alcohol involvement and drunkenness over time (Jackson et al. 1999; Komro et al. 2007). Research also shows that European adolescents, who are more often introduced to alcohol in family contexts, typically are more likely to be involved in binge drinking and intoxication than U.S. adolescents of the same age (Currie et al. 2008; Friese and Grube 2010; Grube 2009).

Third, the home environment is the most popular source of alcohol for children. Among 6th-grade students who had ever had alcohol, the largest percentage (32.7 percent) obtained the alcohol from a parent or guardian the last time they drank (Hearst et al. 2007). Other adults become a more important source of alcohol than parents as children move into adolescence. Greater access to alcohol in the home and greater parental provision of alcohol are associated with greater alcohol intake and problems later on (Komro et al. 2007; van den Eijnden et al. 2011).

In addition to their direct impact on child drinking, parental drinking and alcohol abuse may increase child morbidity and mortality through other means as well. Children also may be placed at increased risk through prenatal exposure to maternal drinking (Jacobson and Jacobson 2002; Mattson et al. 2001; Rasmussen 2005; Richardson et al. 2002; Streissguth et al. 1999); through genetic inheritance of liabilities to alcohol abuse and related addictive behaviors (Schuckit 1994; Sher 1991; Zucker et al. 2003); through alcohol-impaired parenting, abuse, and neglect (Bijur et al. 1992; Dube et al. 2001; Kelleher et al. 1994); and through their adoption of parent-socialized alcohol-specific intentions, attitudes, and expectancies (e.g., Donovan et al. 2009; Handley and Chassin 2009; Tildesley and Andrews 2008), leading to both short-term and longer-term consequences. In addition, children are at risk of injury or death through riding in cars driven by an alcohol-impaired parent: in 2009 alone, 14 percent of the children ages 14 and younger killed in traffic crashes were killed in alcohol-impaired driving crashes, and one-half of these children were passengers in vehicles driven by a driver with a BAC of 0.08 percent or higher (U.S. Department of Transportation 2011).

Deferred Childhood Alcohol Burden Through Long-Term Consequences

The measurable burdens of child and preadolescent drinking are for the most part postponed into adolescence and young adulthood. Early onset of alcohol use predicts involvement in alcohol problems, alcohol abuse, and alcohol dependence in adolescence (Gruber et al. 1996; Hawkins et al. 1997; Horton, 2007; McGue and Iacono, 2005; Pederson and Skrondal, 1998; Warner et al. 2007). Early-onset drinking also relates to a variety of other problematic outcomes in adolescence, including absences from school, delinquent behavior, drinking and driving, smoking, marijuana and other illicit drug use, sexual intercourse, and pregnancy (Ellickson et al. 2001; Gruber et al. 1996; McCluskey et al. 2002; Stueve and O'Donnell, 2005).

There also is evidence that early initiation of alcohol use affects a number of outcomes in young adulthood as well. These young-adult outcomes include not only alcohol use disorder (e.g., Hingson et al. 2006; King and Chassin, 2007) but also prescription drug misuse (Hermos et al. 2008), substance use disorders (Hingson et al. 2008; King and Chassin, 2007), employment problems (Ellickson et al. 2003), unintentional injuries (Hingson and Zha 2009; Hingson et al. 2000), and risky driving and drinking and driving (Hingson et al. 2002; Zakrajsek and Shope 2006). Retrospective data from adults also have shown a relationship between earlier onset of drinking and lifetime experience of an alcohol use disorders (e.g., DeWit et al. 2000; Grant and Dawson 1997). Research currently is lacking, however, on whether early-onset drinking relates to psychosocial functioning in other young-adult life areas, such as educational, occupational, marital, social, political, and community functioning, and relationship with parents.

As yet, there are few studies of the mechanisms linking early-onset drinking to young-adult alcohol problems and other negative outcomes. McGue and Iacono (2008) see this linkage as emanating from the interrelations between early drinking and other problem behaviors in adolescence (Donovan and Jessor 1985) and the stability of this syndrome into young adulthood (Jessor et al. 1991), which is seen as reflecting both inherited vulnerability and the influence of early problem behavior on the selection of risky social environments. Identification of such underlying mediating mechanisms is an important component of establishing any causal linkage between early-onset drinking and these later outcomes that would inform estimation of their alcohol-attributable fractions (Rehm et al. 2010). The greater the role of mediating variables in this pathway, the smaller the alcohol-attributable fraction is likely to be.

Conclusions

In summary, there are few surveillance studies of alcohol use and alcohol-related problems among children and preadolescents, a situation that makes estimation of alcohol burden in this population problematic. The available data indicate that whereas the rates of alcohol use are relatively low in this population, substantial numbers of children do in fact have experience with alcohol. With respect to wholly alcohol-

attributable health conditions, the available data suggest very low levels of alcohol abuse and acute intoxication among children. The scattered and inaccessible nature of much of this available data highlights the need for better ongoing surveillance of this population. Although these direct assessments imply that alcohol burden in children is relatively low, their alcohol burden is increased through the alcohol use and abuse of their parents, and through the increased likelihood among early drinkers of alcohol problems and other negative outcomes in adolescence and young adulthood. ■

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Childhood Trauma, Posttraumatic Stress Disorder, and Alcohol Dependence

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Early-childhood trauma is strongly associated with developing mental health problems, including alcohol dependence, later in life. People with early-life trauma may use alcohol to help cope with trauma-related symptoms. This article reviews the prevalence of early-childhood trauma and its robust association with the development of alcohol use disorders and posttraumatic stress disorder. It also examines the potential biological mechanisms by which early adverse experiences can result in long-lasting changes in neurobiology underlying this vulnerability, as well as pharmacological and behavioral interventions. Recent investigations highlight the importance of assessing trauma among patients with alcohol use disorders and the positive benefits associated with the application of integrative psychosocial interventions that target both trauma-related symptoms and alcohol dependence. **KEY WORDS: Alcohol dependence; alcohol use disorders; childhood; childhood trauma; trauma-related symptoms; posttraumatic stress disorder; coping with stress or anxiety; neurobiology; biological mechanisms; treatment; pharmacological intervention; behavioral intervention; integrative psychosocial intervention; adverse child-rearing environment**

Children exposed to severe adversity early in life are at increased risk of subsequently developing mental health problems, including alcohol dependence. In general, the onset of trauma precedes the onset of alcohol dependence. Although it is impossible to establish a direct causal relationship, this temporal relationship suggests a robust and positive relationship between exposure to early-life trauma and alcohol-related problems later in life. People with trauma-related symptoms and other negative consequences of early-life trauma may use alcohol to help mitigate such symptoms. People with both a positive history of early childhood trauma and co-occurring alcohol dependence have a more severe clinical profile, as well as worse treatment outcomes when compared with those with either early trauma or alcohol dependence alone. Recent investigations highlight the importance of assessing trauma among patients with alcohol use disorders and the positive benefits associated with the application of integrative psychosocial interventions that target both trauma-related symptoms and alcohol dependence. This article reviews the prevalence of early-childhood trauma and its robust association with the development of alcohol use disorders and posttraumatic stress disorder (PTSD). It also examines the potential biological mechanisms by which early adverse experiences can result in long-lasting changes in neurobiology underlying this vulnerability, as well as pharmacologic and behavioral interventions.

Prevalence

There is little doubt that severe childhood adversity may place an individual at life-long risk for a variety of problems, including those related to mental health, physical health, employment, and legal difficulties (Putnam 2006). In a study conducted by the Centers for Disease Control and Prevention and Kaiser Permanente (Adverse Childhood Experiences [ACE] study; Felitti et al. 1998), a sample of 17,337 adults recruited from a large health maintenance organization were surveyed concerning a range of adverse events that might occur during childhood (e.g., physical or sexual abuse, incarcerated household member, emotional neglect) and adult risk behaviors, health status, and disease. The investigators found a graded relationship between the number of adverse childhood experiences (i.e., ACE score), risk behaviors during adulthood, and leading causes of morbidity and mortality in the United States, including heart disease, diabetes, liver disease, and emphysema. It is possible that these increased rates of medical conditions are not a direct result of

childhood adversity but rather the result of dysfunctional and unhealthy behaviors in which many victims of childhood abuse engage.

A number of studies also report that victims of child maltreatment are more likely to have emotional difficulties and psychiatric disorders. One of the most consistent results across these studies is the finding that childhood maltreatment is associated with an increased risk for alcohol and drug use disorders (Enoch 2011). In a population-based sample of 1,411 female adult twins, self-reported childhood sexual abuse was positively associated with a number of psychiatric disorders, but the strongest associations were with alcohol and drug dependence (Kendler et al. 2000). In the ACE study, the risk of alcohol dependence increased 7.2-fold, and illicit drug use increased 4.5-fold for people with four or more ACEs (Anda et al. 2006). People with a history of childhood abuse or neglect are vulnerable to using alcohol in order to cope with stressful situations, which in turn may lead to excessive alcohol use (Schuck and Widom 2001). An investigation by Widom and colleagues (2007) demonstrates that the increased risk of excessive alcohol use among victims of childhood abuse or neglect is consistent and stable into middle adulthood (e.g., age 40). Furthermore, research has shown that alcohol-dependent patients with a history of sexual abuse are more likely than nonabused patients to relapse to alcohol use (87.5 vs. 63.3 percent) and to relapse more quickly (median time to first drink = 60 vs. 115 days) in the first year following inpatient treatment for alcohol dependence (Greenfield et al. 2002).

In addition to alcohol use disorders, childhood adversity is associated with an increased risk of PTSD (Widom 1999). Data from a number of studies over the last 20 years have emphasized the high co-occurrence of PTSD and alcohol disorders. For example, among 3,768 female twins participating in the longitudinal Missouri Adolescent Female Twin Study (MOAFTS), Sartor and colleagues (2010) found that women exposed to trauma were nearly twice as likely to develop alcohol dependence (hazard ratio 1.85), and women exposed to trauma who also had PTSD were even more likely to develop alcohol dependence (hazard ratio 3.54; significantly higher than women with trauma exposure alone) when compared with women who had not experienced trauma. Studies of samples of individuals seeking treatment for alcohol use disorders also find a high prevalence of reported childhood adversity and PTSD. In a study of men and women in treatment for addictions, 62 percent reported having been victims of childhood physical or sexual abuse (Grice et al. 1995). A review of studies of individuals seeking treatment for addictions reveals rates of PTSD as high as 50 percent or greater (Dansky et al. 1994). In the majority of cases, the development of PTSD precedes the development of the substance use disorder.

These high rates of childhood victimization in individuals with PTSD and alcohol and other substance-related problems suggests that there is a link between childhood adversity and the development of these disorders, although it is impossible to establish a direct causal relationship. However, even when studies control for demographic differences, family discord, and parental pathology, the specific relationship between childhood abuse and the development of substance use disorders holds true. Several theoretical connections have been postulated (Miller et al. 1993). Childhood victimization may lead to low self-esteem and the subsequent use of alcohol to deal with negative cognitions. It also is possible that victims of childhood abuse feel that their experiences make them "different" from other children and lead them to withdraw from healthier social circles toward fringe groups, where alcohol use is more accepted. In any case, given that victims of child abuse are more likely to develop alcohol use disorders as adults, early intervention, prevention, and training for parents are all important in interrupting this cycle of violence and alcohol problems.

Neurobiology

Recognizing the pervasive and detrimental effects of adverse childhood experiences on quality of life and health outcomes has led to the exploration of potential biological mechanisms by which early experiences can produce long-lasting changes. Evidence from both animal and human research suggests that early stressors can lead to neurobiological changes in systems known to be involved in the pathophysiology of depression, anxiety, and substance use disorders (De Bellis et al. 1999; Heim and Nemeroff 2001). The hypothalamic–pituitary–adrenal (HPA) axis plays a critical role in the stress response and is involved in the pathophysiology of addictive disorders. Early stressors cause long-term increases in the stress response of the hormone cortisol (Plotsky and Meaney 1993) as well as decreased genetic expression of cortisol receptors and increased expression of corticotropin-releasing factor in the hypothalamus, both of which may contribute to dysregulation of the HPA axis (Ladd et al. 1996). The noradrenergic system also plays a key role in stress (Bremner 2003), and early stressors can lead to long-term decreases in α-2 noradrenergic receptors in the locus coeruleus, which may lead to loss of feedback inhibition of noradrenergic activity with associated increases in the noradrenergic stress responses (Caldji et al. 1998; Sanchez et al. 2001).

In addition to the long-lasting effects of early trauma on the stress response, a number of studies indicate that early trauma has specific effects on the neurotransmitter systems involved in the positive reinforcing effects of alcohol and drugs, particularly the brain pathway for dopamine (i.e., the mesocorticolimbic dopamine system) (Meaney et al. 2002). Higley and colleagues (1991) found that adult rhesus monkeys raised in peer groups without maternal care showed increased HPA response to stress and increased alcohol consumption during periods of stress (Higley et al. 1991). In a series of studies, Meaney

and colleagues (2002) demonstrated that repeated periods of maternal separation in the early life of rats decreased dopamine transporter expression and increased dopamine responses to stress and behavioral responses to stress, cocaine, and amphetamine. These findings suggest that early-life experiences can affect the development of the mesocorticolimbic dopamine system and lead to a vulnerability to addiction in later life. Thus, in addition to effects on stress reactivity, early-life events might predispose individuals to the development of alcohol use disorders by directly influencing the reinforcing effects of alcohol. Other neurotransmitter systems involved in the pathophysiology of alcohol dependence, such as brain-derived neurotrophic factor (BDNF), serotonin, and γ-aminobutyric acid (GABA) systems also are affected by early-life trauma in ways that may influence vulnerability to the development of alcohol dependence, but the mechanistic connections in these systems are under active investigation and are not as well understood (Enoch 2011).

Not all children exposed to early-life trauma develop alcohol dependence or other significant pathology, clearly suggesting that resilience and mediating factors play a role (Enoch 2011). The genetic risk for alcohol and drug dependence involves multiple genes. Emerging evidence suggests that variation in some stress-related genes may determine the risk for psychopathology or resilience in people exposed to early-life trauma. In particular, it seems that there are important variations in the genes encoding the CRF system that can influence the development of alcohol dependence following an early-life trauma in a gene-by-environment interaction. One study of at-risk children found an interaction between a particular genetic variant coding for the CRF receptor (i.e., CRHR1) and sexual trauma in adolescents that predicted an earlier age of onset of drinking and heavy alcohol consumption (Blomeyer et al. 2008). This finding is supported by animal studies demonstrating that the CRHR1 genotype and expression interact with environmental stress to reinstate alcohol-seeking in rodents (Hansson et al. 2006), and a functional CRF promoter variant in monkeys conferred increased stress reactivity and was associated with increased alcohol consumption in animals reared under stressful conditions (Barr et al. 2009). These findings suggest that the interaction of genetic susceptibility and environmental exposure can lead to a pathologically activated CRF system, which increases the risk for the development of alcohol dependence in some people.

Treatment

Both behavioral and pharmacological interventions are important to consider in the treatment of alcohol dependence and trauma/PTSD (Davis et al. 2006; Weiss and Kueppenbender 2006). To date, most empirical studies of behavioral or pharmacological agents have investigated the treatment of either alcohol dependence or PTSD alone.

Psychosocial Interventions

With regard to psychosocial interventions, cognitive–behavioral therapies (CBTs) are the most widely studied and empirically valid treatments for both PTSD and alcohol use disorders. The CBTs used to treat PTSD fall into three main categories: (1) exposure-based therapies, (2) cognition-focused therapy, and (3) anxiety/stress-management therapy. Exposure-based therapies are considered the gold standard treatment for PTSD (Institute of Medicine 2008) and involve having patients confront safe, but anxiety-provoking situations (i.e., physical location where childhood abuse occurred), known as in vivo exposure; and the memory of the traumatic experience, known as imaginal exposure (Foa et al. 2006). With prolonged, repeated in vivo and imaginal exposure, the trauma-related anxiety is extinguished. Cognition-focused therapy includes cognitive therapy, which addresses the meaning that people assign to early-life trauma; and cognitive-processing therapy, which combines a narrative element of exposure therapy with efforts to identify and modify unhelpful cognitions related to the themes of safety, trust, power, esteem, and intimacy (Resick and Schnicke 1992). Finally, stress inoculation training (Meichenbaum and Novaco 1985), one of the most widely used and empirically investigated forms of anxiety management therapies, aims to provide a sense of mastery over PTSD symptoms by teaching patients a variety of coping skills. Stress inoculation training also has been incorporated into CBTs for substance use disorders and includes relaxation training, breathing retraining, thought stopping, self-instruction training, assertiveness training, cognitive restructuring, anger management, and problem solving.

Recently, integrative psychosocial interventions have been developed to address both trauma/PTSD and substance use disorders simultaneously (Back 2010). Clinicians previously believed that trauma interventions were inappropriate until after a patient had been abstinent from alcohol or drugs for a sustained period of time (e.g., 3 months). This model, known as the "sequential" model, posits that continued alcohol use impedes therapeutic efforts to address and process the trauma, and that trauma interventions commenced before sustained abstinence would result in increased risk of relapse. Contrary to these beliefs, however, recent data reported by several different investigators in the United States and Australia show that treatment outcomes of substance dependent patients who engage in integrative CBT interventions typically experience significant improvements in both conditions and that rates of relapse are not increased by the introduction of therapy for trauma (Brady et al. 2001; Hien et al. 2004; McGovern et al. 2009; Najavits 2002; Triffleman et al. 1999). Proponents of integrative treatments posit that unprocessed trauma-related memories and PTSD symptoms may, at least in part, drive alcohol use. Thus, attending to and treating the trauma-related

symptoms early in the process of therapy may improve the chances of long-term recovery from alcohol (Back et al. 2006; Hien et al. 2010). Although more randomized controlled trials of integrative treatments are needed, the studies to date clearly demonstrate that for the majority of alcohol-dependent patients with trauma/PTSD, the inclusion of trauma interventions confers substantial therapeutic benefits.

Pharmacological Interventions

There are several general issues to consider when treating co-occurring alcohol dependence and trauma/PTSD. When pharmacological agents are used, treatment should generally follow routine clinical practice for the treatment of PTSD. Regardless, relapse is common, and it is critical to consider the potential toxic interactions that may occur between the prescribed medication and alcohol. Given the high co-occurrence of alcohol and illicit drug use, potential toxic interactions between the prescribed medication and other substances of abuse must also be addressed. The pharmacological agent with the least abuse liability potential should be chosen for this population. Although benzodiazepines are effective in providing immediate relief of anxiety symptoms, they are generally not considered a first-line treatment for patients with alcohol dependence given the abuse potential of benzodiazepines. During the initial phase of treatment, when latency of onset of antidepressants is an issue, benzodiazepines may be considered as adjunctive medication. The amount of benzodiazepines prescribed to the patient should be limited, and the patient should be closely monitored for relapse or nonmedical use of benzodiazepines or other medications.

The use of pharmacological agents to specifically target alcohol dependence and PTSD is underexplored. Most studies to date, however, show promise and suggest that patients with co-occurring alcohol dependence and trauma/PTSD respond well to standard PTSD pharmacotherapies. Sertraline, a serotonin-specific reuptake inhibitor, has been investigated in patients with comorbid alcohol dependence and PTSD. The first study was a small (n = 9) open-label, 12-week trial, which demonstrated significant pre–post decreases in alcohol use severity (e.g., number of drinking days, number of drinks per day), as well as PTSD symptoms of re-experiencing the trauma, avoidance, and hyperarousal (Brady et al. 1995). A second study examined the efficacy of 12 weeks of sertraline compared with placebo in 94 patients with alcohol dependence and PTSD (Brady et al. 2005). The primary outcome analysis indicated no significant effect of sertraline on alcohol-related outcomes and only trend-level findings for the PTSD outcomes. The sertraline-treated group showed statistical trends for greater improvement in the experience of sudden flashbacks of the traumatic event and hyperarousal symptoms (e.g., insomnia, inability to concentrate). Follow-up cluster analyses suggested that individuals with primary PTSD, compared with primary alcohol dependence, derived more benefit from sertraline treatment as evidenced by significantly less severe alcohol use. The results suggested that patients with early-onset alcohol dependence actually had worse alcohol-related outcomes with sertraline treatment compared with placebo (Brady et al. 2005).

In another study of 254 veterans with alcohol dependence and a variety of co-occurring mood and anxiety disorders (Petrakis et al. 2005), naltrexone, disulfiram, or a combination of both was added to treatment as usual. A high percentage (42.9 percent) of the study participants had PTSD, although data analysis for specific disorders was not conducted. Alcohol-related outcomes improved significantly in patients treated with either medication alone or with combination therapy, compared with placebo, but there was no added improvement with combination therapy when compared with monotherapy. This study strongly suggests that alcohol-dependent patients with co-occurring PTSD should receive medications targeting alcohol consumption.

There is good rationale for the exploration of a number of other compounds in the treatment of co-occurring PTSD and alcohol dependence. Prazosin blocks a specific α_1-adrenergic receptor and has shown promise in several well-controlled trials for the treatment of PTSD, particularly in decreasing PTSD-related sleep disturbance and nightmares (Raskin et al. 2007). In a preliminary study, prazosin decreased alcohol consumption in an alcohol-dependent population (Simpson et al. 2009). This inexpensive and relatively safe drug warrants investigation in the treatment of co-occurring PTSD and alcohol dependence. In addition, several anticonvulsant agents, such as topirimate, have shown promise in the treatment of alcohol dependence (Johnson et al. 2003). It is hypothesized that actions on the glutamatergic systems might be responsible for these agents' therapeutic actions. PTSD also has been associated with glutamatergic dysregulation, and anticonvulsant agents have shown promise in small-number, open-label studies in the treatment of PTSD. This is another area in which additional investigation is warranted. More research clearly is needed to help advance the behavioral and pharmacological treatment of co-occurring trauma/PTSD and substance use disorders.

Conclusions

Epidemiologic studies as well as studies in treatment-seeking populations converge to support the finding that early-life trauma is common in people with alcohol dependence. There are a number of potential mechanistic explanations for the connection between early-life trauma and the development of alcohol dependence. These include psychological and developmental issues that are affected by trauma, as well as neurobiological effects of early trauma that can lead to increased vulnerability to the development of alcohol and other substance use disorders. These explanatory

hypotheses are not mutually exclusive. There is a growing literature on efficacious psychotherapeutic and pharmacotherapeutic treatments for individuals with co-occurring PTSD and alcohol dependence. Integrative psychosocial interventions combining efficacious interventions from the alcohol and PTSD fields have shown promise. Evidence suggests that agents targeting alcohol consumption (i.e., disulfiram, naltrexone) can be useful in patients with co-occurring PTSD and alcohol dependence, but additional investigation clearly is needed. ■

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