| Title | **Insomnia and regulation of sleep-wake cycle with drugs among adolescent risky drinkers** |

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STUDY OBJECTIVES

We aimed to explore symptoms of insomnia in a group of risky drinking youth, their use of drugs as sleep/wake aids, and the relationships between alcohol and other drug use and insomnia.

METHODS

Face-to-face interviews were conducted with 596 Australian 14-19 year olds identified as engaging in regular risky drinking. They completed the Insomnia Severity Index and were assessed for recent alcohol and other drug use, including drugs used specifically as sleep-aids or to stay awake. Alcohol-related problems, emotional distress, self-control and working outside of traditional hours were also assessed using validated scales.

RESULTS

More than one third (36%) reported moderate to very severe sleep-onset insomnia, and 39% screened positive for clinical insomnia using adolescent criteria. Three quarters used drugs in the past two weeks to regulate their sleep cycle (65% used stimulants, mainly caffeine, to stay awake, and 32% used a depressant, mainly cannabis, to get to sleep). Regression analyses showed that after controlling for variables such as gender, emotional distress, self-control, alcohol use problems, and past 6 month illicit or non-prescribed drug use, those who used drugs specifically to get to sleep or to stay awake were respectively 2.0 (p<.001) and 1.7 (p=.02) times more likely to report clinical insomnia.

CONCLUSIONS

Insomnia was commonly reported in this community sample of risky drinking adolescents. Those with symptoms of insomnia appeared to be managing their sleep-related symptoms through alcohol and other drug use, which may have further exacerbated their sleep issues.

Brief summary

(a) Current knowledge/study rationale

There is a bidirectional relationship between sleep disturbance and alcohol and other drug related problems. To date however, there has been limited exploration of risky drinking adolescents' experience of sleep problems, and their use of drugs to regulate their sleep-wake cycle.

(b) Study impact

Controlling for various psychological and behavioral confounds, use of drugs specifically identified as sleep/wake aids, were associated with higher odds of insomnia amongst the risky drinking teenagers. That is, contrary to their intended function of regulating sleep-wake cycles, these drugs may actually be compounding sleeping problems. Interventions to improve sleep quality may have positive flow-on effects in other health areas such as heavy alcohol use.

Introduction

Prevalence and outcomes of adolescent insomnia/sleep problems

Risky alcohol consumption and self-reported sleep problems including "feeling sleepy during the day", "difficulty falling asleep" and "difficulty waking in the morning" [1] are some of the most common, and also most modifiable risk factors influencing adolescent health [2]. Approximately one in 10 teenagers in the general population experience clinical insomnia [3-5], and up to one third of school-age children and half of adolescents in countries including the United States report sub-clinical but substantive sleep problems [6-8]. In adolescents, sleep problems have been associated with heavy alcohol use, smoking, cannabis use, depression, impaired immune function, and risky sexual behaviors [9,10].

Bidirectional relationship between sleep and AOD

There is burgeoning evidence that there is a bidirectional relationship between sleep disturbance and alcohol and other drug (AOD) use issues. Problems with sleep routines during childhood or early adolescence predict later risky AOD use [3,11-13]. In addition, AOD use can impair young adults' sleep-maintenance and total sleep time [14,15], and insomnia can predict relapse into alcohol dependence in adults [16].

Previous studies suggest a common sleep/AOD trajectory is that of childhood sleep difficulties, earlier initiation into AOD use, then of AOD-related problems such as higher risk drinking, illicit drug use, and driving under the influence of alcohol during adolescence and young adulthood [12,17,18]. As sleep difficulties appear to continue in parallel with the adolescent AOD trajectory, risky drinking youth are more likely to be experiencing sleep problems than their abstaining or low risk drinking peers, and their overall wellbeing may be compromised along two dimensions. To date however, there has been limited exploration of risky drinking adolescents' experience of sleep problems, and their use of drugs to regulate their sleep-wake cycle.

Recently, the work of Miller *et al*. confirmed this pattern by assessing the sleeping patterns of 829 substance naïve 12 year olds and examined their AOD use at age 16. They found that shorter sleep duration and greater sleepiness during the day prospectively predicted the onset of alcohol use, risky drinking, and alcohol-related problems. For example, for every extra hour of sleep reported, the odds of having ever had a full alcoholic drink was reduced by 15%. These sleep indicators

retained their predictive capacity even after controlling for psychiatric symptoms which commonly co-occur with sleep and AOD disorders [19].

Hasler *et al*. recruited children aged 9-13 years old who had a father with a substance use disorder, and surveyed them until age 30 [20]. Their findings were consistent with the previous cross-sectional and longitudinal findings, and extended the temporal reach of the literature with disturbed childhood sleep predicting substance use disorders in early adulthood. Furthermore, they found that restless sleep predicted earlier onset of alcohol and cannabis use, but not cocaine. They speculated this may be related to the sedative effects of alcohol and cannabis, though similar to Miller *et al*., the specific function of the drugs were not assessed (that is, if they were used recreationally or as a sleep-aid).

Risk factors associated with poor sleep outcomes

The risk factors in the sleep-alcohol nexus may be interactive [21], working within a broader framework of risk factors. For example, up to 73% of depressed adolescents report sleep problems [22], and a meta-analysis with 172,000 participants found that individuals with insomnia were twice as likely to develop depression [23]. The inclusion of psychiatric variables such as internalising problems (e.g. depression and anxiety), and externalising problems (e.g. aggression) reduce the association between adolescent risky alcohol use and sleep problems [24]. Recently, Miller *et al*. examined heavy drinking college students and found that their alcohol-related consequences were elevated when both poor sleep quality and psychiatric symptoms were present. However, students who reported only poor sleep, or only a positive psychiatric screen had a similar number of alcohol-related harms to the students who reported neither risk factor [21].

Trait impulsivity and self-control have been associated with both risky alcohol use and sleep problems, and it has been suggested that executive functioning may be a mediating factor that is common to sleep, AOD use and psychiatric problems [18,19p,25]. Pre-morbid deficits in working memory and impulse control may be the common origin for a range of dysregulations, and in turn, the distress of these dysregulations may further impair psychological resources for inhibitory processes [26,27]. For example, diminished executive control may impede the establishment of a regular sleep schedule, the resulting sleep deprivation can reduce reaction time, which individuals may in turn compensate for through more impulsive behaviour [28].

Shift work, which can include non-traditional work hours, is a risk factor for insomnia among adults [29]. Despite 15-19 year olds reporting the highest rates (18%) of shift work of all age brackets [30], there has also been limited examination of the potential impact of shift work on adolescent sleeping patterns. This issue may be of increasing importance as being a full time student while engaged in paid work appears to be increasing, from 34% of Australian 15-24 year olds in 1990 to 43% in 2016 [31].

Rationale

Similar to other designs [21,32], this study targeted a higher risk adolescent sample as a more efficient means of examining the central alcohol-sleep relationship. These young people were identified as being at high risk of alcohol related harms, but underrepresented in current national AOD surveys [33-36]. They were recruited from the community on the basis of their drinking patterns, not from any engagement in a sleep clinic (so were not presumed to have a pre-existing issue). Our 596 adolescents reported engagement in a range of study-based and other occupations, which is a broader selection compared to Miller *et al*.'s 385 heavy drinking college students. Further, unlike Hasler *et al*., our participants were selected specifically as risky drinkers, as opposed to being at risk of AOD use by virtue of their father's history of dependence.

While there is a body of literature that suggests sleep difficulties and risky AOD use are likely to co-occur, how adolescents behaviourally regulate this comorbidity is an area this study sought to explore. To our knowledge, this is the first study to examine the potential impact of drugs used specifically for the means of regulating the sleep-wake cycle on symptoms of insomnia in a risky drinking adolescent sample.

We aimed to: (1) estimate the association between insomnia symptoms and alcohol use in a risky drinking adolescent sample, (2) assess their consumption of drugs used to regulate their sleep-wake cycle, (3) examine the impact of these AOD sleep-wake regulators on insomnia, while controlling for a range of potential confounding influences including psychological distress, self-control, alcohol-related problems, illicit drug use, and engaging in non-traditional work hours.

Methods

Participants

Participants were 596 risky drinking Australian adolescents aged 14-19 years (mean age: 17.20 years standard deviation=1.38; 14-15 years: n=88; 16-17 years: n=237; 18-19 years: n= 271). Nearly half (48%) of participants were female. Most were students (school: 46%; university: 33%; technical college: 4%; employed full time: 3%; trade apprentices: 2%; unemployed: 2%). One in ten participants were born overseas and 14% spoke a language other than English at home (n=594). Few (n=5; <1%) participants were in any form of alcohol and other drug treatment. More than a third (43%) worked outside of traditional '9-5' hours (e.g. night or overtime shifts) in the past 2 weeks. A quarter had worked 1-4 days and 18% worked six or more days in the fortnight (n=588).

Consistent with previous Australian surveys, risky drinking was defined as consuming standard drinks (SD) of alcohol (1 SD = 10g of alcohol) in patterns consistent with the 'top 25%' of drinkers from their age and gender cohort [37-39]. Screening criteria for risky drinking by age and gender were as follows:

- 14-15 year olds - 1+ SD in a single sitting at least once a month
- 16-17 year olds - 5+SD per single occasion at least twice a month
- 18-19 year old females - 7+SD in a single sitting at least twice a month
- 18-19 year old males - 9+SD per occasion at least twice month.

Across age and gender groupings, 59% of participants consumed 9+SD in a single session at least twice a month (n=596).

Measures

Sleep characteristics

This study reports upon the sleep-related variables of insomnia, non-traditional work hours, and the use of drugs either as sleep-aids, or to stay awake, assessed with a reference period of the two weeks immediately prior to interview.

Clinically-relevant insomnia was identified using the seven-item Insomnia Severity Index (ISI) [40]. Consistent with recommendations for administration to adolescents, the item "waking up too early" was expanded to read "waking up too early and not being able to go back to sleep" [41,42]. ISI items were summed with scores ≥9 indicating clinical insomnia in adolescents [42]. For adult populations,

scores of 8-14 suggest subthreshold insomnia, scores 15-21 are indicative of moderate severity clinical insomnia, and scores of 22-28 indicate severe clinical insomnia [40].

Respondents were asked "How often have you worked outside of traditional '9-5' hours? (over the last 2 weeks) E.g. night or overtime shifts" (5-7 days a week, 3-4 days a week, 1-2 days a week, once every 2 weeks, not at all).

They were also asked whether they had used any of a list of depressant drugs to "help you get to sleep" (cannabis, drugs bought over the counter at the pharmacy where no prescription was required, alcohol, prescription medications, specified other drug), or used any of a list of stimulant drugs to "to stay awake" (caffeinated soft drinks, coffee/tea, energy drinks, cigarettes, dexamphetamine, meth/amphetamine, specified other drug). These items were dichotomized into the use of a drug specifically used to "get to sleep" or to "stay awake" in the past two weeks.

Emotional distress and self-control

Emotional distress experienced in the past 30 days was assessed using Kessler *et al*.'s six-item psychological distress scale (K6). K6 scores of 0-7 denote no to low distress, 8-12 moderate distress and scores of 13 and above are indicative of high distress and probable mental illness [43].

Self-control was assessed across the domains of self-discipline, deliberate/non-impulsive action, healthy habits, work ethic and reliability using the validated Brief Self-Control (B-SC) Scale [26]. The 13 B-SC items were summed, the resulting total scores appeared broadly consistent with general population norms, and the scores were split into quartiles for regression analyses.

Alcohol use and other drug use

The Alcohol Use Disorders Identification Test (AUDIT) is a 10-item screening tool developed by the World Health Organisation to detect risky drinking patterns [44]. As this was a purposive risky drinking sample all respondents were 'at risk' using adolescent criteria [45,46]. For the regression analyses, participants were categorised using adult guidelines with scores of 8-15 indicating medium levels of alcohol problems (appropriate for simple advice focused on the reduction of hazardous drinking); scores 16-19 indicating high levels of problems (suggesting the need for brief counselling and continued monitoring); and scores of 20+ indicating very high problems (strongly suggesting further diagnostic evaluation for alcohol dependence).

Participants also indicated whether they had used any of 10 identified illicit or nonprescribed drugs in the past 6 months (cannabis, ecstasy, hallucinogens, inhalants, pain killers [not used as prescribed], benzodiazepines or sleeping pills [not used as prescribed], dexamphetamine [not used as prescribed], cocaine, methamphetamine or amphetamine, ketamine). This was dichotomised into the use of an illicit or non-prescribed drugs (yes/no). So, this item reflected the use of an illicit drug in the past 6 months, irrespective of reason for use (e.g. recreational, sleep-wake regulation or other reason).

Procedure

Participants were a convenience sample recruited primarily through paid social media advertisements. The adverts were targeted to 14-19 year old Australians, and included the question "do you drink regularly?" to further select for alcohol users. Adolescents interested in the study could email, SMS or telephone their nearest research unit for initial screening and interview booking. Eligibility was confirmed during the interview using selection criteria items relating to alcohol use frequency and quantity. More than half (59%) had responded to a social media advert, a third (37%) were referred through a friend, 5% saw a poster at their educational facility and 4% were recruited through a youth service they used (n=584). After informed consent was obtained, the confidential and anonymous face-to-face interviews took approximately 45 minutes. Participants were reimbursed $AUD40 for their time and travel costs. Interviews occurred in all eight Australian capital cities with institutional ethics approval granted from all participating locations (Curtin University, University of New South Wales, Monash University, University of Tasmania, Flinders University, Australian Capital Territory Health Research Records and Governance Office, Charles Darwin University, University of Queensland).

Data Analyses

Relevant data are described as percentages, and correlations were calculated using Spearman's rho due to non-normal distribution of the ISI scores.

A three stage hierarchical multiple logistic regression was conducted to assess nine factors on the likelihood of a positive screen for clinical insomnia using adolescent-criteria. The first stage included the variables (1) gender, (2) age, (3) psychological distress and (4) self-regulation. The second stage included assessments of (5) alcohol-related problems, and (6) illicit or non-prescribed drug use. The final stage included sleep-related variables of (7) working outside of 'traditional' hours, (8) use of a drug to stay awake, and (9) use of a drug to get to sleep.

Analyses were computed in IBM SPSS version 24.

Results

ISI scores

Using adolescent criteria (ISI≥9), 39% of the participants reported symptoms suggestive of clinical insomnia [42]. Using adult criteria, 33% had symptoms of subthreshold insomnia (ISI 8-14), 11% had scores indicative of moderate severity clinical insomnia (ISI 15-21), and 2% with severe clinical insomnia (ISI 22-28) (Morin 2011). The mean total ISI score was 7.60 (SD=5.57, n=595), and the endorsement of each ISI item are more specifically presented in Table 1.

Table 1. Endorsement rate on the Insomnia Severity Index

Please rate the severity of your insomnia (sleeping) problems over the past two weeks …	None	Mild	Moderate	Severe	Very severe	Total
Difficulty falling asleep	36.0%	27.6%	23.7%	9.3%	3.4%	594
Difficulty staying asleep	56.9%	21.0%	13.7%	5.9%	2.5%	591
Problems waking up too early and not being able to go back to sleep	53.8%	20.1%	12.3%	10.6%	3.2%	593

	Very Satisfied	Satisfied	Moderately satisfied	Dissatisfied	Very dissatisfied	Total
How SATISFIED or DISSATISFIED are you with your sleep pattern?	8.9%	23.2%	30.4%	29.6%	7.9%	595

	Not at all Noticeable	A Little	Somewhat	Much	Very Much Noticeable	Total
How NOTICEABLE to others do you think your sleep problem is in terms of impairing the quality of your life?	48.5%	27.8%	14.2%	5.3%	4.2%	590

	Not at all Worried	A Little	Somewhat	Much	Very Much Worried	Total
How WORRIED or DISTRESSED are you about your sleep problem?	59.0%	23.1%	13.7%	2.9%	1.4%	592

	Not at all Interfering	A Little	Somewhat	Much	Very Much Interfering	Total
To what extent do you consider your sleep problem to INTERFERE with your daily functioning?	31.5%	32.0%	21.5%	11.5%	3.4%	590

Use of drugs for sleep-wake cycle

Almost three quarters (72%) of this group appeared to be self-regulating their sleep-wake cycles with drugs, and 21% were using an illicit drug to do so.

To stay awake, 65% reported using a stimulant in the past 2 weeks. The most commonly reported drugs used to stay awake were coffee/tea (56%), energy drinks (22%), caffeinated soft drinks (21%), cigarettes (11%), dexamphetamine (3%), and 3% used another drug (n=595).

A fifth (22%) reported having used alcohol in their lifetime to help get to sleep (n=593). In the past two weeks, 32% had used a depressant drug to help get to sleep (cannabis: 19%; alcohol: 10%; prescription medications: 10%; over the counter medications: 6%; n=588).

Almost half (43%) of participants worked outside of traditional '9-5' hours (e.g. night or overtime shifts) in the past 2 weeks. A quarter had worked 1-4 days and 18% worked six or more days in the fortnight (n=588). While not significant in our regression model, we note that shift work may impact on sleep as engagement in both full time study and casual work can impact on total sleep time, and secondly, the timing of that casual work (e.g. night shifts) may impact on sleep via disruption of a sleep onset routine.

Correlations between ISI and other variables

ISI scores indicative of more severe symptoms of insomnia were significantly more likely to occur among females, and were correlated with higher psychological distress in the past four weeks, lower self-control, higher AUDIT scores, illicit or non-prescribed drug use in the past 6 months, use of a drug to stay awake, and use of a drug to get to sleep in the past two weeks (see Table 2).

Table 2. Demographic, lifestyle, and clinical characteristics of participants included in the logistic regression model.

Variable	Correlations with Insomnia Severity Index score			Categories used for regression analysis	
	r_s[1]	p	N		n (%)[2]
Gender	0.134	<0.001	593	Male	297 (52.1%)
				Female	273 (47.9%)
Age	0.005	0.894	595	14-15 years	84 (14.7%)
				16-17 years	226 (39.6%)
				18-19 years	260 (45.6%)
Kessler's psychological distress (K6) score	0.456	<0.001	594	No to low distress (K6 score 0-7)	416 (73.0%)
				Moderate distress (K6 score 8-12)	94 (16.5%)
				High distress and probable mental illness (K6 score 13-24)	60 (10.5%)
Tangney's Brief Self Control Scale (B-SC) score	-0.297	<0.001	594	≤34 (least control)	159 (27.9%)
				35-40	158 (27.7%)
				41-45	129 (22.6%)
				≥46 (most control)	124 (21.8%)
Alcohol problems (AUDIT score)	0.298	<0.001	580	Low problems (AUDIT 0-7)	24 (4.2%)
				Medium problems (AUDIT 8-15)	276 (48.4%)
				High problems (AUDIT 16-19)	146 (25.6%)
				Very high problems (AUDIT>20) [3]	124 (21.8%)
Illicit or non-prescribed drug use	0.095	0.02	595	No	119 (20.9%)
				Used in past 6 months	451 (79.1%)
Worked outside of traditional 9-5 hours	-0.053	0.196	588	No	324 (56.8%)
				Yes in past 2 weeks	246 (43.2%)
Used a drug to stay awake	0.202	<0.001	595	No	195 (34.2%)
				Stimulant used in past 2 weeks	375 (65.8%)
Used a drug to get to sleep	0.325	<0.001	595	No	392 (68.8%)
				Sleep aid used in past 2 weeks	178 (31.2%)

[1] Spearman's rho used due to ISI scores falling in a non-normal distribution.

[2] Categories reflect the sample size available for the regression analysis (n=570).

[3] 'Very high problems' used as reference group in regression due to modest cell size of 'low problems' group

Regression analysis

Step 1 of the model with the variables age, gender, psychological distress and self-regulation was statistically significant, explained 21.9% of variance in insomnia status, and correctly classified 71.8% of cases (see Table 3). Higher distress and lower self-regulation uniquely contributed to reports of insomnia. Those with the highest distress scores and moderate distress scores were respectively 7.9 and 3.7 times more likely to report insomnia compared to those with no or low psychological distress. Participants with lowest self-control scores were twice as likely to report insomnia compared to those in the quartile with highest self-control scores.

In the second step, AUDIT scores for alcohol use problems, and use of other drugs were added to the model. In this statistically significant six variable model, gender, psychological distress, and alcohol-related problems uniquely contributed to reports of insomnia. Females were 1.5 times more likely, more distressed respondents were 3.9 to 7.2 times more likely, and participants who had a 'very high' alcohol problems were 2.1 times more likely than those who had a 'medium' alcohol problems to report insomnia.

In the final model, drugs used to stay awake, and drugs to get to sleep were added. Five variables made a unique statistically significant contribution to this nine variable model: gender, psychological distress, alcohol use, drugs used to stay awake, and drugs used to get to sleep. Females were 1.6 times more likely, more distressed participants were 3.7 to 6.0 times more likely, and those with very high alcohol problems were twice as likely as those who had medium problems. Participants who used a drug to stay awake were 1.7 times more likely, and those who reported using a drug to get to sleep were 2.2 times more likely to report symptoms of clinical insomnia compared to those who did not use a drug to stay awake or get to get to sleep, respectively.

Table 3. Three stage hierarchical logistic regression analysis of factors associated with insomnia.

DV: Adolescent-criteria insomnia (ISI ≥9)	Model 1		Model 2		Model 3	
Model Chi-square, p value	100.49	<0.001	110.67	<0.001	132.19	<0.001
Cox & Snell R Square	16.16%		17.65%		20.70%	
Nagelkerke R Square	21.93%		23.95%		28.09%	
Hosmer-Lemeshow GOF test, p value	0.31		0.56		0.29	
Cases correctly classified	71.80%		72.30%		72.50%	
Variables	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Female gender	1.43 (0.98-2.09)	0.060	1.55 (1.05-2.28)	0.027	1.64 (1.10-2.45)	0.015
Age (14-15 year olds = reference)						
16-17	0.94 (0.53-1.66)	0.827	0.96 (0.54-1.72)	0.891	0.94 (0.52-1.70)	0.832
18-19	0.97 (0.55-1.70)	0.919	0.89 (0.50-1.59)	0.698	0.89 (0.49-1.62)	0.713
Psychological distress (no-low distress=reference)						
Moderate distress (K6 8-12)	3.66 (2.23-6.00)	<0.001	3.87 (2.34-6.40)	<0.001	3.70 (2.21-6.20)	<0.001
High distress and probable mental illness (K6 13-24)	7.92 (3.96-15.82)	<0.001	7.23 (3.57-14.63)	<0.001	6.00 (2.92-12.31)	<0.001
Self Control (most control=reference)						
B-SC ≤34 (least control)	2.04 (1.17-3.56)	0.011	1.59 (0.87-2.88)	0.130	1.31 (0.71-2.41)	0.389
B-SC 35-40	1.34 (0.77-2.33)	0.295	1.16 (0.65-2.06)	0.612	1.01 (0.56-1.82)	0.968
B-SC 41-45	1.04 (0.59-1.86)	0.883	1.02 (0.57-1.83)	0.956	0.95 (0.52-1.72)	0.853
Alcohol use (Very high problems AUDIT>20=reference)						
Low problems (AUDIT 0-7)			0.70 (0.25-1.94)	0.490	0.89 (0.31-2.52)	0.827
Medium problems (AUDIT 8-15)			0.47 (0.28-0.80)	0.005	0.51 (0.30-0.88)	0.016
High problems (AUDIT 16-19)			0.83 (0.48-1.43)	0.499	0.88 (0.51-1.55)	0.667
Illicit or non-prescribed drug use in the past 6 months (no=reference)			1.09 (0.67-1.76)	0.738	0.90 (0.55-1.48)	0.686
Worked outside of traditional 9-5 hours in the past 2 weeks (no=reference)					0.93 (0.63-1.38)	0.728
Used a drug in the past 2 weeks to stay awake (no=reference)					1.69 (1.10-2.58)	0.016
Used a drug in the past 2 weeks to get to sleep (no=reference)					2.20 (1.43-3.39)	<0.001

AUDIT = Alcohol Use Disorders Identification Test, B-SC = Brief Self Control Scale, CI = confidence interval, DV = dependant variable, GOF = goodness of fit, ISI = Insomnia Severity Score, K6 = Kessler 6-item psychological distress scale, OR = odds ratio.

In recognition that tea, coffee and caffeinated soft drinks may be consumed in small quantities as a part of a typical diet or also consumed in larger quantities to maximize their stimulant properties, these products were analysed as a group separate to all the other stimulants used to stay awake. This analysis appeared broadly similar to Model 3 with tea/coffee/caffeinated soft drink users 1.8 times more likely to report adolescent insomnia (p=.007), controlling for all other factors in the model. In contrast, the smaller group of energy drink/cigarette/amphetamine type stimulant users did not demonstrate significantly higher odds (p=.95).

Discussion

Our study examined insomnia among adolescent risky drinkers. We found clinically significant insomnia and psychological distress symptoms were common; and that participants reported a broad range of psychoactive substances to sleep and to stay awake. Risky drinking, psychological distress and sleep problems may each independently inhibit adolescent development, but in combination, as was the norm in this group, may place adolescent risky alcohol users at an elevated risk of harm. For example, deficiencies in these domains may all uniquely diminish working memory capacity, and therefore impair decision-making processes around further behavioural regulation [47].

Consistent with both adolescent and adult literature, participants insomnia symptoms were associated with gender [48,49], emotional distress [22,50], self-control [25], and alcohol and other drug use problems [18,22]. Furthermore, given the same psychological and behavioural profile (emotional distress, self-control, drug use), the use of drugs explicitly described as used to help them get to sleep or to stay awake was associated with even greater rates of insomnia. That is, contrary to their intended function of regulating sleep-wake cycles, these drugs may actually be compounding sleeping problems.

Insomnia among participants was higher than for adolescents in the Australian general population. Over a third (39%) of study participants screened positive for clinical insomnia using adolescent-appropriate ISI criteria. Using stricter adult criteria, 33% of participants had subthreshold insomnia and 13% clinical insomnia. In comparison, an Australian general population study of 1512 individuals found that 2% of 14-17 year olds and 11% of 18-24 year olds had ISI adult-criteria clinical insomnia [51]. The mean ISI score for this study (mean=7.6, SD=5.6) was only slightly higher, and contained higher variance than the largest adolescent general population survey available, 1516 Chinese 12-19 year

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olds (ISI=7.4, SD=4.6)[42]. This finding is consistent with international literature which associates poorer adolescent sleep with higher alcohol use [3,52].

This study extends the work within the field, particularly in the examination of the effects of AOD use to regulate sleep-wake behaviours during adolescence. Almost three-quarters of this risky drinking sample used drugs to regulate their sleep-wake cycles over the past two weeks (mostly caffeine, 21% an illicit drug). The final model revealed that those who reported insomnia were twice as likely to have used a drug in the past 2 weeks to stay awake or to get to sleep. Though this drug use could be a consequence of insomnia, due to the cross-sectional nature of the dataset, it is possible that the drug use could have also been in turn impacting on the insomnia symptoms.

A third had used a depressant drug, most commonly cannabis (19%), to help them get to sleep in the past two weeks. In contrast, 14% of general population 14-19 year olds used cannabis for any reason in the past 12 months [53]. Adolescents commonly report cannabis use for general relaxation [54]. The few studies that specifically focused on cannabis use and sleep suggest that cannabis can reduce sleep latency in the short term, but can have mixed longer-term effects, especially among recreational users [55]. Lifetime cannabis use is a risk factor for shorter sleep durations in a young adult general population [56], withdrawal among dependent cannabis users keeps the user awake [57], and shorter sleep duration predicts the onset of cannabis use [19]. That is to say, the use of cannabis as a sleep aid may have had unintended, opposite, effects that compounded sleep-issues.

Almost two thirds reported using a stimulant, most commonly caffeine, in the past fortnight to stay awake. In contrast, an estimated 26% of general population 14-16 year old Australians consumed caffeinated beverages in the day prior to survey [58], and 14-18 year olds consumed a mean of 39-52mg per day of caffeine [59]. Despite discrepancies in reference time frame, the study samples' use of caffeine was likely more pronounced compared to general population adolescents, in line with their generally higher AOD use. Given that caffeine has previously been implicated in sleep issues in the general population, how caffeine is related to insomnia symptoms (including assessment of caffeine quantity), among risky drinking adolescents could be explored in greater detail in the future.

As a cohort, it is interesting to note that most study participants were students, and 40% of them also worked. The increasing trend of simultaneous engagement in full-time education and employment [31], non-traditional work hours, and the availability of energy drinks may influence choices around the use of drugs that promote wakefulness and productivity. In turn, the use of

stimulants such as caffeine are associated with almost double the likelihood of difficulty sleeping [60,61]. That is, similar to alcohol, there could be a bidirectional relationship between caffeine and sleep problems [60]. Furthermore, it is of note that as sleep deprivation can affect decision making [47], the risk of work-related injuries may be elevated in this group.

The issues raised above are of concern, but evidence-based interventions regarding adolescent risky drinking, insomnia, psychological distress, and sleep/awakening management are available. Brief interventions can improve the sleep quality of adolescents [62,63], and some argue that independent treatment of sleep disorders may have positive flow-on effects in other health areas such as alcohol use. For example, Fucito *et al*. engaged college drinkers who were experiencing sleep problems and a brief intervention on sleep hygiene and other health strategies resulted in a variety of health benefits, including reductions in alcohol consumption [64]. Similarly, as sleep deprivation and fragmentation can affect executive functions and risk taking [47], treating insomnia in adolescents can also improve executive function [65]. This adolescent comorbidity may also be framed as an opportunity for intervention engagement. Seeking help for sleep problems may be a more acceptable avenue through which related AOD issues can be addressed. The rise of anonymous online Cognitive Behavioural Therapy interventions may further reduce adolescent barriers to engagement [60].

Limitations

As this study was designed to recruit adolescents who were underrepresented in current national health surveys, and were at higher risk of both alcohol and sleep-related problems, this sample is not representative of young people in general [33-36]. So, the results presented here are likely indicative of the upper limits of the range in levels of use and harms.

This study reports associations between AOD use and sleep outcomes in a cross-sectional sample of adolescents and therefore cannot be used to infer causality. However, the population examined includes a broad range of adolescents with respect to age, types of students and non-students, and specifically recruited a community-based sample rather than a clinically-based sample, suggesting that there is a degree of robustness or generalisability to other risky drinking populations of young people. Together, these qualities of the sample provide a broader understanding of the AOD-sleep relationship.

Importantly, this study builds upon the limited range of Australian sleep studies on adolescents [4,6,51,66,67]. It is of note that the Australian legal purchase age for alcohol is 18 years, compared to 21 in the USA where the bulk of sleep studies are conducted, suggesting the co-morbidity between sleep and alcohol may be occurring at a younger age.

This study relied upon self-report on sleep characteristics as opposed to objective measures within a sleep laboratory setting. Though adolescents' self-reported sleep patterns correlate with actigraphy and sleep readings [68], future studies could make use of these measures and ask for further detail such as bedtime, wake time, daytime sleepiness, use of technology or other light emitting devices, and pre-existing sleep conditions.

Conclusions

This study used a series of validated scales to assess the impact of constructs such as mood, self-control, and AOD use on insomnia among a large community-sample of non-treatment seeking risky drinking adolescents. Aside from insomnia symptoms being commonly reported by the sample, the most significant finding was that the majority reported the use of depressants and stimulants specifically to get to sleep/stay awake. The regular use of such drugs to regulate sleep-wake cycles may be compounding the sleep disruption that they are meant to be addressing.

Abbreviations

AOD   Alcohol and Other Drugs

AUD   Australian Dollars (participant reimbursement was approximately USD30)

AUDIT   Alcohol Use Disorders Identification Test

B-SC   Brief Self-Control Scale

ISI   Insomnia Severity Index

K6   Kessler's six-item psychological distress scale

SD   Australian Standard Drink (1 SD = 10g of alcohol)

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