Title: 'Wide Awake Drunkenness'? Investigating the association between alcohol intoxication and stimulant use in the night-time economy

Running head: Alcohol intoxication and stimulant use

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Word count: 3838 (minus abstract, tables, figures and references)

Key words: alcohol, intoxication, blood alcohol concentration, stimulants, energy drinks, pre-drinking, night-time economy, licensed venues

Declarations of interest: This study was supported by funding from the National Drug Law Enforcement Research Fund (NDLERF), National Health and Medical Research Council (NHMRC), Australian Research Council (ARC) and Victorian Health Promotion Fund (VicHealth). Professor Lubman has previously received speaker fees from AstraZeneca and Janssen, and provided consultancy advice to Lundbeck. The researchers have no other

connections with the tobacco, alcohol, pharmaceutical or gaming industries, or anybody substantially funded by one of these organisations.

Abstract

Aims: We tested whether patrons of the night-economy who had co-consumed energy drinks or illicit stimulants with alcohol had higher blood alcohol concentration (BAC) levels than patrons who had consumed only alcohol. **Design:** Street intercept surveys (n=4227) were undertaken between 9pm-5am over a period of seven months. **Setting:** Interviews were undertaken with patrons walking through entertainment precincts, queuing to enter venues, or exiting venues, in five Australian cities. **Participants:** The response rate was 92.1%; more than half of the study sample was male (60.2%) and the median age was 23 years (range 18-72). **Measurements:** Data were collected on demographics, length of drinking session, venue types visited, types and quantity of alcohol consumed and other substance use. A BAC reading was recorded and a sub-sample of participants were tested for other drug use. **Findings:** Compared to alcohol-only consumers (0.068%), illicit stimulant consumers (0.080%; p=.004) and energy drink consumers (0.074%; p<.001) had a significantly higher mean BAC reading, and were more likely to engage in pre-drinking (66%, 82% and 78% respectively, p<.001) and longer drinking sessions (4 hours, 5 hours and 4.5 hours respectively, p<.001). However, stimulant use was not independently associated with higher BAC in the final multivariable model (illicit stimulants p=.198; energy drinks p=.112). Interaction analyses showed that stimulant users had a higher BAC in the initial stages of the drinking session, but not after 4-6 hours. **Conclusions:** While stimulant use does not predict BAC in and of itself, stimulants users are more likely to engage in prolonged sessions of heavy alcohol consumption and a range of risk-taking behaviours on a night out, which may explain higher levels of BAC among stimulants users, at least in the initial stages of the drinking session.

Introduction

Over the past five years the co-consumption of alcohol and stimulants has received increased attention, reflecting novel combined use of alcohol with illicit and licit stimulants, including energy drinks. In particular, much of this attention has questioned whether the co-consumption of alcohol and energy drinks increases stimulation and reduces sedation, thereby prolonging the drinking session, facilitating alcohol intake and enabling a wakeful or 'wide awake' drunkenness (1, 2).

In support of this theory, a number of cross-sectional studies found that compared to those who did not use energy drinks when consuming alcohol, people who combined alcohol and energy drinks reported consuming more alcohol (frequency and quantity), other substance use, drink-driving, unsafe sexual behaviour, and experiencing negative health consequences such as being hurt or injured (3-12). Further, it was identified that those who consumed alcohol with energy drinks for hedonistic motives or to reduce alcohol-related intoxication (as opposed to social or endurance motives) were at increased risk of negative outcomes (13). A number of laboratory studies have found little or no difference between self-reported and objectively measured levels of intoxication following consumption of alcohol and energy drinks relative to alcohol alone (14-17), with the exception of self-reported increases in stimulation (15, 17).

Several factors have limited the extent to which these previous studies have been able to explore the association between energy drink consumption and intoxication. Survey studies relying on self-reported consumption in the past are limited by their potential for recall bias, which is likely compounded by intoxication and reliance on a 'typical occasion' of consumption, a measurement less accurate than specific recent event recall (18). These studies also lacked objective measurement of blood alcohol concentration (BAC) (19). Previous laboratory studies have not used quantities of alcohol higher than a BAC of 0.089% and two energy drinks, which is less alcohol and energy drinks than many consumers report ingesting on a night out (e.g., 6, 20-22). Furthermore, laboratory studies cannot adequately replicate real-world contexts (e.g., crowding, visual stimuli and other environmental and social factors) that might influence the association between alcohol intoxication and stimulant use.

As a consequence, an important (and largely missing) piece of the puzzle in terms of understanding whether co-consuming energy drinks with alcohol is associated with increases in alcohol consumption, is studies undertaken in naturalistic settings. One previous study, undertaken by Thombs et al. (23) in the US state of Florida, involving interviews with patrons exiting licensed venues in a college bar district, found that patrons (n=697) who reported consuming energy drinks with alcohol were 3.32 times more likely to record a BAC of 0.08% or greater, after adjusting for demographic characteristics and risk of alcohol dependence. This study did not control for a range of drinking practices that might also have predicted elevated BAC levels. For example, other field studies have found that pre-drinking, having consumed spirits, location of drinking, being interviewed later in the night and drinking for longer are important predictors of BAC (24-28).

There has been less research exploring the association between alcohol intoxication and illicit stimulant use, despite evidence that methamphetamine, cocaine and ecstasy are commonly combined with alcohol in the context of a 'big night out' (29-32), and that young people combine alcohol with illicit stimulants to prolong their drinking session, enable greater alcohol consumption and reduce the potential for unfavourable (i.e., 'messy' or 'drowsy') alcohol intoxication (33, 34). Experimental studies have found that the co-consumption of alcohol and stimulants decreases BAC (35-37), but increases heart rate (35, 37). Two of these studies also found that combining alcohol with illicit stimulants diminished the subjective effects of alcohol but not the objective effects (36, 37). That is, participants felt less intoxicated but their actual performance remained as impaired as when consuming alcohol alone. This might potentially lead to poorer decision-making and increased likelihood of involvement in risk-taking behaviours such as drink-driving, underscoring the need for more research to unpack this relationship.

We tested whether patrons of the night-economy who had co-consumed stimulants (either energy drinks or illicit stimulants) with alcohol, had higher BAC levels than patrons who had only consumed alcohol. We hypothesised that co-consumption of alcohol and stimulants would be associated with higher BAC than alcohol alone. In addition, since previous studies suggested that one mechanism by which stimulant use can influence BAC is by prolonging the length of drinking sessions (1, 3), we also tested the moderating effects of stimulant consumption on the association between BAC and length of drinking session.

Methods

Setting

Data were collected in the night-time entertainment districts of five Australian cities. These locations were chosen to enable the investigation of jurisdictional differences between the two largest Australian cities of Melbourne and Sydney (each with over 4 million residents), with smaller regional cities in the same states: Geelong (approximately 175,000 residents) and Wollongong (approximately 290,000 residents). Perth was selected as it represents a unique smaller capital city (1.7 million residents) on the opposite coast of Australia. All five cities have popular and busy entertainment districts and late trading hours (i.e., venues open until 3am, and in some cases as late as 7am). The legal drinking age in Australia is 18 years and the legal BAC limit for driving is 0.05%.

Procedure

Short interviews were conducted with patrons in these five cities over a period of seven months (December 2011 to June 2012). In each city, teams of 6-12 researchers collected data in four-hour shifts between 9pm and 5am on Friday and Saturday nights. The choice of time of year, interviewer numbers and length of shifts were informed by previous street survey work undertaken by the team (38). Based on this previous work, it was estimated that a period of six months would elicit the intended opportunistic sample size of approximately 4000 participants.

Every third person who appeared older than 18 years was approached when walking through entertainment precinct areas, queuing to enter venues, or exiting venues. Interviewers, who wore easily identifiable university clothing, explained that the study was exploring nightlife behaviours and invited patrons to undertake a five-minute survey. Potential participants were offered a business card with a link to the project webpage (http://www.deakin.edu.au/pointed) which contained information about the purpose of the project and contact details for the lead investigator and ethics committee. Verbal consent was sought before the interview began. The interview was anonymous and the only exclusion criteria were being under 18 years of age and not being able to provide informed consent. Interviews were not conducted with people who were judged as being too heavily intoxicated to participate and/or offer truthful responses, and where the interviewer felt unsafe doing so (n=7, with a further n=3 terminated mid-way).

Data were collected using Tap Forms™ software on iPod Touch devices and BAC readings were recorded in the survey. In two study sites (Melbourne and Geelong) every tenth person was asked to undergo a swab for the presence of other drugs, which participants were advised they could refuse. The purpose of the drug test was to understand the reliability of self-reported drug use. The testing required one non-invasive scrape of the tongue and results were identified within five to ten minutes. The study was approved by the ethics committees of universities in each city. See Miller et al. (39) for the full study protocol.

Measures

An investigator designed questionnaire collected information on demographics (age, gender and occupation), length of drinking session ("How many hours have you been 'going' for?"), venue types visited ("Where have you spent time today/tonight?"), types and quantity of alcohol consumed ("What alcoholic beverages have consumed today/tonight?"; "How many standard drinks [which is 10g of ethanol in Australia] have you consumed tonight?"), engagement in pre-drinking ("Did you consume alcohol before going to licensed venues today/tonight?"; "How many standard pre-drinks did you consume?"), energy drink consumption ("Have you consumed any energy drinks today/tonight?"; "How many energy drinks have you had?"), and consumption of illicit drugs ("Have you consumed any illicit drugs today/tonight?"; "Which illicit drugs have you consumed?"). Where participants were unsure about the number of standard drinks they had consumed, a visual guide was presented to show how many standard drinks are in various sized bottles of beer, wine and spirits, and interviewers helped participants calculate their drinks.

Breathalyser readings were recorded on an Alcosense Prodigy MkII. Drug tests were undertaken using the DrugWipe 6S, which tests for meth/amphetamine, cocaine, opiates, cannabis and benzodiazepines. The DrugWipe tests positive for meth/amphetamine if any number of amphetamine derivatives have been consumed, including MDMA (ecstasy) and ephedrine. The tests are most accurate if drugs have been consumed in the previous 12 hours, but in some cases can detect drug use up to 24 hours prior (40).

Statistical Analyses

During data cleaning, cases missing >90% of data (n=28) were removed. Cases with BAC reading >0.35% (n=34) were set to missing as readings higher than this were considered implausible and likely to be the result of data entry error or residual mouth alcohol.

Descriptive statistics were initially computed to explore the drinking patterns of stimulant users. Two types of stimulants were assessed: illicit stimulants (ecstasy, methamphetamine, cocaine and/or mephedrone) and energy drinks (any use and quantity consumed). Multivariable regression modelling was then used to identify the predictors of BAC levels. While the most commonly applied regression model for a continuous outcome is the normal model, this type of model assumes that variable of interest is symmetrically distributed around a mean in the underlying population. This is clearly problematic for modelling BAC levels, where the majority of observations would be expected to have BAC levels at the lower end of the distribution, with progressively fewer observations having increasingly higher BAC. To ensure appropriate and efficient choice of a statistical model, we compared fit of two alternative models intended for the analysis of positively skewed distributions, including log-normal and gamma regressions. Fit of these models was assessed using probability-probability (P-P) plots and two goodness of fit indices, including -2 log-likelihood (-2LL) and Corrected Akaike's Information Criterion (cAIC) (41), with lower values indicative of a better fit between the observed data and theoretical model (42). Based on P-P plots, gamma model had a very close fit for the observed data across the full continuum of BAC while the log-normal model substantially overestimated expected BAC at both lower and higher end of the distribution and underestimated BAC levels in the middle of the distribution. Goodness of fit was also more favourable for the gamma (-2LL=-10596, cAIC=-10592) than log-normal (-2LL=-10419, cAIC=-10415) model. Consequently, data were analysed using gamma regression (with log link). However, following recommendation of Wiens (28), log-normal model was also utilised as an ad hoc robustness analysis, to assess the extent to which study conclusions are independent of the underlying statistical model.

To allow for clustered nature of data due to interviews being conducted in five cities across Australia, gamma regression modelling was conducted within the multilevel modelling framework, with city modelled as random effect. Model building proceeded in a number of pre-defined steps. First, an intercept-only model was fitted to the data, followed by the random intercept model. In the next step (Stage 1), background variables, such as demographic information, time of interview, venue types visited, alcohol consumption practices and cannabis use (other illicit drugs were excluded because there were too few cases) were entered into the model, followed by stimulant consumption variables in Stage 2 and multiplicative interactions between stimulant use indicators and length of drinking session in Stage 3. Once all person-level predictors of the BAC were entered into the model, we explored between-city variation in the associations between each of the predictors and BAC levels by fitting random slopes models. The statistical significance of random slopes was assessed with likelihood ratio tests (LRT), with significant random effects incorporated into the model (Stage 4).

Data were analysed using SAS version 9.3 (Copyright © 2013, SAS Institute Inc., Cary, NC, USA). In all analyses, p-values <.05 were interpreted as statistically significant.

Missing data

Missing data were minimal and were present only on number of standard drinks consumed (2.5%), sex (0.9%), age (0.8%), and length of drinking session (0.4%). Little's (43) test indicated that the pattern of missing values was consistent with being missing completely at random, Chi-Square=8.1, DF=8, p=.428. Subsequent statistical analyses utilised the 2886 observations with complete data (96% of the total available sample).

Results

Of the 4591 people invited to participate, 4227 agreed to be interviewed (92.1% response rate). Most participants (n=3740; 88.5%) reported alcohol consumption on the current night. Of those, 113 (3.0%) declined the breathalyser test and 606 (16.2%) returned a BAC reading of 0. The remaining 3021 individuals (80.8%) were included in subsequent analyses.

Characteristics of study participants are summarised in Table 1. Participants ranged in age between 18 and 72 years, with a median age of 23 years (interquartile range [IQR] 20-27). More than half of the study sample was male (n=1819; 60.2%). The respondents self-reported consuming a median of 8 standard drinks (IQR 5-11) and recorded median BAC of 0.068% (IQR 0.039-0.102). Among those who reported co-consumption of alcohol and energy drinks on the current night (n=637; 21.1%); the median number of energy drinks consumed was 1 (IQR 1-3). Just under one-tenth of the sample (n=289; 9.6%) reported other drug consumption, including cannabis (n=97), ecstasy (n=93), methamphetamine (n=69) and cocaine (n=45). Drugs less frequently reported were LSD (n=7), benzodiazepines (n=4), GHB (n=2), mephedrone (n=2) and opiates (n=1). Overall, 181 (6.0%) individuals reported consuming at least one type of illicit simulant. Co-consumption of illicit stimulants and energy drinks was relatively infrequent (n=61; 2.0%).

Of the participants offered a drug swab (n=257), 18.7% (n=48) refused. Of those who were drug tested (n=209), 17.7% (n=37) returned a positive drug swab (approximately double the amount of people who self-reported drug use prior to interview). The most commonly reported drugs detected were meth/amphetamine (n=28), cannabis (n=12) and cocaine (n=6).

Characteristics of stimulant users

Table 1 shows the characteristics of illicit stimulant and energy drink consumers. Of note, those who co-consumed alcohol and either type of stimulant had significantly higher median BAC readings, self-reported number of standard drinks and longer drinking sessions, and were more likely to report pre-drinking (p<.001). Those who consumed alcohol with illicit stimulants were significantly more likely to be male (p<.001), while energy drink consumption was more frequent among younger age groups (p<.001).

Bivariable regressions

In the initial stages of analysis, random intercept accounted for a significant amount of variance in BAC levels (LRT Chi-Square=16.8, DF=1, p<.001) and was therefore included in all further analyses. In bivariable regressions (Table 2), individuals who consumed illicit stimulants (p=.021) or energy drinks (p=.009) had significantly higher levels of BAC. Other factors significantly associated with increased BAC included being 20 years or older (p=.012), being male (p<.001), being interviewed after midnight (p<.001), engagement in pre-drinking (p<.001), reporting more pre-drinks consumed (p=.001), longer drinking session (p<.001), having spent time at a private home (p<.001), sporting club (p=.004), sports event (p=.002) or hotel/pub/bar (p=.041), and consumption of full strength beer (p<.001) and wine or champagne (p=.002).

Multivariable models

Stage 1 multivariable variables, including demographic factors, alcohol consumption practices and cannabis consumption explained a significant amount of variation in BAC levels, LRT Chi-Square=85.7, DF=24, p<.001. When co-consumption of stimulants were added to the model (Stage 2), they further improved the predictive ability of the model, LRT Chi-Square=7.9, DF=3, p=.048. However, none of these variables made a significant individual contribution (Table 2). The addition of stimulant type by length of drinking session interactions in Stage 3 made a further significant contribution to the model (LRT Chi-Square=18.7, DF=2, p<.001), with both variables contributing significantly (Table 2).

In the final step, exploration of between-city variation in the associations between BAC levels and each of the predictors (random slopes) indicated that accounting for between-city variation in the strength of association between BAC and spending the night in a nightclub resulted in a significant improvement in the predictive ability of the regression model, LRT Chi-Square=8.6, DF=1, p=.003. Random slope for venue type nightclub was therefore incorporated into the model, with results for other variables remaining virtually unchanged (Table 2). In the final model, there was an increase of 4% points in mean BAC levels for each additional hour drinking (exponential regression coefficient b=1.04; 95% CI 1.03-1.05). However, there was a decrease of 3% points in mean BAC levels with each hour of drinking for those who consumed illicit stimulants (b=0.97, 95% CI 0.95-0.99) and a decrease of 2% points in BAC with every hour of drinking for those who consumed energy drinks (b=0.98, 95% CI 0.96-0.99).

Stimulant consumption by length of drinking session interactions

Figures 1 and 2 show the average BAC levels of those who had been drinking for shorter and longer periods. As Figure 1 indicates, those who had, and had not, consumed illicit stimulants had similar BAC levels in the first two hours of drinking, followed by a more rapid increase in BAC after 2-4 hours for those who consumed illicit stimulants. However, after more than 6 hours, those who consumed illicit stimulants recorded lower average BAC levels.

For those who had, and had not, consumed energy drinks, BAC levels increased almost linearly with the number of hours been drinking up until 4-6 hours. Energy drink consumers appeared to have a higher BAC in the initial stages of drinking; however, after 6 hours, the pattern reversed, with lower mean BAC levels for those who had consumed energy drinks.

Robustness analysis using log-normal model

A multilevel log-normal model yielded results that were very similar to those of gamma regression, with the exception of one of the covariates (spending time at a nightclub) making no significant contribution to the log-normal model (p=.086) whilst being a significant predictor in the gamma model (p=.025). Additionally, interaction between the use of illicit stimulants and length drinking session was not significant in the log-normal model (p=.080) but was significant in gamma (p=.013) model, suggesting that this interaction term is related to BAC levels on a 'natural' scale (as modelled by gamma regression) but is not related to log-BAC (as modelled by log-normal model).

Discussion

Six percent of alcohol consumers interviewed in the Australian night-time economy reported consuming at least one type of illicit simulant on the current night out. Those who consumed illicit stimulants were significantly more likely to be male, engage in pre-drinking, to have spent time at a nightclub and to have consumed full strength beer, spirits and cannabis. More than one in five participants reported consumption of alcohol and energy drinks on the current night out and energy drink consumers were significantly more likely to be younger, to be interviewed after midnight, to engage in pre-drinking, to have spent time at nightclub, and to have consumed spirits or 'shots'.

As with previous research (23), our initial descriptive and bivariable regression analyses indicated that patrons who consumed stimulants (licit or illicit) with alcohol had higher BAC levels; however, these factors were not independently associated with higher BAC in the final multivariable model. Our results suggest that stimulant users are demographically and behaviourally different to alcohol-only consumers and engage in different patterns of drinking to non-stimulant users, and this may explain higher levels of intoxication among stimulant users, at least in the initial stages of drinking. As proposed in previous research (3-12), our findings suggest that people who consume stimulants might have a greater propensity for engaging in risky behaviours in the night-time economy, including pre-drinking, heavy alcohol consumption and illicit drug use; however, the cross-sectional nature of this research means that causal relationships cannot be identified and more research is required to unpack the direction of this relationship and the role of stimulants in facilitating these behaviours.

As aforementioned, recent debates have suggested that co-consumption of alcohol and stimulants might increase stimulation and reduce sedation, thereby prolonging the drinking session (1, 2). Our interaction analyses showed that stimulant users had elevated BAC levels in the initial hours of their drinking session, suggesting that stimulant use may facilitate faster alcohol consumption at the beginning of a drinking session, as endorsed in a previous qualitative study (22). However, our interaction analyses show that after six or more hours, stimulant use was no longer associated with higher BAC. One potential explanation for this is that stimulant users slow their drinking later in the evening, perhaps because they shift their focus from alcohol to stimulant use, as established in a previous ethnographic study (34). A second potential explanation is that there may be a pharmacological interaction whereby stimulant use decreases BAC, as evidenced by experimental studies showing that the co-consumption of alcohol and illicit stimulants decreases BAC relative to alcohol-only (35-37). Further research is needed to explore this, particularly with greater quantities of energy drinks than have been used previously in experimental research.

Factors that were independently associated with higher BAC levels in the final model included pre-drinking, being interviewed after midnight, drinking for longer and consumption of beer and wine/champagne. While most of these factors have been endorsed in previous research as factors predicting higher BAC (24, 25), the finding that beer and wine/champagne predicted a higher BAC differs from a previous study that showed spirit consumption was associated with greater BAC levels (24). This may be related to beer and wine being the cheapest and most commonly consumed drinks in Australia. These findings suggest that the types of interventions likely to be effective in reducing alcohol intoxication in the night-time economy are those with a strong evidence base for reducing alcohol consumption and related harm (44), such as restrictions on trading hours (given the elevated intoxication of those drinking longer and interviewed after midnight) and raising the price of alcohol in off-premise outlets, as price is a motivating factor for pre-drinking (45).

There are a number of study limitations that must be considered in the interpretation of these findings. First, although we identified an association between increased BAC levels and a number of factors, this does not imply causation and there may be a range of additional factors that explain the associations we identified. When interpreting the findings, it is important to keep in mind that given data collection occurred during a night out, some patrons may have consumed energy drinks or illicit drugs after they were interviewed. Furthermore, we did not collect information on other caffeine use, and although the drug tests were most likely to detect use in the preceding 12 hours (40), they may have potentially detected drugs used up to 24 hours prior, which may be one potential explanation for the discrepancy between self-reported drug use and positive drug test results.

Conclusions

Consistent with previous research, our analyses indicate that patrons who consumed stimulants with alcohol had higher BAC levels; however, these findings became non-significant once alcohol consumption practices such as pre-drinking, time of night and length of session were controlled. Our findings suggest that people who consume stimulants are more likely to engage in prolonged sessions of heavy alcohol consumption and a range of risk-taking behaviours on a night out, and as such, targeted interventions directed at these patrons is recommended.

Acknowledgements: This study was supported by funding from the National Drug Law Enforcement Research Fund (NDLERF), Australian Government Department of Health and Ageing. Amy Pennay (APP1069907) and Rebecca Jenkinson (APP1054674) are funded by NHMRC Early Career Fellowships and Nicolas Droste is funded by an ARC PhD Scholarship (LP110200699), supported by VicHealth. Thank you to Sarah Callinan for initial statistical advice and Robin Room and Sandra Kuntsche for their comments on an earlier version of this paper.

References

1. Arria A, O'Brien M. The “High” Risk of Energy Drinks. Journal of the American Medical Association. 2011;305(6):600-1.

2. Peacock A, Pennay A, Droste N, Bruno R, Lubman D. ‘High’ Risk? A Systematic Review of the Acute Outcomes of Mixing Alcohol with Energy Drinks. Addiction. 2014;in press.

3. Brache K, Stockwell T. Drinking patterns and risk behaviors associated with combined alcohol and energy drink consumption in college drinkers. Addictive Behaviors. 2011;36:1133-40.

4. O'Brien MC, McCoy TP, Rhodes SD, Wagoner A, Wolfson M. Caffeinated cocktails: Energy drink consumption, high-risk driving, and alcohol related consequences among college students. Academic Emergency Medicine. 2008;15(5):453-60.

5. Miller KE. Alcohol mixed with energy drink use and sexual risk-taking: Casual, intoxicated, and unprotected sex. Journal of Caffeine Research. 2012;Online access.

6. Woolsey C, Waigandt A, Beck NC. Athletes and energy drinks: Reported risk-taking and consequences from the combined use of alcohol and energy drinks. Journal of Applied Sport Psychology. 2010;22:65-71.

7. Velazquez CE, Poulos NS, Latimer LA, Pasch KE. Associations between energy drink consumption and alcohol use behaviors among college students. Drug and Alcohol Dependence. 2012 Jun 1;123(1-3):167-72.

8. Patrick ME, Maggs JL. Energy Drinks and Alcohol: Links to Alcohol Behaviors and Consequences Across 56 Days. Journal of Adolescent Health. 2014;54:454-9.

9. Trapp GSA, Allen KL, O'Sullivan T, Robinson M, Jacoby P, Oddy WH. Energy drink consumption among young Australian adults: Associations with alcohol and illicit drug use. Drug and Alcohol Dependence. 2013;134:30-7.

10. Flotta D, Mico R, Nobile CG, Pileggi C, Bianco A, Pavia M. Consumption of Energy Drinks, Alcohol, and Alcohol-Mixed Energy Drinks Among Italian Adolescents. Alcoholism: Clinical and Experimental Research. 2014;38(6):1654–61.

11. Striley CW, Khan SR. Review of the energy drink literature from 2013: findings continue to support most risk from mixing with alcohol. Current Opinion in Psychiatry. 2014;27:263–8.

12. Terry-McElrath YM, O'Malley PM, Johnston LD. Energy Drinks, Soft Drinks, and Substance Use Among United States Secondary School Students. Journal of Addiction Medicine. 2014;8(1):6-13.

13. Droste N, Tonner L, Zinkiewicz L, Pennay A, Lubman D, Miller P. Combined Alcohol and Energy Drink Use:Motivations as Predictors of Consumption Patterns, Risk of Alcohol Dependence, and Experience of Injury and Aggression. Alcoholism: Clinical and Experimental Research. 2014;38(7):2087-95.

14. Marczinski CA, & Fillmore, M. T. Dissociative antagnostic effects of caffeine on alcohol-induced impairment of behavioral control. Experimental and Clinical Psychopharmacology. 2003;11:228-36.

15. Ferreira SE, de Mello MT, Pompeia S, Souza-Formigoni MLO. Effects of energy drink ingestion on alcohol intoxication. Alcoholism: Clinical and Experimental Research. 2006;30(4):598-605.

16. Alford C, Hamilton-Morris J, Verster JC. The effects of energy drink in combination with alcohol on performance and subjective awareness. Psychopharmacology (Berl). 2012 Mar 29.

17. Peacock A, Bruno R, Martin FH, Carr A. The Impact of Alcohol and Energy Drink Consumption on Intoxication and Risk-Taking Behavior. Alcoholism: Clinical and Experimental Research. 2013;37(7):1234-42.

18. Stockwell T, Donath S, Cooper-Stanbury M, Chikritzhs T, Catalano P, Mateo C. Under-reporting of alcohol consumption in household surveys: a comparison of quantity-frequency, graduated-frequency and recent recall. Addiction. 2004;99(8):1024-33.

19. Clapp JD, Holmes MR, Reed MB, Shillington AM, Freisthler B, Lange JE. Measuring College Students' Alcohol Consumption in Natural Drinking Environments : Field Methodologies for Bars and Parties. Evaluation Review. 2007;31:469-89.

20. Woolsey C. Energy drink cocktails: A dangerous combination for athletes and beyond. Journal of Alcohol and Drug Education. 2010;54(3):41-68.

21. Sindich N, Burns L. Australian Trends in Ecstasy and Related Drug Markets 2009: Findings from the Ecstasy and Related Drugs Reporting System (EDRS). Australian Drug Trends Series No. 46. Sydney: National Drug and Alcohol Research Centre, University of New South Wales2010.

22. Pennay A, Lubman D. Alcohol and energy drinks: a pilot study exploring patterns of consumption, social contexts, benefits and harms. BMC Research Notes. 2012;5(369).

23. Thombs DL, O'Mara RJ, Tsukamoto M, Rossheim ME, Weiler RM, Merves ML, et al. Event-level analyses of energy drink consumption and alcohol intoxication in bar patrons. Addictive Behaviors. 2010;35(4):325-30.

24. Hughes K, Quigg Z, Bellis MA, van Hasselt N, Calafat A, Kosir M, et al. Drinking behaviours and blood alcohol concentration in four European drinking environments: a cross-sectional study. BMC Public Health. 2011;11(918).

25. Clapp JD, Won Min J, Shillington AM, Reed MB, Ketchie Croff J. Person and Environment Predictors of Blood Alcohol Concentrations: A Multi-Level Study of College Parties. Alcoholism: Clinical and Experimental Research. 2008;32(1):100-7.

26. Bellis MA, Hughes K, Quigg Z, Morleo M, Jarman I, Lisboa P. Cross-sectional measures and modelled estimates of blood alcohol levels in UK nightlife and their

relationships with drinking behaviours and observed signs of inebriation. Substance Abuse Treatment, Prevention and Policy. 2010;5(5):online open access.

27. Hughes K, Anderson Z, Morleo M, Bellis MA. Alcohol, nightlife and violence: the relative contributions of drinking before and during nights out to negative health and criminal justice outcomes. Addiction. 2007;103:60-5.

28. Wiens BL. When log-normal and gamma models give different results: a case study. The American Statistician. 1999;53(2):89-93.

29. Kinner S, George J, Johnston J, Dunn M, Degenhardt L. Pills and pints: Risky drinking and alcohol-related harms among regular ecstasy users in Australia. Drug and Alcohol Review. 2012;31(3):273-80.

30. Riley S, James C, Gregory D, Dingle H, Cadger M. Patterns of recreational drug use at dance events in Edinburgh, Scotland. Addiction. 2001;96:1035-47.

31. Grov C, Kelly BC, Parsons T. Polydrug use among club-going young adults recruited through time-space sampling. Substance Use and Misuse. 2009;44(6):848-84.

32. Barrett SP, Gross SR, Garand I, Pihl RO. Patterns of Simultaneous Polystubtance Use in Canadian Rave Attendees. Substance Use and Misuse. 2005;40:1525-37.

33. Hunt G, Evans K, Moloney M, Bailey N. Combining Different Substances in the Dance Scene: Enhancing Pleasure, Managing Risk and Timing Effects. Journal of Drug Issues. 2009;39(3):495-521.

34. Pennay A. Carnal pleasures and grotesque bodies: Regulating the body during a “big night out” of alcohol and party drug use. Contemporary Drug Problems. 2012;39(Fall):397-428.

35. McCance-Katz EF, Kosten TR, Jatlow P. Concurrent Use of Cocaine and Alcohol Is More Potent and Potentially More Toxic than Use of Either Alone— A Multiple-Dose Study. Biological Psychiatry. 1998;44:250-9.

36. Hernández-López C, Farré M, Roset PN, Menoyo E, Pizarro N, Ortuño J, et al. 3,4-Methylenedioxymethamphetamine (Ecstasy) and Alcohol Interactions in Humans: Psychomotor Performance, Subjective Effects, and Pharmacokinetics. The Journal of Pharmacology and Experimental Therapeutics. 2002;300(1):236-44.

37. Mendelson J, Jones RT, Upton R, Jacob P. Methamphetamine and ethanol interactions in humans. Clinical Pharmacology & Therapeutics 1995;57(5):559-68.

38. Miller P, et al. Dealing with Alcohol and the Night-Time Economy (DANTE): Final Report. Geelong: Deakin University and Hunter New England Population Health2012.

39. Miller P, Pennay A, Jenkinson R, Droste N, Chikritzhs T, Tomsen S, et al. Patron Offending and Intoxication in Night Time Entertainment Districts (POINTED): A Study Protocol. International Journal of Alcohol and Drug Research. 2013;2(1):69-76.

40. Aberl F, VanDine R. Saliva and Sweat Testing With Drugwipe®: A Review. In: Wong RC, Tse HY, editors. Drugs of Abuse: Body Fluid Testing. Totowa, NJ: Humana Press Inc; 2005.

41. Sugiura N. Further analysis of the data by Akaike's information criterion and the finite corrections. Communications in Statistics - Theory and Methods. 1978;17(1):13-26.

42. SAS Institute Inc. Base SAS® 9.3 Procedures Guide. Cary, NC, USA: SAS Institute Inc2011.

43. Little RJA. A test of missing completely at random for multivariate data with missing values. Journal of the American Statistical Association. 1988;83:1198-202.

44. Babor T, Caetano R, Casswell S, Edwards G, Giesbrecht N, Graham K, et al. Alcohol: No Ordinary Commodity. Oxford: Oxford University Press; 2010.

45. Wells S, Graham K, Purcell J. Policy implications of the widespread practice of 'pre-drinking' or 'pre-gaming' before going to public drinking establishments - are current prevention strategies backfiring? Addiction. 2009;104:4-9.

Tables

Table 1. Characteristics of Study Participants by Stimulant Use Status, Selected Cities (Melbourne, Geelong, Sydney, Wollongong and Perth), Australia, December 2011-June 2012.

	Total (n=3021)		Illicit stimulants					Energy drinks				
			No (n=2840)		Yes (n=181)		p-value[1]	No (n=2384)		Yes (n=637)		p-value[1]
	n	%	n	%	n	%		n	%	n	%	
Blood alcohol concentration, Median (IQR)	0.068	(0.039-0.102)	0.067	(0.039-0.102)	0.080	(0.050-0.110)	**0.004**	0.067	(0.037-0.101)	0.074	(0.045-0.106)	**<.001**
Age group												
18-19	567	(18.9)	521	(18.7)	43	(24.0)	.469	413	(17.6)	151	(24.2)	**<.001**
20-24	1263	(42.1)	1179	(42.2)	72	(40.2)		967	(41.2)	284	(45.4)	
25-29	680	(22.7)	640	(22.9)	35	(19.6)		562	(24.0)	113	(18.1)	
30-39	373	(12.4)	346	(12.4)	23	(12.8)		303	(12.9)	66	(10.6)	
40+	115	(3.8)	105	(3.8)	6	(3.4)		100	(4.3)	11	(1.8)	
Male sex	1819	(60.8)	1673	(59.9)	135	(75.4)	**<.001**	1425	(60.8)	383	(61.3)	.890
Interview after midnight	1373	(45.4)	1250	(44.8)	91	(50.8)	.134	1001	(42.7)	340	(54.4)	**<.001**
Engagement in pre-drinking	1982	(65.6)	1806	(64.7)	147	(82.1)	**<.001**	1468	(62.6)	485	(77.6)	**<.001**
Number of pre-drinks, Median (IQR)	1	(0-1)	1	(0-1)	1	(1-1)	<.001	1	(0-1)	1	(1-1)	<.001
Venues spent time tonight												
Private home	927	(30.7)	847	(30.3)	64	(35.8)	.160	696	(29.7)	215	(34.4)	.029
Sporting club	51	(1.7)	45	(1.6)	6	(3.4)	.080	41	(1.7)	10	(1.6)	.794
Sports event	60	(2.0)	53	(1.9)	5	(2.8)	.440	47	(2.0)	11	(1.8)	.598
Restaurant	315	(10.4)	304	(10.9)	7	(3.9)	**.003**	267	(11.4)	44	(7.0)	**.001**
Hotel/Pub/Bar	1730	(57.3)	1606	(57.5)	102	(57.0)	.920	1368	(58.3)	340	(54.4)	.090
Nightclub	621	(20.6)	553	(19.8)	55	(30.7)	**<.001**	422	(18.0)	186	(29.8)	**<.001**
Public location (e.g., park/street)	167	(5.5)	146	(5.2)	20	(11.2)	**.001**	117	(5.0)	49	(7.8)	**.007**
Length of session (hours), Median (IQR)	4	(2.5-6)	4	(2.5-6)	5	(2.5-8)	**<.001**	4	(2.5-6)	4.5	(3-6.5)	**<.001**
Types of drinks consumed												
Full strength beer	1551	(51.3)	1414	(50.7)	111	(62.0)	**.002**	1230	(52.5)	295	(47.2)	**.025**
Cider	311	(10.3)	283	(10.1)	26	(14.5)	.063	259	(11.0)	50	(8.0)	**.032**
Shots	317	(10.5)	284	(10.2)	26	(14.5)	.080	204	(8.7)	106	(17.0)	**<.001**
Cocktails	206	(6.8)	196	(7.0)	6	(3.4)	.054	162	(6.9)	40	(6.4)	.666
Wine or champagne	735	(24.3)	699	(25.0)	25	(14.0)	**.001**	625	(26.7)	99	(15.8)	**<.001**
Spirits	1593	(52.7)	1448	(51.9)	117	(65.4)	**.001**	1115	(47.5)	450	(72.0)	**<.001**
Number of standard drinks, Median (IQR)	8	(5-11)	8	(5-10)	12	(8-15)	**<.001**	7	(5-10)	9	(6-13)	**<.001**
Cannabis consumption	97	(3.2)	76	(2.7)	20	(11.2)	**<.001**	74	(3.2)	22	(3.5)	.696

Note: [1]from Chi-Square or Mann-Whitney tests, as appropriate; IQR=interquartile range; significant association are bolded.

Table 2. Results of Gamma Regressions Assessing Predictors of Blood Alcohol Concentration >0 (n=3021), Selected Cities (Melbourne, Geelong, Sydney, Wollongong and Perth), Australia, December 2011-June 2012.

Predictors	Null model	Bivariable regressions with random intercepts			Stage 1: background variables			Stage 2: stimulant consumption variables			Stage 3: interaction terms			Stage 4: random slopes		
		ExpB¹	95% CI	P-value	ExpB¹	95%CI	P-value	ExpB¹	95% CI	P-value	ExpB¹	95% CI	P-value	ExpB¹	95% CI	P-value
Fixed effects																
Intercept (SE)	0.08 (0.01)	0.08 (0.03)			0.04 (0.08)			0.04 (0.08)			0.04 (0.08)			0.04 (0.08)		
Age group (years)				**.048**			.173			.180			.152			.178
18-19		0.85	(0.72-0.98)	**.012**	0.92	(0.79-1.04)	.181	0.91	(0.79-1.04)	.176	0.92	(0.79-1.04)	.187	0.91	(0.77-1.05)	.187
20-24		0.91	(0.78-1.03)	.114	0.97	(0.85-1.09)	.658	0.97	(0.85-1.09)	.624	0.98	(0.86-1.10)	.707	0.97	(0.84-1.1)	.642
25-29		0.91	(0.78-1.03)	.126	0.94	(0.82-1.06)	.335	0.94	(0.82-1.06)	.317	0.94	(0.82-1.06)	.341	0.93	(0.8-1.06)	.287
30-39		0.94	(0.80-1.07)	.331	1.00	(0.87-1.13)	.984	1.00	(0.87-1.13)	.966	1.00	(0.87-1.13)	.998	0.99	(0.85-1.13)	.912
40+		Reference			Reference			Reference			Reference			Reference		
Male sex		1.13	(1.08-1.17)	**<.001**	0.94	(0.85-1.04)	.229	0.96	(0.87-1.05)	.342	0.97	(0.88-1.06)	.456	0.95	(0.86-1.04)	.268
Interview after midnight		1.13	(1.08-1.17)	**<.001**	1.07	(1.02-1.12)	**.006**	1.07	(1.02-1.11)	**.006**	1.06	(1.02-1.11)	**.008**	1.07	(1.02-1.12)	**.011**
Engagement in pre-drinking		1.18	(1.14-1.23)	**<.001**	1.12	(1.07-1.18)	**<.001**	1.13	(1.07-1.18)	**<.001**	1.13	(1.08-1.18)	**<.001**	1.14	(1.09-1.2)	**<.001**
Number of pre-drinks		1.02	(1.01-1.03)	**.001**	0.99	(0.98-1.01)	.321	1.00	(0.98-1.01)	.373	1.00	(0.98-1.01)	.360	0.99	(0.98-1.01)	.345
Venues spent time tonight																
Private home		1.10	(1.06-1.15)	**<.001**	1.04	(0.99-1.10)	.120	1.04	(0.99-1.10)	.118	1.05	(0.99-1.10)	.095	1.05	(0.99-1.11)	.118
Sporting club		1.30	(1.12-1.48)	**.004**	1.00	(0.83-1.17)	.992	1.00	(0.82-1.17)	.956	0.98	(0.81-1.15)	.844	0.97	(0.78-1.16)	.750
Sports event		1.30	(1.14-1.47)	**.002**	1.11	(0.95-1.26)	.218	1.10	(0.94-1.26)	.225	1.10	(0.94-1.26)	.254	1.10	(0.93-1.28)	.276
Restaurant		0.85	(0.77-0.92)	**<.001**	0.89	(0.81-0.97)	**.003**	0.89	(0.82-0.97)	**.003**	0.89	(0.81-0.97)	**.003**	0.88	(0.80-0.96)	**.002**
Hotel/Pub/Bar		1.05	(1.00-1.10)	**.041**	0.98	(0.93-1.04)	.538	0.99	(0.93-1.04)	.589	0.98	(0.93-1.04)	.542	0.98	(0.93-1.04)	.551
Nightclub		0.99	(0.93-1.05)	.698	0.92	(0.86-0.98)	**.007**	0.92	(0.86-0.99)	**.012**	0.92	(0.85-0.98)	**.006**	0.91	(0.83-0.99)	**.025**
Public location (e.g., park/street)		1.04	(0.94-1.14)	.431	1.05	(0.95-1.15)	.314	1.06	(0.96-1.15)	.279	1.05	(0.96-1.15)	.294	1.06	(0.95-1.17)	.295
Length of drinking session		1.05	(1.04-1.06)	**<.001**	1.02	(1.02-1.03)	**<.001**	1.02	(1.02-1.03)	**<.001**	1.04	(1.03-1.05)	**<.001**	1.04	(1.03-1.05)	**<.001**
Types of drinks consumed																
Full strength beer		1.20	(1.15-1.24)	**<.001**	1.09	(1.04-1.15)	**.002**	1.09	(1.03-1.14)	**.002**	1.09	(1.04-1.14)	**.002**	1.10	(1.04-1.15)	**.003**
Cider		1.00	(0.92-1.07)	.940	0.98	(0.91-1.06)	.641	0.98	(0.91-1.06)	.645	0.98	(0.91-1.05)	.609	0.98	(0.90-1.06)	.584
Shots		1.04	(0.96-1.11)	.329	0.95	(0.87-1.02)	.134	0.95	(0.88-1.02)	.158	0.95	(0.88-1.02)	.185	0.95	(0.87-1.03)	.179
Cocktails		0.87	(0.78-0.96)	**.003**	0.84	(0.75-0.93)	**<.001**	0.83	(0.74-0.92)	**<.001**	0.84	(0.75-0.93)	**.001**	0.83	(0.74-0.93)	**.001**
Wine		1.09	(1.04-1.14)	**.002**	1.18	(1.12-1.23)	**<.001**	1.18	(1.12-1.23)	**<.001**	1.18	(1.12-1.23)	**<.001**	1.19	(1.13-1.25)	**<.001**
Spirits		1.04	(1.00-1.09)	.076	1.00	(0.95-1.05)	.952	1.00	(0.95-1.05)	.895	0.99	(0.95-1.04)	.802	0.99	(0.94-1.04)	.689
Number of standard drinks		1.04	(1.04-1.05)	**<.001**	1.04	(1.03-1.04)	**<.001**	1.04	(1.03-1.04)	**<.001**	1.04	(1.03-1.04)	**<.001**	1.04	(1.04-1.05)	**<.001**
Cannabis consumption		0.93	(0.80-1.06)	.300	0.84	(0.71-0.97)	**.007**	0.85	(0.72-0.97)	**.010**	0.85	(0.72-0.98)	**.012**	0.84	(0.70-0.97)	**.011**

	Random intercept model			Stage 1 model			Stage 2 model			Stage 3 model			Stage 4 model		
Stimulants consumed															
Illicit stimulants	1.12	(1.02-1.22)	**.021**				0.90	(0.79-1.01)	.061	0.93	(0.81-1.04)	.196	0.92	(0.80-1.05)	.198
Energy drinks (yes/no)	1.08	(1.02-1.13)	**.009**				1.09	(0.99-1.18)	.112	1.09	(0.99-1.19)	.103	1.09	(0.99-1.2)	.112
Number of energy drinks	1.02	(1.00-1.04)	.065				0.98	(0.95-1.00)	.072	0.98	(0.95-1.01)	.122	0.98	(0.95-1.00)	.098
Illicit stimulants by length of drinking session[2]										0.98	(0.96-0.99)	**.012**	0.97	(0.95-0.99)	**.013**
Energy drinks by length of drinking session										0.98	(0.96-0.99)	**.007**	0.98	(0.96-0.99)	**.007**

Random effects	*Random intercept model*		*Stage 1 model*		*Stage 2 model*		*Stage 3 model*		*Stage 4 model*	
	Estimate	*SE*	*Estimate*	*SE*	*Estimate*	*SE*	*Estimate*	*SE*	*Estimate*	*SE*
Level 1: Person										
Residual variance	0.410	0.010	0.347	0.009	0.346	0.009	0.343	0.009	0.341	.009
Level 2: City										
Intercept	0.004	0.003	0.004	0.003	0.004	0.003	0.004	0.003	0.003	0.003
Slope (venue spent time tonight: nightclub)									0.013	0.011

Note: [1]exponentiated regression coefficient, representing percentage difference in the mean levels of alcohol for a one unit difference in the values of a predictor; [2]length of drinking session was mean-centered prior to computing the interactions to avoid multicollinearity, SE= standard error; significant associations are bolded.

Figures

Figure 1. Association between Blood Alcohol Levels and Length of Drinking Session, By Illicit Stimulant Consumption Status, Selected Cities (Melbourne, Geelong, Sydney, Wollongong and Perth), Australia, December 2011-June 2012.

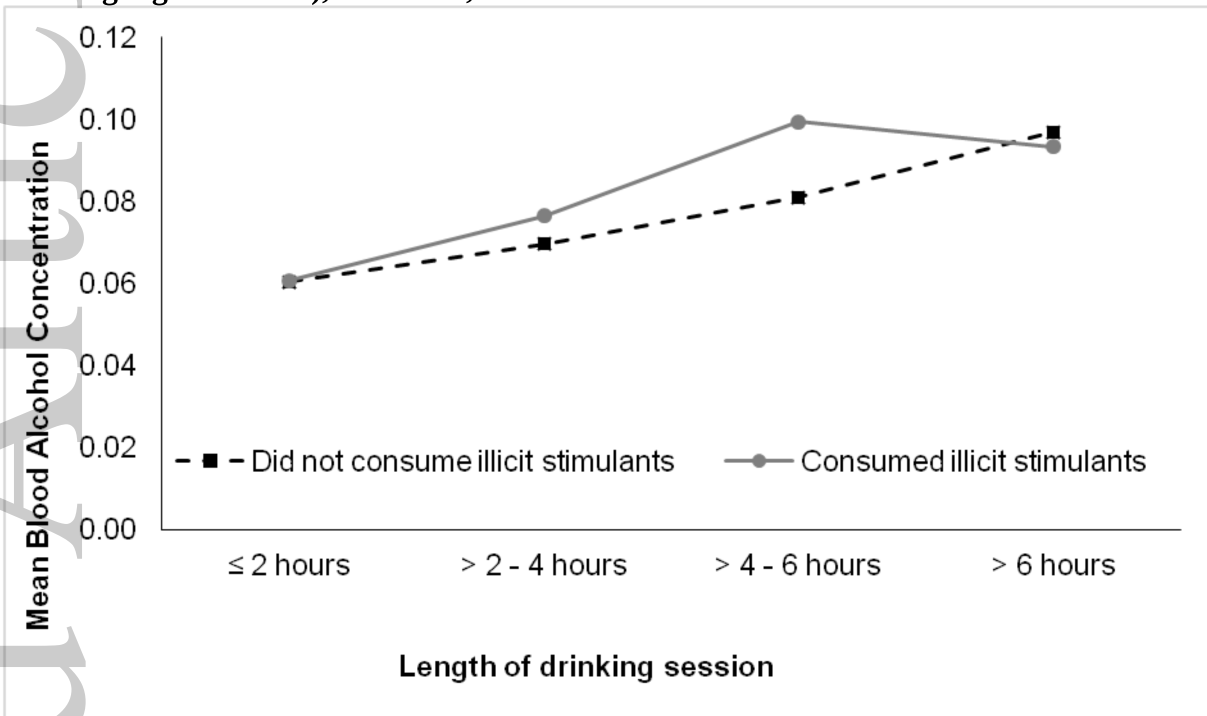

Figure 2. Association between Blood Alcohol Levels and Length of Drinking Session, By Energy Drinks Consumption Status, Selected Cities (Melbourne, Geelong, Sydney, Wollongong and Perth), Australia, December 2011-June 2012.