Alcohol-related risk from pre-loading and heavy episodic drinking (HED) among a cohort of young Australian women: a cross-sectional analysis

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Abstract

Objective: To cross-sectionally examine heavy episodic drinking (HED) and pre-loading with alcohol among young Australian women in relation to the alcohol-induced adverse outcomes of memory loss, vomiting and injury.

Methods: A total of 7,800 participants, aged 20–25 years, from the 1989–95 cohort of the Australian Longitudinal Study on Women's Health answered all questions on alcohol use, reported drinking alcohol in the previous year and were not pregnant at the third survey in 2015. Log-binomial models were used to estimate prevalence ratios for adverse outcomes associated with increased frequency of HED and pre-loading.

Results: The majority of participants reported HED (83.4%) and/or pre-loading (65.6%), which had a moderate correlation (r=0.646). Just over half (55.2%) of participants experienced at least one adverse event, with vomiting being most common. As the frequency of HED or pre-loading increased, so did the risk of an adverse outcome.

Conclusions: Both HED and pre-loading pose a risk to young Australian women, and that risk rises with increased frequency.

Implications for public health: Although HED has been a target of public health policy and interventions, pre-loading has received limited attention. In addition to addressing HED, there is a need to consider the risk posed by pre-loading, a related, yet unique risky drinking behaviour.

Key words: alcohol drinking, pre-loading, harm, women's health, heavy episodic drinking

International alcohol guidelines provide recommendations on levels of consumption that would minimise related harm.[1] However, there is variance in the alcohol limits included in different guidelines.[1] This variance may be partly due to discrepancies in regards to how 'risky' drinking is defined and the drinking patterns that result in harm.[2] However, reviews of the literature have found there is a consensus that heavy episodic drinking (HED), variously defined, is linked with a multitude of acute adverse events.[2,3] In some countries, such as Australia and the UK, alcohol guidelines include the risks of harm from HED.[4,5] For example, the Australian National Health and Medical Research Council (NHMRC) alcohol guidelines recommend that to reduce the risk of harm on a single occasion that men and women should drink no more than four standard drinks of alcohol.[4]

Despite alcohol guidelines, HED, defined by the World Health Organization as drinking 60 grams of pure alcohol on a single occasion at least once a month, is common in high-income countries worldwide, particularly among young adults.[6] For example, within Australia, 67% of all men and 55% of all women aged 18–24 reported HED, that is, drinking in excess of the NHMRC alcohol guideline for single-occasion risk.[7] According to data from the 2016 National Drug Strategy Household Survey (NDSHS), the proportion of Australians aged in their twenties exceeding the single-occasion risk alcohol guideline is higher than any other age group despite having decreased over time, although not between the two most recent surveys.[8] There is a higher reported prevalence of HED among men, but this rate has decreased over recent years, whereas HED has remained stable for Australian women according to the 2017–18 National Health Survey.[7]

In addition to the public health concern over harm associated with HED, a growing body of research has also been examining the prevalence of pre-loading associated with alcohol-related harm. Pre-loading, also referred to as pre-gaming, pre-drinking, front-loading or pre-partying, describes a pattern of drinking whereby the individual typically consumes alcohol off-premise before going out to a licensed venue or event. A 2014 review reported that the majority of the research into this behaviour had been conducted in the US or the UK.[9] More recently, a number of other countries such as Switzerland,[10,11] Denmark,[12] Brazil,[13] New Zealand[14] and Australia[15-18] have also started to investigate this phenomenon. However, the generalisability of these studies to a larger population is not always possible due to limits in sample size, representativeness and cultural differences.

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The DANTE project, which was conducted in two Australian cities, found that two-thirds of the nearly 4,000 Australians interviewed took part in pre-loading with alcohol, with the primary reason for doing so being the lower cost of packaged alcohol compared to alcohol bought in a venue.[19] The SmartStart project run in three Queensland cities found that 80% of participants had pre-loaded before going out, with 45% citing socialisation as the primary reason, followed by the cost of alcohol (38%).[15] A qualitative component of a study in Victoria found that the three main reasons young women (N=60) reported pre-loading was to reduce the money they spent on alcohol, to become intoxicated before going out and to enhance socialisation with friends.[16]

Pre-loading with alcohol has been found to increase the risk of intoxication, violence and sexual assault,[9] as well as non-violent alcohol-related injuries[20] and blackouts.[21] Similar risks are also increased with HED, especially in men who have been found to partake in more hazardous behaviour than women when consuming alcohol.[4,6,22-24] Young people are particularly at risk, as they are more likely to engage in risky drinking behaviours.[7] In 2013, a report by the New South Wales Standing Committee on Social Issues highlighted that addressing HED and pre-loading with alcohol among young Australians was necessary to reduce alcohol-related harm in this population group.[25] Some evidence suggests that being female increases the risk of particular adverse outcomes from pre-loading, such as emergency department visits[26] and forgetting what happened the previous night.[15] The relationship between pre-loading with age and sex differs across countries, suggesting a need for each country to investigate its own unique situation.[27] Although previous research has found that pre-loading is associated with drinking in excess,[9] little has been done to assess the additional burden that pre-loading may place on those already at risk of harm from their HED behaviour, particularly for young women.

Therefore, this study aims to:

- identify the prevalence of young Australian women's frequency of HED and frequency of pre-loading with alcohol;
- investigate the relationship between these alcohol consumption behaviours and adverse alcohol-induced events; and
- determine whether increases in the frequency of pre-loading with alcohol increases the risk of alcohol-induced harm to young women who are already at risk from HED.

Methods

Participants

In 2012–13, 17,010 young Australian women born between 1989 and 1995, aged 18–23 years, were recruited into a new cohort (i.e. the 1989–95 cohort) of the Australian Longitudinal Study on Women's Health (www.alswh.org.au). Recruitment was through a combination of offline and online recruitment methods, which have been described previously.[28] Participants gave informed consent for annual follow-up surveys. Ethics approval was obtained from the Human Research Ethics Committees of the Universities of Newcastle (H-2012-0256) and Queensland (2012000950). Recruited participants were broadly representative of Australian women with respect to geographical distribution, age and marital status, based on comparisons with the 2011 Australian Census, although there is some over-representation of women with vocational or tertiary qualifications.[29]

In 2015, when aged 20–25 years old, 8,961 eligible participants completed the third survey (54.9% survey response rate), which included questions relating to alcohol intake and adverse alcohol-induced events. Participants who had responded to all alcohol-related questions, were not pregnant and reported drinking alcohol in the previous year were included in the analysis.

Primary outcomes

The primary outcomes measured were alcohol-induced vomiting, memory loss and injury. To measure these alcohol-induced events from short-term alcohol consumption, participants were asked, 'In the last 12 months, about how often have you: drunk so much that you vomited?; drunk so much that you didn't remember what happened?; drunk so much that you injured yourself?' These questions all had five responses ('Never', 'Less than once a month', 'About once a month', 'About once a week' and 'More than once a week'). To assess the likelihood of a single occasion of harm, in line with current Australian National Health and Medical Research Council (NHMRC) alcohol guidelines,[4] these responses were collapsed and categorised as a binary ever/never outcome.

Alcohol-related measures

Two main alcohol measures were used as the main explanatory variables: frequency of HED and frequency of pre-loading with alcohol. HED was defined as exceeding the NHMRC alcohol guideline for alcohol-related risk on a single occasion (i.e. more than four standard drinks per single occasion).[4] To measure frequency of HED, participants were asked, 'How often do you have five or more standard drinks of alcohol on one occasion?', whereby one standard drink=10 grams of alcohol.[4] To assess frequency of pre-loading with alcohol, participants were asked, 'In the last twelve months, about how often have you pre-loaded with alcohol before going out?' There were five response options for both alcohol measures. The responses 'about once a week' and 'more than once a week' were collapsed into a 'weekly or more' response, resulting in four response categories for each measure (never, less than once a month, about once a month, weekly or more).

As previous research has identified several sociodemographic and health risk behaviours associated with patterns of alcohol use (i.e. primary explanatory variables in this study),[30,31] a number of these potential confounders that were available from the survey data were selected and controlled for.

Sociodemographic measures

Sociodemographic measures analysed were: area of residence; education; studying status; working status; ability to manage on income; relationship status; whether they were living with one or both parents; and whether they were living with children. Area of residence was classified as: major city; inner regional; or outer regional/remote/very remote (based on their Accessibility/Remoteness Index of Australia ARIA+ score).[32] Highest level of education was classified as: year 12 or less; certificate/diploma; or university degree. Participants were asked how many hours they spent studying or in paid work in a usual week. Responses for each variable were classified into three categories: not working or not studying (0 hours per week); part-time (1–34 hours per week); and full-time (35 or more hours per week). Ability to manage on income was based on the question 'How do you manage on the income you have available?' with response options collapsed into 'difficult/impossible' and 'easy/not bad'. Relationship status was collapsed into 'not partnered' or 'partnered'.

Health risk behaviour measures

Health risk behaviours analysed were: current smoking status, use of illicit drugs in the past 12 months, level of daily physical activity and deliberate self-harm in the past 12 months. Participants were classified as non-smokers or current smokers based on their response to the question 'Do you *currently* smoke tobacco?' (response options 'daily', 'less than daily', 'not at all'). Participants who responded as trying either marijuana or another illicit drug in the past 12 months were classified as having consumed an illicit drug in the past 12 months, or else not. Participants were classified as having 'inactive/low' or 'medium/high' levels of physical activity if they did more or less than the equivalent of 150 minutes of moderate-intensity physical activity in the week before survey completion.[33] This was calculated based on frequency and duration reported for the activities of: walking briskly, completing vigorous household or garden chores, moderate leisure exercise or vigorous leisure exercise.[34] Participants were classified as deliberately self-harming themselves in the past 12 months if they answered, 'Yes, in the last twelve months' to a question asking 'Have you deliberately hurt yourself or done anything that you knew might have harmed or even killed you?'

Statistical analysis

One-way frequencies were computed for each of the alcohol-related measures. HED and pre-loading frequency were cross-tabulated and a Spearman correlation coefficient was computed. Sociodemographic and health risk behaviour measures were summarised against frequency of HED and pre-loading using two-way frequencies. Chi-squared tests were used to test group differences using a significance level of $p<0.01$.

Log-binomial models were used to estimate prevalence ratios, with each of the three adverse alcohol-induced events treated as outcomes in separate models.[28] Only data from participants with no missing co-variate information was included in the models. The main predictors of interest in these models were the frequency of HED or pre-loading. Initially, HED (Models 1–3) and pre-loading (Models 4-6) were entered as main predictors in separate models, where sociodemographic and health behaviours factors were controlled for. Pre-loading models containing an interaction term for the original HED and pre-loading classifications were attempted; however, due to low counts in some groups, model convergence failed. In order to accommodate the very low frequencies in some cells (eg. weekly HED with no pre-loading, or vice versa), both the HED and pre-loading frequency variables were collapsed to three levels (less than monthly, monthly, weekly or more) and a new variable that describes the combined alcohol consumption behaviour of participants was created. This new variable had nine levels (one for each combination of the two three-level variables). Thus, a final set of models (Models 7–9), with combined alcohol consumption behaviour as the main predictor of the adverse outcomes, was run for all three outcomes. Models 7–9 were run twice, once with the lowest frequency level of alcohol consumption behaviour as the reference group, and again with the highest frequency level as the reference. This was done to determine if high frequencies of pre-loading or HED only reduced the prevalence of the adverse outcomes compared to high levels of both behaviours. (Full model results are included in Supplementary Tables 1–9.)

The COPY method described by Deddens et al. (2003) was used with 1,000 copies for all log-binomial models to assist in model convergence.[35] A two-sided significance level of $p<0.01$ was chosen with 99% confidence intervals reported. Analyses were restricted to observations with complete non-missing data for all models. All analysis was conducted in SAS 9.4.

Results

Alcohol consumption behaviours

Participants were ineligible for the study if they had not responded to all alcohol-related questions (n=60), were pregnant (n=523), or did not report drinking alcohol in the previous year (n=713). These exclusions left 7800 women eligible for analysis. Around two-thirds (65.6%) of participants reported alcohol pre-loading, while 83.4% reported HED at least once or more frequently in the past 12 months. A total of 10% reported HED weekly or more, and 6% reported alcohol pre-loading at the same frequency (Table 1). It was rare for participants to report weekly HED in the absence of pre-loading, or vice versa (n=51, 0.7%), while 58% reported the same frequency for both HED and pre-loading. There was a moderate correlation observed between HED and pre-loading (r_s=0.646, $p<0.001$).

All sociodemographic or health risk behaviour variables were found to be associated with either pre-loading or HED, with the exception of participant's ability to manage on available income (Table 2).

Adverse alcohol-induced events

Of the 7,800 participants analysed, 44.6% of participants reported vomiting due to alcohol in the past 12 months (41.1% less than once a month, 3.1% about once a month, 0.4% about once a week, 0.05% more than once a week); 31.5% reported memory loss due to alcohol in the past 12 months (27.2% less than once a month, 3.5% about once a month, 0.7% about once a week, 0.1% more than once a week); and 15.5% reported an injury due to alcohol in the past 12 months (13.7% less than once a month, 1.5% about once a month, 0.3% about once a week, 0.1% more than once a week). More than half of the participants (55.2%) indicated experiencing at least one of these events in the past year, with 709 women (9.1%) reporting all three adverse events.

The fully adjusted models (observations with no missing covariates, n=7,569) showed an increased frequency of HED (Models 1–3, Table 3) was associated with increased prevalence of all three adverse alcohol-induced events. The prevalence of the three adverse outcomes (vomiting, memory loss or injury) was increased more than 7-fold with weekly or more HED, with the strongest association observed for injury (PR=29.4). An increasing frequency of pre-loading was also associated with increased prevalence

Table 1: Frequency of HED and pre-loading with alcohol in the past 12 months among young Australian women aged 20-25 (N=7,800).

Alcohol pre-loading in past 12 months	HED in past 12 months				
	Never (n)	Less than monthly (n)	About monthly (n)	Weekly or more (n)	Row total n (%)
Never	1,094	1,358	180	49	2,681 (34.4%)
Less than monthly	190	2,307	678	147	3,322 (42.6%)
About monthly	6	226	794	287	1,313 (16.8%)
Weekly or more	2	26	126	330	484 (6.2%)
Column total n (%)	1,292 (16.6%)	3,917 (50.2%)	1,778 (22.8%)	813 (10.4%)	7,800

Table 2: Sociodemographic and health risk behaviours of young Australian women (N=7,800) according to HED and alcohol pre-loading.

	N	HED				Alcohol pre-loading			
		Never	Less than monthly	Monthly	Weekly	Never	Less than monthly	Monthly	Weekly
		% (99%CI)	% (99%CI)	% (99%CI)	% (99%CI)	% (99%CI)	% (99%CI)	% (99%CI)	% (99% CI)
Area of Residence[†]									
Major City	5,874	16.5 (15.4, 17.6)	49.7 (48.2, 51.2)	23.1 (21.9, 24.3)	10.7 (9.8, 11.6)	33.5 (32.1, 34.9)	42.9 (41.5, 44.3)	17.1 (16, 18.2)	6.4 (5.7, 7.1)
Inner Regional	1,232	16.7 (15.6, 17.8)	54.1 (52.6, 55.6)	21.0 (19.8, 22.2)	8.2 (7.4, 9.0)	37.5 (36.1, 38.9)	42.7 (41.3, 44.1)	15.5 (14.4, 16.6)	4.3 (3.7, 4.9)
Outer Regional/Remote	603	16.6 (15.5, 17.7)	48.9 (47.4, 50.4)	23.2 (22.0, 24.4)	11.3 (10.4, 12.2)	37.5 (36.1, 38.9)	40.3 (38.9, 41.7)	15.1 (14.1, 16.1)	7.1 (6.3, 7.9)
Education[*†]									
Year 12 or less	2,392	16.5 (15.4, 17.6)	48.8 (47.3, 50.3)	23.0 (21.8, 24.2)	11.7 (10.8, 12.6)	31.0 (29.6, 32.4)	42.4 (41.0, 43.8)	17.9 (16.8, 19)	8.7 (7.9, 9.5)
Certificate/Diploma	2,112	16.8 (15.7, 17.9)	53.2 (51.7, 54.7)	20.8 (19.6, 22.0)	9.3 (8.5, 10.1)	38.2 (36.8, 39.6)	41.7 (40.3, 43.1)	15.2 (14.2, 16.2)	4.8 (4.2, 5.4)
University degree	3,279	16.4 (15.3, 17.5)	49.4 (47.9, 50.9)	23.9 (22.7, 25.1)	10.2 (9.3, 11.1)	34.3 (32.9, 35.7)	43.3 (41.9, 44.7)	17.1 (16.0, 18.2)	5.3 (4.6, 6.0)
Studying Status[†]									
Not Studying	3,085	16.6 (15.5, 17.7)	49.7 (48.2, 51.2)	22.3 (21.1, 23.5)	11.4 (10.5, 12.3)	37.5 (36.1, 38.9)	41.5 (40.1, 42.9)	15.4 (14.3, 16.5)	5.6 (4.9, 6.3)
Studying: Part-time	3,840	16.5 (15.4, 17.6)	50.0 (48.5, 51.5)	23.6 (22.4, 24.8)	9.9 (9.0, 10.8)	32.1 (30.7, 33.5)	43.3 (41.9, 44.7)	18.0 (16.9, 19.1)	6.7 (6.0, 7.4)
Studying: Full-time	854	16.7 (15.6, 17.8)	53.7 (52.2, 55.2)	20.5 (19.3, 21.7)	9.0 (8.2, 9.8)	33.4 (32.0, 34.8)	43.8 (42.4, 45.2)	16.5 (15.4, 17.6)	6.3 (5.6, 7.0)
Working Status[*†]									
Not Working	1,282	21.1 (19.9, 22.3)	53.5 (52.0, 55.0)	17.2 (16.1, 18.3)	8.1 (7.3, 8.9)	43.1 (41.7, 44.5)	39.5 (38.1, 40.9)	12.7 (11.7, 13.7)	4.7 (4.1, 5.3)
Working: Part-time	3,776	16.6 (15.5, 17.7)	49.9 (48.4, 51.4)	23.4 (22.2, 24.6)	10.0 (9.1, 10.9)	32.3 (30.9, 33.7)	42.3 (40.9, 43.7)	18.2 (17.1, 19.3)	7.2 (6.4, 8.0)
Working: Full-time	2,722	14.2 (13.2, 15.2)	49.3 (47.8, 50.8)	24.5 (23.2, 25.8)	12.0 (11.1, 12.9)	33.2 (31.8, 34.6)	44.5 (43.0, 46.0)	16.8 (15.7, 17.9)	5.5 (4.8, 6.2)
Manage on income									
Difficult/Impossible	4,101	15.8 (14.7, 16.9)	50.5 (49.0, 52.0)	22.9 (21.7, 24.1)	10.8 (9.9, 11.7)	33.5 (32.1, 34.9)	42.6 (41.2, 44.0)	17.3 (16.2, 18.4)	6.5 (5.8, 7.2)
Easy/Not bad	3,679	17.3 (16.2, 18.4)	50.0 (48.5, 51.5)	22.7 (21.5, 23.9)	10.0 (9.1, 10.9)	35.3 (33.9, 36.7)	42.6 (41.2, 44.0)	16.2 (15.1, 17.3)	5.8 (5.1, 6.5)
Relationship Status[*†]									
Partnered	2,329	19.1 (18.0, 20.2)	53.6 (52.1, 55.1)	19.3 (18.1, 20.5)	8.0 (7.2, 8.8)	42.6 (41.2, 44.0)	43.2 (41.8, 44.6)	11.1 (10.2, 12.0)	3.1 (2.6, 3.6)
Single	5,451	15.4 (14.3, 16.5)	48.9 (47.4, 50.4)	24.3 (23.0, 25.6)	11.4 (10.5, 12.3)	30.9 (29.6, 32.2)	42.4 (41.0, 43.8)	19.2 (18.0, 20.4)	7.5 (6.7, 8.3)
Current smoking status[*†]									
Current Smoker	1,332	5.9 (5.2, 6.6)	40.5 (39.1, 41.9)	30.4 (29.1, 31.7)	23.2 (22.0, 24.4)	32.9 (31.5, 34.3)	43.8 (42.4, 45.2)	17.6 (16.5, 18.7)	5.7 (5.0, 6.4)
Non-Smoker	6,468	18.8 (17.7, 19.9)	52.2 (50.7, 53.7)	21.2 (20.0, 22.4)	7.8 (7.0, 8.6)	35.2 (33.8, 36.6)	41.9 (40.5, 43.3)	16.3 (15.2, 17.4)	6.5 (5.8, 7.2)
Daily activity[*†]									
Inactive/Low	2,221	19.8 (18.6, 21.0)	51.5 (50.0, 53.0)	19.2 (18.0, 20.4)	9.5 (8.6, 10.4)	60.4 (59.0, 61.8)	34.8 (33.4, 36.2)	3.6 (3.1, 4.1)	1.2 (0.9, 1.5)
Moderate/High	5,467	15.3 (14.2, 16.4)	49.8 (48.3, 51.3)	24.0 (22.8, 25.2)	10.8 (9.9, 11.7)	32.9 (31.5, 34.3)	43.0 (41.6, 44.4)	17.6 (16.5, 18.7)	6.5 (5.8, 7.2)
Living with parents[*]									
One or both parents	2,953	17.6 (16.5, 18.7)	51.6 (50.1, 53.1)	22.2 (21.0, 23.4)	8.6 (7.8, 9.4)	21.6 (20.4, 22.8)	39.4 (38.0, 40.8)	25.5 (24.2, 26.8)	13.4 (12.4, 14.4)
Not living with parents	4,827	15.9 (14.8, 17)	49.5 (48.0, 51.0)	23.1 (21.9, 24.3)	11.5 (10.6, 12.4)	37.0 (35.6, 38.4)	43.2 (41.8, 44.6)	15.0 (14.0, 16.0)	4.7 (4.1, 5.3)

Table 2 cont.: Sociodemographic and health risk behaviours of young Australian women (N=7,800) according to HED and alcohol pre-loading.

	N	HED				Alcohol pre-loading			
		Never	Less than monthly	Monthly	Weekly	Never	Less than monthly	Monthly	Weekly
		% (99%CI)	% (99%CI)	% (99%CI)	% (99%CI)	% (99%CI)	% (99%CI)	% (99%CI)	% (99%CI)
Living with children*†									
One or more children	414	29.2	56.3	10.9	3.6	44.1	42.2	11.1	2.6
		(27.9, 30.5)	(54.9, 57.7)	(10.0, 11.8)	(3.1, 4.1)	(42.6, 45.6)	(40.8, 43.6)	(10.2, 12.0)	(2.1, 3.1)
Not living with children	7,366	15.8	49.9	23.4	10.8	15.9	43.3	27.7	13.1
		(14.7, 16.9)	(48.4, 51.4)	(22.2, 24.6)	(9.9, 11.7)	(14.8, 17.0)	(41.9, 44.7)	(26.4, 29.0)	(12.1, 14.1)
Consumed illicit drugs in the past 12 months*†									
No	5,102	22.6	55.1	17.0	5.3	40.0	41.8	13.5	4.7
		(21.4, 23.8)	(53.6, 56.6)	(15.9, 18.1)	(4.6, 6.0)	(38.6, 41.4)	(40.4, 43.2)	(12.5, 14.5)	(4.1, 5.3)
Yes	2,697	5.1	40.9	33.8	20.1	32.2	43.0	18.1	6.7
		(4.5, 5.7)	(39.5, 42.3)	(32.4, 35.2)	(18.9, 21.3)	(30.8, 33.6)	(41.6, 44.4)	(17.0, 19.2)	(6.0, 7.4)
Deliberate self-harm in the past 12 months*									
No	6,898	16.7	50.7	22.6	10.0	34.5	42.8	16.6	6.1
		(15.6, 17.8)	(49.2, 52.2)	(21.4, 23.8)	(9.1, 10.9)	(33.1, 35.9)	(41.4, 44.2)	(15.5, 17.7)	(5.4, 6.8)
Yes	891	15.8	46.4	24.0	13.8	33.1	41.3	18.2	7.4
		(14.7, 16.9)	(44.9, 47.9)	(22.8, 25.2)	(12.8, 14.8)	(31.7, 34.5)	(39.9, 42.7)	(17.1, 19.3)	(6.6, 8.2)

Notes:

** p<0.01 based on Pearson's chi-square test against HED frequency*

† p<0.01 based on Pearson's chi-square test against pre-loading frequency

Percentages may not sum to 100 due to missing data

of the three adverse outcomes (Models 4–6, Table 3), with weekly pre-loading observed to increase the risk by 3-fold (for vomiting) up to 9-fold (for injury). Results from unadjusted models showed similar relationships, with the inclusion of demographics and health risk behaviours attenuating the prevalence ratios (see Supplementary Tables 1–9 for full results for the unadjusted and fully-adjusted estimates for all models).

Models 7–9 (Table 4), where a variable representing the combined levels of HED and pre-loading frequency (with the 'never' and 'less than monthly' groups collapsed together) was the main predictor of interest, showed all levels of combined consumption behaviour to have statistically significant higher prevalences than the lowest frequency consumption group (i.e. 'less than monthly' frequencies of both behaviours). This was consistent across the three outcomes.

Across all three outcomes, when using the highest frequency consumption group (i.e. weekly HED and weekly pre-loading) as the reference group (Models 7–9, Table 4), weekly HED and less than monthly pre-loading was associated with significantly lower prevalences of memory loss (PR=0.84 [0.71, 0.97]) and injury (PR=0.71 [0.53, 0.91]) and a borderline significant lower prevalence of vomiting (PR=0.88 [0.75, 1.00]). Less than monthly HED and weekly pre-loading was not associated with a significant reduction in the prevalence of the adverse events (vomiting: PR=0.95 [0.65, 1.12]; memory loss: PR=0.79 [0.45, 1.09]; injury: PR=0.73 [0.31, 1.24]).

Discussion

Both HED and pre-loading with alcohol were found to be common drinking behaviours among the young (i.e. aged 20–25 years) women in this study, with more than 80% of participants reporting HED and nearly two-thirds reporting pre-loading. More than half of these young Australian women reported experiencing an adverse alcohol-induced event, with the most common event being vomiting. Not surprisingly, the two drinking behaviours were moderately correlated. However, the risk of alcohol-related harm was not fully accounted for by HED alone, as a reduction in the frequency of pre-loading behaviour to less than monthly significantly reduced the risk of adverse harm for those who partook in HED on a weekly basis. Interestingly, the same could not be said for a reduction in HED to less than monthly when pre-loading continued at a weekly rate. The inability to detect an effect in this latter combination group (HED less than monthly/pre-loading weekly) may be due to the limited number of participants in the group.

The prevalence of HED among 20–25-year-old women who consume any alcohol measured in this study is higher than the 65% reported for women aged 18–24 in the most recent Australian National Health Survey.[7] However, slight variations in age and other demographics, and differences in methods used to measure HED could contribute to the higher prevalence reported in the current study. Specifically, the National Health Survey conducts face-to-face household interviews, where other household members may be present, so there may be a higher likelihood of underreporting due to higher social desirability bias compared to the ALSWH self-administered online survey.[36] In addition to providing an alternative national estimate of HED for young Australian women, this study also provides a first glimpse of their pre-loading behaviour at a national level. The 65% prevalence of pre-loading in this study corresponds with previous research based on specific geographical samples across Australia that have reported around 50–80% of Australians pre-load with alcohol.[15-18,20]

Not surprisingly, each increase in the frequency of HED or pre-loading resulted in an increased prevalence of harm across all three of the adverse events, as the more often one partakes in risky behaviour the more likely it is that an adverse event is experienced. Most notably, participants who reported HED weekly had a prevalence ratio of self-injury nearly thirty times greater than that of participants who never reported HED. The prevalence of self-injury was also nine

times that of women who never pre-loaded for young women who reported pre-loading weekly.

Previous work has indicated a positive relationship between pre-loading and heavy episodic drinking, noting that pre-loading is associated with intoxication and adverse harm.[9,37] This study expands on this relationship by looking at the combination of the frequency of these two drinking behaviours in relation to harm. Specifically, of the young women who already drank above alcohol guidelines for risk of harm on a single occasion (HED) on a weekly basis, those who pre-loaded less than monthly (compared to those pre-loading weekly) had reduced prevalence of an alcohol-induced adverse event. The findings additionally indicate that high frequency of pre-loading and low frequency of HED is not any different to high frequency of pre-loading and high frequency of HED when looking at the prevalence of the adverse outcomes. These initial findings suggest that pre-loading may influence the adverse outcomes in addition to HED and that the association of pre-loading and experiencing alcohol-induced vomiting, memory loss or injury cannot be solely accounted for by the moderate correlation between pre-loading and HED. This study adds to the existing literature on the harms of HED[2,3] by providing a preliminary investigation into the potential additional risk that pre-loading may be placing on young Australian women. Pre-loading with alcohol needs to be considered in addition to HED when looking at strategies to minimise risk of harm.

Table 3: Prevalence ratio estimates for adverse alcohol-induced events within past 12 months among young Australian women (aged 20-25 years), according to frequency of HED or alcohol pre-loading adjusted for sociodemographic factors and health risk behaviours

Drinking behaviour over past 12 months	Adverse alcohol-induced events within past 12 months (outcomes)[b]		
	Vomited (Ever vs. Never) PR (99% CI)	Memory loss (Ever vs. Never) PR (99% CI)	Injury (Ever vs. Never) PR (99% CI)
HED[a] (n=7,569)	Model 1	Model 2	Model 3
Never	ref	ref	ref
Less than monthly	4.57 (3.62, 5.91)*	6.67 (4.55, 10.33)*	8.02 (4.21, 18.01)*
Monthly	6.90 (5.45, 8.93)*	14.40 (9.84, 22.27)*	19.44 (10.22, 43.63)*
Weekly	7.56 (5.95, 9.80)*	18.10 (12.33, 28.05)*	29.44 (15.41, 66.24)*
Alcohol Pre-loading[a] (n=7,569)	Model 4	Model 5	Model 6
Never	ref	ref	ref
Less than monthly	2.33 (2.09, 2.61)*	2.71 (2.31, 3.21)*	3.39 (2.58, 4.54)*
Monthly	3.07 (2.73, 3.46)*	4.98 (4.23, 5.90)*	6.67 (5.04, 8.98)*
Weekly	3.37 (2.96, 3.83)*	5.59 (4.70, 6.68)*	9.19 (6.86, 12.50)*

Notes:

PR = prevalence ratio; CI = confidence interval

a: Models adjusted for sociodemographic factors and health risk behaviours: area of residence, education level, current studying status, current working status, ability to manage on income and relationship status, whether the person is living with children, whether the person is living with parents, current smoking status, physical activity, illicit drug consumption, deliberate self-harm.

b: Within the past 12 months

** p<0.01*

Limitations

Further investigation is required to assess the interaction and cumulative effects of HED and pre-loading. Even with a relatively large sample size, due to the correlation between HED and pre-loading behaviours it is difficult to test for interaction effects and thus assess additional levels of risk faced by people who do not partake in HED but do pre-load. However, this study does provide some preliminary results as to how the combination of the frequencies of these two drinking behaviours may be contributing to risk of harm on a single occasion. The ALSWH questions ask about usual alcohol consumption and alcohol-related outcomes

Table 4: Prevalence ratio estimates for adverse alcohol-induced events within past 12 months among young Australian women (aged 20-25 years), according to combination of HED and alcohol pre-loading adjusted for sociodemographic factors and health risk behaviours (n=7,569).

HED & pre-loading combinations[a]		Adverse alcohol-induced events (outcomes)[b]					
		Vomited (Ever vs. Never) PR (99% CI) Model 7		Memory loss (Ever vs. Never) PR (99% CI) Model 8		Injury (Ever vs. Never) PR (99% CI) Model 9	
HED frequency	Pre-load frequency	Lowest consumption as reference[c]	Highest consumption as reference[d]	Lowest consumption as reference[c]	Highest consumption as reference[d]	Lowest consumption as reference[c]	Highest consumption as reference[d]
< Monthly	< Monthly	ref	0.46 (0.41, 0.50)*	ref	0.26 (0.23, 0.29)*	ref	0.17 (0.14, 0.21)*
< Monthly	Monthly	1.62 (1.35, 1.89)*	0.74 (0.61, 0.86)*	2.38 (1.89, 2.92)*	0.61 (0.49, 0.75)*	2.79 (1.88, 3.93)*	0.47 (0.32, 0.66)*
< Monthly	Weekly	2.09 (1.43, 2.49)*	0.95 (0.65, 1.12)	3.08 (1.77, 4.28)*	0.79 (0.45, 1.09)	4.31 (1.80, 7.42)*	0.73 (0.31, 1.24)
Monthly	< Monthly	1.72 (1.56, 1.89)*	0.79 (0.71, 0.87)*	2.40 (2.09, 2.74)*	0.62 (0.54, 0.70)*	2.68 (2.13, 3.37)*	0.46 (0.36, 0.57)*
Monthly	Monthly	2.05 (1.87, 2.23)*	0.93 (0.86, 1.01)	3.37 (3.00, 3.79)*	0.87 (0.79, 0.96)*	3.90 (3.18, 4.78)*	0.66 (0.56, 0.79)*
Monthly	Weekly	2.10 (1.77, 2.40)*	0.96 (0.81, 1.09)	3.40 (2.74, 4.07)*	0.87 (0.71, 1.03)	4.52 (3.12, 6.21)*	0.77 (0.54, 1.03)
Weekly	< Monthly	1.93 (1.65, 2.20)*	0.88 (0.75, 1.00)	3.28 (2.73, 3.84)*	0.84 (0.71, 0.97)*	4.15 (3.06, 5.45)*	0.71 (0.53, 0.91)*
Weekly	Monthly	2.03 (1.80, 2.27)*	0.92 (0.82, 1.03)	3.74 (3.25, 4.27)*	0.96 (0.85, 1.07)	5.01 (3.92, 6.32)*	0.85 (0.69, 1.03)
Weekly	Weekly	2.20 (1.99, 2.41)*	ref	3.90 (3.43, 4.41)*	ref	5.87 (4.77, 7.22)*	ref

Notes:

PR = prevalence ratio; CI = confidence interval

a: Models adjusted for sociodemographic factors and health risk behaviours: area of residence, education level, current studying status, current working status, ability to manage on income and relationship status, whether the person is living with children, whether the person is living with parents, current smoking status, physical activity, illicit drug consumption, deliberate self-harm.

b: Within the past 12 months

c: Lowest consumption frequency being <monthly HED and <monthly pre-loading

d: Highest consumption frequency being weekly HED and weekly pre-loading

** p<0.01*

in the previous year, so it is not possible to analyse outcomes based on an individual occasion to associate levels of consumption directly with an adverse event. The presence of low numbers in some of the higher levels of HED and pre-loading leads to very wide confidence intervals around some modelling estimates.

Implications for public health

HED within Australia, particularly among young people, has been a major target of public health interventions. A number of powerful interventions have been venue-focused, such as a tax on the supply of alcoholic drinks, introducing early lockouts, and targeting venues that were linked to alcohol-related incidents.[38-40] In the case of pre-loading, such approaches have little impact as the alcohol is being consumed prior to entering licenced venues or events. If anything, such strategies could potentially lead to more people engaging in pre-drinking behaviour, as a Queensland study found that restricting alcohol sales in an entertainment district led to an increase in pre-loading and higher levels of intoxication when entering the entertainment district.[38] As pre-loading is predictive of higher overall consumption,[9] interventions that do not take potential changes to pre-loading into account could potentially increase risk of harm. The New South Wales Standing Committee recommended that more research was needed in relation to effective policy to address pre-loading, as policies aimed at increasing the cost of alcohol in venues may inadvertently be increasing pre-loading among young people who often report cost as a reason they pre-load.[25] Public health strategies aimed at reducing overall individual consumption, including pre-loading, and minimising alcohol-related harm are required in conjunction with venue-focused interventions. The effects of strategies to reduce alcohol consumption in licenced venues need to be evaluated for the unintended impacts on pre-loading in homes, parks or other unlicensed and unregulated locations. An overall approach to developing skills in reducing risk from drinking should also be employed using evidence-based measures such as community-based digital interventions or brief interventions from health professionals.[41,42]

Addressing harmful alcohol consumption through public health guidelines and interventions is a key strategy in mitigating the overall burdens alcohol places on society at large. To be effective, such guidelines and interventions need to be properly informed by the existing evidence base of nationally representative alcohol consumption patterns and the associated harms. Both policy and practice aimed at addressing adverse alcohol-related harm, particularly among young women, can use this broadly representative national data on the extent to which pre-loading exists among Australian women in their early-mid-twenties and how it increases the risk of harm, particularly among those already at risk from frequent HED. Without investigating and addressing pre-loading behaviours, alcohol consumption guidelines and public health interventions may be incomplete.

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Data accessibility

Data are available from the Australian Longitudinal Study on Women's Health website (http://alswh.org.au/how-to-access-the-data/alswh-data) for researchers who comply with the confidentiality requirements.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Table 1: Full log-binomial model estimates of PR's modelling ever vs. never drunk so much you threw up, with HED as the main predictor.

Supplementary Table 2: Full log-binomial model estimates of PR's modelling ever vs. never drunk so much you forgot what happened with HED as the main predictor.

Supplementary Table 3: Full log-binomial model estimates of PR's modelling ever vs. never drunk so much you injured yourself with HED as the main predictor.

Supplementary Table 4: Full log-binomial model estimates of PR's modelling ever vs. never drunk so much you threw up, with preloading as the main predictor.

Supplementary Table 5: Full log-binomial model estimates of PR's modelling ever vs. never drunk so much you forgot what happened with preloading as the main predictor.

Supplementary Table 6: Full log-binomial model estimates of PR's modelling ever vs. never drunk so much you injured yourself with preloading as the main predictor.

Supplementary Table 7: Full log-binomial model estimates of PR's modelling ever vs. never drunk so much you threw up, with combined alcohol consumption behaviour as main predictor.

Supplementary Table 8: Full log-binomial model estimates of PR's modelling ever vs. never drunk so much you forgot what happened, with combined alcohol consumption behaviour as main predictor.

Supplementary Table 9: Full log-binomial model estimates of PR's modelling ever vs. never drunk so much you injured yourself, with combined alcohol consumption behaviour as main predictor.