



**The persistence of adolescent binge drinking into adulthood: Findings from a 15-year prospective cohort study**

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# The persistence of adolescent binge drinking into adulthood: Findings from a 15-year prospective cohort study

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## Article summary

### Article focus

- Alcohol is a major source of preventable disease burden among young people.
- Although young people drink less often than adults, they may consume large amounts in a single session (“binge” drinking).
- We know little about the persistence of binge drinking in adolescence into young adulthood. We aimed to: 1) Examine the persistence of adolescent “binge” and “heavy binge” drinking from adolescence to young adulthood; 2) Examine which characteristics of adolescent binge drinkers predict the persistence of “binge” and “heavy binge” alcohol use into young adulthood.

### Key messages

- Half of the males and a third of females in a cohort of young Australians: reported past-week binge drinking in adolescence.
- The overwhelming majority of these adolescent binge drinkers continued to binge drink in young adulthood.
- Past-week binge drinking was reported in at least one young adulthood wave by around 70% of males and 48% of females who had not reported past-week binge drinking in adolescence.
- The high rate of persistence of binge drinking into adulthood indicates the need for policies to reduce its onset in adolescence such as limiting availability, increasing costs and discouraging drinking to intoxication.

### Strengths and limitations

- This well-conducted prospective study, with very high retention, has provided unique prospective data on the persistence of a prevalent and hazardous drinking pattern into adulthood.
- The following limitations do need to be acknowledged. First, non-response in longitudinal studies is often associated with alcohol and drug use. We used multiple imputation to minimise the impact of this potential bias. Second, our data do not capture the full extent of binge

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3 drinking in this cohort because not all binge alcohol use will have been captured within the one  
4 week reference period. Both of these limitations mean that if anything our findings on levels of  
5 binge drinking are conservative in estimating total exposure to these levels of drinking overall  
6 and over time.  
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- Third, all data were based on self-report, however there is reasonable evidence that young  
11 people's reports of alcohol use are both reliable and valid when reports are made in a  
12 confidential manner, and without any consequences for disclosing.  
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  - Fourth, we used the same definition of binge and heavy binge drinking in adolescent and young  
14 adults. It is likely that the same amount of alcohol will have a greater adverse impact on  
15 adolescents than on adults.  
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## Abstract

*Background:* Binge drinking in adolescence has become common in many countries but we know little about whether it persists into adulthood.

*Methods:* A 15-year prospective cohort study in Victoria, Australia. 1943 adolescents were recruited from secondary schools at age 14-15 years. Levels of past-week “binge” drinking (5+ standard drinks (SD) on a day, each 10g alcohol) and “heavy binge” drinking (20+ SD on a day for males, 11+ for females) were assessed during six adolescent waves, and across three adult waves up to age 29 years.

*Results:* Half of males (52%) and a third of females (34%) reported past-week binge drinking in adolescence. 90% of male and 70% of female adolescent-onset binge drinkers continued to binge drink into young adulthood. Seventy percent of males and 48% of females who were not adolescent-onset binge drinkers reported binge drinking in young adulthood. Past-week “heavy binge drinking”, reported by 19% of males and 15% females in adolescence, increased substantially in the young adult waves (38% males, 27% females in any adult wave). There was some evidence of a decline at 29 years. Among adolescent binge drinkers (n=821), young adult binge and heavy binge drinking were predicted by being male, adolescent antisocial behaviour, and adverse consequences of drinking in adolescence (intense drinking, physical harm, and sexual risk taking related to alcohol consumption).

*Conclusions:* Binge alcohol use is common and persistent among young Australians. Efforts to prevent the onset of binge drinking during adolescence may substantially reduce harmful patterns of alcohol use in young adulthood.

## Introduction

Alcohol is a major source of preventable disease burden among young people(1): it is thought to contribute to 320,000 deaths globally among 15-29 year olds each year, comprising 9% of all deaths in this group(2); the burden attributable to alcohol use as a risk factor among young people aged 15-29 years (20 million disability adjusted life years (DALYs)) is thought to account for one third of all global alcohol attributable burden (59 million DALYs)(3).

Alcohol use typically begins in adolescence(4, 5). Although young people drink less often than adults(4), they may consume larger amounts in a single session(6-8). Among school students across 14 European countries in 2011, 41% reported past-month “binge” drinking (5+ standard alcoholic drinks(9); levels in the United Kingdom were 54%(9). Similar drinking levels occur in young Australians(10). One in five Australian males and females 16-24 years report drinking 20+ and 11+ standard drinks in a session (each 10g alcohol), respectively, at least monthly in the past year(11).

We do not know a great deal about how persistent binge alcohol use in adolescence is because few longitudinal studies have examined its natural history from adolescence into adulthood(12). We investigated the persistence of binge drinking into adulthood using a 15-year prospective cohort study of young Australians that assessed alcohol use during adolescence and up to age 29 years.

We aimed to:

1. Examine the persistence of adolescent “binge” and “heavy binge” drinking from adolescence to young adulthood;
2. Examine which characteristics of adolescent binge drinkers predict the persistence of “binge” and “heavy binge” alcohol use into young adulthood.

## Methods

### Sample

Between August 1992 and 2007, we conducted nine waves of interviews with a cohort then resident in the state of Victoria, Australia (for more details see(13, 14)). At the beginning of the adolescent phase (waves 1-2) parental consent was obtained; in adult waves participants were informed in writing and gave verbal consent.

At baseline, a representative sample of the Victorian population of school pupils aged 14-15 years (year 9) was recruited. Retention in school to year 9 among Victorian young people in 1992-3 was 98%. A two-stage cluster sampling procedure was used, with two classes selected at random. Stage one, 45 schools were randomly chosen from a stratified frame of government, Catholic and independent private schools. Stage two, one class was selected at random from each participating school, entering in the last part of year 9 (wave 1), followed by a second class in the second wave six months later (wave 2). Participants were interviewed at 6-month intervals from 14-19 years (waves 3-6) with three waves in young adulthood: 20-21 years (wave 7), 24-25 years (wave 8), and 28-29 years (wave 9). In waves 1-6, participants self-administered the questionnaire on laptops, with telephone follow-up of those absent from school; waves 7-9 involved computer-assisted telephone interviews(15). From a total of 2032 students, 1943 (95.6%) participated at least once in adolescence (Figure 1); 1756 (53% female) participated in at least one adult wave and were known to be alive at wave 9; 1282 completed all three adult waves; 293 completed two, and 181 completed one. By the end of wave 9, nine participants were known to have died, 108 lost to follow-up and 319 refused participation; 1501 participants were interviewed, 1407 of whom did the full (1383) or part (24) interview schedule, and 94 a paper questionnaire. In this paper, we only used adolescent data from waves 2-6 as over half of the adolescents did not participate in wave 1.

**Figure 1 about here**

### Measures

#### *Alcohol consumption*

Alcohol consumption was recorded at all adolescent and adult phases in an alcohol diary by any participants who reporting drinking in the previous week. In the adolescent phase, respondents completed a seven-day alcohol diary. In the adult phase in order to minimise

respondent burden, participants were only asked to complete a four-day diary including all weekend days (Friday to Sunday) and the most recent weekday. Types of alcohol (beer, cider, spirits, mixed drinks, wine etc.), brand names, and the amounts consumed (glass, pint, bottle, can, etc.) were recorded. We calculated the number of standard drink (SD) units (10g alcohol) consumed on each day/occasion, and at each wave. Two measures of binge drinking were estimated (using the same definition in adolescent and adult phases).

- (1) *'Binge' drinking*: Defined (at each wave) as having drunk 5 or more SDs on at least one day during the diary week. *Any binge drinking* was defined in adolescence and adulthood as binge drinking on one or more adolescent waves. For each phase, we identified the number of waves of binge drinking: never, one wave and on two or more waves (in adolescence, 2+ of five assessment waves; in adulthood; 2+ of three waves). *Persistent binge drinking* was defined as binge drinking on two or more waves.
- (2) *'Heavy' binge drinking*: Defined as having drunk >20 SDs for males and  $\geq 11$  SDs for females on any day over the diary week(11). These levels were taken from a previous study of young people(11), using Australian National Health and Medical Research Council levels for "high risk" drinking for males and females. *Any 'heavy' binge drinking* in adolescence and adulthood was defined as having done so on any wave. The number of waves in each phase was identified as above. *Persistence of 'heavy' binge drinking* was defined as drinking to this level on two or more waves (adolescence, 2+ of five waves; adulthood; 2+ of three waves).

*Incident drinking* was defined as first reporting binge or heavy binge drinking in young adulthood. *Continuity of binge drinking* and of *heavy binge drinking* was defined as the same pattern of drinking in adolescence and also adulthood. *Discontinuity* was defined as adolescent binge or heavy binge drinking without binge/heavy binge drinking in young adulthood.

### ***Prognostic factors***

*Adolescent tobacco smoking* was assessed at each adolescent wave. Participants who reported smoking daily in the week prior to survey at any one adolescent wave were classified as daily smokers during adolescence.



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3 *Adolescent cannabis use* was assessed using reported frequency of use in the previous six  
4 months at each wave. Maximal cannabis use during the adolescent phases (i.e. most  
5 frequent level reported across any wave) was categorised as *none/occasional* and  
6 *daily/weekly*.  
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11 *Adolescent antisocial behaviour* was assessed using 10 items from the Moffitt and Silva self-  
12 report early delinquency scale(16) that assessed property damage, interpersonal conflict  
13 and theft. Participants were asked if they had engaged in any of these behaviours *never*,  
14 *once*, or *more than once* in the last 6 months. *Antisocial behaviour* was defined as any  
15 antisocial behaviour on more than one adolescent wave, and/or 2+ behaviours in the same  
16 wave.  
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22 *Early onset sexual behaviour:* participants were asked if they had ever had sex (“gone all the  
23 way” or had sexual intercourse) at each adolescence wave and their age of first sex at each  
24 young adulthood wave. Those reporting sexual activity before 16 years were classified as  
25 *early onset sexually active*.  
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31 *Adolescent mental health* was assessed using the Clinical Interview Schedule (CIS-R)(17),  
32 which assesses depression and anxiety in non-clinical populations; a cut-off of >11 defined a  
33 mixed depression-anxiety state requiring clinical intervention . Mental health problems  
34 were summarised as having occurred: never, in one, or 2+ adolescent waves.  
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39 *Adolescent alcohol-related consequences:* Eight questions were asked about problems  
40 related to alcohol over the past six months in all adolescent waves. These were categorised  
41 into four types of consequences: *intense drinking*, (drank so much that the next day couldn’t  
42 remember what you said/did); *alcohol-related social problems* (lost friends, had trouble at  
43 school, or argued with family, because of drinking); *alcohol-related injury, accident or*  
44 *violence* (violent and had a fight, or had an injury or an accident, because of drinking); and  
45 *alcohol-related sexual risk taking* (had sex without using contraceptives, had sex without  
46 using protection, or had sex and regretted it, because of drinking). For each of the four types  
47 of consequences, persistence in adolescence was defined as engaging in the behaviour  
48 either across multiple waves or more than once on one wave.  
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## 55 56 57 **Statistical Analysis** 58 59 60

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3 We calculated the prevalence at each wave and the number of waves of each type of binge  
4 drinking in adolescence and adulthood. We also estimated the continuity and discontinuity  
5 of binge and heavy binge drinking between the two phases. Among those reporting  
6 adolescent binge drinking, (n=821), logistic regression was used to investigate associations  
7 between adolescent predictors and any binge and heavy binge drinking in young adulthood.  
8 These associations were initially examined separately and then jointly in multivariable  
9 models. Interactions between the adolescent predictors and sex were examined in the  
10 multivariable models but evidence for differential sex effects was weak. In order to retain  
11 information from individuals with incomplete data (and thereby minimise the effects of  
12 participation bias), the prevalence of binge and heavy binge drinking during both adolescent  
13 and young adult phases was estimated using multiple imputation(18, 19) (see online  
14 **appendix**). All data analysis was undertaken using Stata 12(20).

#### 25 **Ethics**

26 The Ethics in Human Research Committee of the Royal Children's Hospital, Melbourne  
27 approved all data collection protocols.  
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#### 31 **Role of the funding source**

32 Funding to support the work for this manuscript was provided by Australian Rotary Health.  
33 Data collection for this study was supported by the National Health and Medical Research  
34 Council, Australia and the operational infrastructure support programme, Government of  
35 Victoria, Australia. The funders had no role in design, data collection or analysis, data  
36 interpretation, writing of the article or decision to publish. The corresponding author had  
37 full access to all the data in the study and had final responsibility for the decision to submit  
38 for publication.  
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## Results

The analysis utilised data from waves 2 to 9 for all participants (n=1934) who completed the survey at least once in adolescence (waves 2-6) and were alive at wave 9, with multiple imputation used for incomplete records. The results from complete case analyses are presented in the **online appendix** to show that there were no appreciable differences in the pattern of results compared to the imputed data.

### Past-week Binge Drinking

Past-week binge drinking (5+ SDs of 10g alcohol on a day) across adolescence (Figure 2a) increased for males from 14.4% in wave 2 (mean age 15.5years) to 31.1% in wave 6 (17.4yrs) and for females from 7.6% to 15.0%. Persistent adolescent past-week binge drinking (across 2+ adolescent waves) was reported by one in three males (31.8%) and one in seven females (15.3%; Table 1a). In the adulthood waves, the prevalence of binge drinking was higher for males and females than in the adolescent phase and levels for males were higher than females. In adulthood (Table 1a, Figure 2a), over eighty per cent of males reported binge drinking on at least one adult wave and more than half of females did so. Six in ten (59.1%) males and one in four (24.5%) females reported binge drinking across multiple adult waves (Table 1a).

Only 15% of males and a third of females reported that they did not binge drink during adolescence or young adulthood. Almost seven in eight males and two thirds of females reported binge drinking in the last week on at least one wave in adolescence and young adulthood. Nearly half of males and a quarter of females did so in adolescence *and* young adulthood. The overwhelming majority of adolescent-onset binge drinkers (nine in ten male and seven in ten female adolescent-onset binge drinkers) continued to binge drink in young adulthood (Table 1a). The number of binge drinkers was increased by incident binge drinking young adults who did not report binge drinking in adolescence: one third of males and females. Only 4.4% of males and 9.5% females who were adolescent binge drinkers did not report binge drinking in adulthood.

**Figure 2a and 2b about here**

### Past-week Heavy Binge Drinking

During adolescence, males and females reported similar levels of heavy binge use at each wave but males (7.9%) were more likely to persist in heavy binge drinking than females (4.7%; Table 1b). Past-week heavy binge drinking did not increase substantially until the young adult waves (Figure 2b). Around two in five males and one in four females reported past-week heavy binge drinking on at least one adult wave (Table 1b). At ages 20 and 24 years, around 20% of males and 13% of females reported heavy binge drinking. There was a decline in past-week heavy binge drinking by age 29 years.

Just under half of the males (45.6%) and a third of females (36.2%) reported past-week heavy binge drinking at least once during adolescence or young adulthood (Table 1b). Sixty one percent of males and 42% of females who reported heavy binge drinking in adolescence, continued into young adulthood (Table 1b). Of those who engaged in heavy binge drinking at some point, 58% first reported doing so in young adulthood.

#### Table 1a and 1b about here

#### *Young adult binge and heavy binge alcohol use among adolescent-onset binge drinkers*

Levels of past-week binge and heavy binge drinking in adulthood, among adolescent-onset binge and heavy binge drinkers, are presented in Figure 3. Males with adolescent-onset binge drinking were more likely to continue binge drinking in adulthood than females (Figure 3a): around seven in ten males reported doing so, compared to fewer than half of females. By 29 years, female adolescent-onset binge drinkers had substantially lower levels of binge drinking than in earlier waves, and much lower levels than males. Levels of adult heavy binge drinking did not differ markedly by sex among adolescent-onset binge drinkers; around 20-30% reported past-week heavy binge drinking at ages 20 and 24, with lower levels at 29 years (wave 9; Figure 3a). Among adolescent-onset heavy binge drinkers, the patterns and levels followed a similar sex pattern to that in adolescent-onset binge drinkers (Figure 3b).

#### Figure 3a and 3b about here

Table 2 presents the characteristics that predicted binge and heavy binge drinking at any adult wave in adolescent-onset binge drinkers (n=821). At a univariate level, among adolescent-onset binge drinkers, those who were male and with adolescent antisocial

behaviour were more likely to report young adult binge and heavy binge drinking in the past week. Among adolescent binge drinkers, those who reported negative consequences of alcohol use in adolescence were more likely to report adult binge and heavy binge alcohol use. Adolescent binge drinkers who reported early onset sexual activity and weekly/daily adolescent cannabis use also had higher odds of adult heavy binge drinking. In multivariable analyses that included all covariates, female binge drinkers had lower odds than males of adult binge (OR 0.23, 95%CI 0.13-0.40) and heavy binge use (OR 0.63, 95%CI 0.43-0.92). Additionally, for heavy binge use, there was an increased risk if sexual risk taking had occurred in adolescence.

**Table 2 about here**

## Discussion

To our knowledge this is one of few longitudinal studies charting the persistence of binge use of alcohol from adolescence into young adulthood(12). Consistent with cross-sectional surveys in England(21), the USA, and Europe(5, 9), we found binge drinking was highly prevalent in both sexes and normative in young Australian males. A substantial minority also engaged in a heavy binge drinking (drinking more than 20 drinks on an occasion). Over half of males and a third of females reported binge drinking in the past week at some time during adolescence, and one in five males and one in seven females reported what we defined as "heavy binge drinking".

The overwhelming majority of those who reported binge drinking in adolescence continued to do so in young adulthood. Even if past-week binge drinking was not reported in the teens, it was reported in at least one wave in young adulthood by 70% of males and 48% of females who did not report binge drinking at any time in adolescence.

Among those who reported binge drinking in adolescence, variables that predicted binge and heavy binge drinking in young adulthood included: regular (weekly+) cannabis use, antisocial behaviour, and early onset sexual activity. The most consistent predictors of both adult binge and heavy binge drinking were reporting adverse consequences of alcohol use in adolescence, namely "intense drinking" (could not remember the night before because of drinking), social problems, sexual risk taking and physical harm. Adolescent binge drinkers who engaged in other risky behaviours, and who had experienced negative consequences of alcohol use, were most likely to continue drinking at these levels in adulthood. At a multivariate level, the strongest predictor of adult binge drinking among adolescent binge drinkers was being male.

These patterns of binge drinking in adolescence are a public health concern for two reasons. First, heavy alcohol use substantially increases the risks of: motor vehicle accidents, other injuries, alcohol-related assaults, and suicides in young people(22). Secondly the longer-term health effects of persistent binge drinking include: alcohol dependence, liver disease and cancer. In most adolescent binge drinkers, binge drinking was clearly not just an "adolescent phase"; it was a pattern persisted into young adulthood. There is an urgent

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3 need to understand why such high levels of alcohol use in adolescence continue into young  
4 adulthood.  
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7 Social acceptability, ready availability and low cost of alcohol are likely important drivers of  
8 early initiation and continuing high levels of consumption. Both the taste(23) and  
9 packaging(24) of pre-mixed drinks are particularly attractive to young people; exposure to  
10 some forms of advertising is also associated with increased consumption(25), as are  
11 increased numbers of outlets selling alcohol(26-28), extended opening hours(29, 30), and  
12 reduced alcohol taxes(29, 31) (though only applied similarly across products(32)). The  
13 *persistence* of binge drinking into young adulthood may also be related to a delay in  
14 'maturing out' of drinking as a result of the postponement of major social role transitions  
15 such as marriage and parenthood into later adulthood(33).  
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### 24 **Limitations**

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26 The following limitations need to be acknowledged. First, non-response in longitudinal  
27 studies is often associated with alcohol and drug use. We used multiple imputation to  
28 minimise the impact of this potential bias, but this method carries its own assumptions and  
29 it is difficult to assess exactly how much residual bias might remain. The method of multiple  
30 imputation assumes that data were missing at random, an assumption that is strengthened  
31 by the inclusion of auxiliary variables in the imputation model, but this assumption is  
32 unlikely to be true.  
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36 Second, our data do not capture the full extent of binge drinking in this cohort because not  
37 all binge alcohol use will have been captured within the one week reference period. Both of  
38 these limitations mean that if anything our findings on levels of binge drinking are  
39 conservative in estimating total exposure to these levels of drinking overall and over time.  
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43 Third, all data were based on self-report. There is reasonable evidence for that young  
44 people's reports of alcohol use are both reliable and valid when reports are made in a  
45 confidential manner, and without any consequences for disclosing use (as was the case  
46 here)(34, 35).  
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50 Fourth, we used the same definition of binge and heavy binge drinking in adolescent and  
51 young adults. It is likely that the same amount of alcohol will have a greater adverse impact  
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3 on adolescents than on adults. Notwithstanding these limitations, this study has provided  
4 unique prospective data on the persistence of a prevalent and hazardous drinking pattern  
5 into adulthood.  
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### 8 9 **Conclusions**

10 Alcohol is one of the biggest risk factors for disease burden among young people. Heavy  
11 consumption in young people is common and persistence into young adulthood is much  
12 more likely than not. The adoption of policies and interventions to reduce availability,  
13 increase costs and discourage drinking to intoxication are urgently needed.  
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## Author contributions

LD, GP, WS and CO'L conceived of the study. CO'L and HR conducted the analyses. LD led the writing of the manuscript. All authors commented on the analytic plan, interpretation, and contributed to the editing and final approval of the manuscript.

## Competing Interests

None

## Data sharing

Raw data are not available. However requests for additional information may be directed to LD and GP.

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8 **Figure 1: Sampling and ascertainment in the Victorian Adolescent Health Cohort, 1992 to 2008**  
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10 **Figure 2a: Levels of past week binge alcohol use among males and females (5 or more standard drinks on a day in the past week) by age**  
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12 **Figure 2b: Levels of past week "heavy binge" alcohol use among males and females (11 or more standard drinks on a day in the past week for females, 20 or more for males) by age**  
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15 **Figure 3a: Levels of past week binge and "heavy binge" drinking for males and females who reported binge drinking at one or more waves in adolescence, by age**  
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19 **Figure 3b: Levels of past week binge and "heavy binge" drinking for males and females who reported "heavy binge" drinking at one or more wave in adolescence, by age**  
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Table 1a. Past week binge drinking during adolescence and young adulthood, by sex

|   | Binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                   |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                               | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 135                             | 14.4 | (12.1 - 16.7) | 76              | 7.6  | (5.90 - 9.30) | 211            | 10.9 | (9.50 - 12.3) |
| Wave 3 (mean age 15.9 years)  | 170                             | 18.1 | (15.5 - 20.7) | 96              | 9.6  | (7.50 - 11.7) | 265            | 13.7 | (12.1 - 15.4) |
| Wave 4 (mean age 16.4 years)  | 208                             | 22.3 | (19.3 - 25.3) | 140             | 14.1 | (11.8 - 16.3) | 349            | 18.0 | (16.2 - 19.9) |
| Wave 5 (mean age 16.8 years)  | 265                             | 28.3 | (25.1 - 31.5) | 152             | 15.2 | (12.9 - 17.6) | 417            | 21.6 | (19.6 - 23.5) |
| Wave 6 (mean age 17.4 years)  | 291                             | 31.1 | (28.0 - 34.3) | 150             | 15.0 | (12.6 - 17.4) | 441            | 22.8 | (20.8 - 24.8) |
| <b>Number of adolescent waves of any binge drinking</b>   |                                 |      |               |                 |      |               |                |      |               |
| Never   | 453                             | 48.5 | (45.0 - 52.0) | 660             | 66.1 | (63.0 - 69.1) | 1113           | 57.6 | (55.2 - 60.0) |
| 1 wave  | 184                             | 19.7 | (16.8 - 22.6) | 186             | 18.6 | (16.0 - 21.2) | 370            | 19.1 | (17.1 - 21.1) |
| 2+ waves  | 297                             | 31.8 | (28.5 - 35.1) | 153             | 15.3 | (13.0 - 17.7) | 451            | 23.3 | (21.3 - 25.3) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 509                             | 54.5 | (51.1 - 57.9) | 318             | 31.8 | (28.7 - 34.9) | 827            | 42.8 | (40.4 - 45.1) |
| Wave 8 (mean age 24.1 years)  | 550                             | 58.8 | (55.2 - 62.4) | 335             | 33.5 | (30.3 - 36.7) | 885            | 45.8 | (43.3 - 48.2) |
| Wave 9 (mean age 29.0 years)  | 524                             | 56.1 | (52.3 - 59.8) | 233             | 23.3 | (20.2 - 26.4) | 757            | 39.2 | (36.6 - 41.8) |
| <b>Number of adult waves of any binge drinking</b>  |                                 |      |               |                 |      |               |                |      |               |
| Never   | 178                             | 19.1 | (16.2 - 21.9) | 437             | 43.8 | (40.4 - 47.1) | 616            | 31.8 | (29.6 - 34.1) |
| 1 wave  | 204                             | 21.8 | (18.9 - 24.8) | 316             | 31.7 | (28.4 - 35.0) | 521            | 26.9 | (24.7 - 29.1) |
| 2+ waves  | 552                             | 59.1 | (55.7 - 62.5) | 245             | 24.5 | (21.5 - 27.6) | 798            | 41.2 | (38.8 - 43.7) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                 |      |               |                 |      |               |                |      |               |
| None in either phase  | 137                             | 14.7 | (12.2 - 17.2) | 342             | 34.2 | (31.0 - 37.5) | 479            | 24.8 | (22.7 - 26.9) |
| Incident in young adulthood   | 316                             | 33.8 | (30.3 - 37.3) | 318             | 31.9 | (28.7 - 35.0) | 634            | 32.8 | (30.4 - 35.2) |
| Remitted by young adulthood (adolescence only)  | 41                              | 4.4  | (2.80 - 6.00) | 95              | 9.5  | (7.50 - 11.6) | 136            | 7.1  | (5.80 - 8.30) |
| Continuing in young adulthood (both phases)   | 441                             | 47.1 | (43.5 - 50.7) | 244             | 24.4 | (21.6 - 27.2) | 684            | 35.4 | (33.1 - 37.7) |

Note: "Binge" drinking defined as 5 or more drinks in one day in the past week.

Table 1b. Past week heavy binge drinking during adolescence and young adulthood, by sex

|   | Heavy binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                         |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                                     | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 44                                    | 4.8  | (3.40 - 6.10) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.80) |
| Wave 3 (mean age 15.9 years)  | 45                                    | 4.8  | (3.40 - 6.20) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.90) |
| Wave 4 (mean age 16.4 years)  | 49                                    | 5.2  | (3.70 - 6.70) | 54              | 5.4  | (4.00 - 6.90) | 103            | 5.3  | (4.30 - 6.30) |
| Wave 5 (mean age 16.8 years)  | 79                                    | 8.5  | (6.40 - 10.5) | 66              | 6.6  | (5.00 - 8.10) | 145            | 7.5  | (6.20 - 8.80) |
| Wave 6 (mean age 17.4 years)  | 67                                    | 7.1  | (5.20 - 9.00) | 38              | 3.8  | (2.60 - 5.00) | 105            | 5.4  | (4.30 - 6.50) |
| <b>Number of adolescent waves of any heavy binge drinking</b>                                   |                                       |      |               |                 |      |               |                |      |               |
| Never   | 755                                   | 80.7 | (78.1 - 83.4) | 847             | 84.7 | (82.5 - 87.0) | 1601           | 82.8 | (81.1 - 84.5) |
| 1 wave  | 106                                   | 11.4 | (9.10 - 13.6) | 106             | 10.6 | (8.60 - 12.5) | 212            | 11.0 | (9.50 - 12.4) |
| 2+ waves  | 74                                    | 7.9  | (6.10 - 9.70) | 47              | 4.7  | (3.30 - 6.00) | 121            | 6.2  | (5.10 - 7.30) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 177                                   | 18.9 | (16.3 - 21.6) | 134             | 13.4 | (11.2 - 15.6) | 311            | 16.1 | (14.4 - 17.8) |
| Wave 8 (mean age 24.1 years)  | 201                                   | 21.4 | (18.7 - 24.2) | 135             | 13.5 | (11.3 - 15.8) | 336            | 17.4 | (15.6 - 19.1) |
| Wave 9 (mean age 29.0 years)  | 132                                   | 14.1 | (11.4 - 16.7) | 78              | 7.8  | (6.10 - 9.60) | 210            | 10.8 | (9.30 - 12.4) |
| <b>Number of adult waves of any heavy binge drinking</b>  |                                       |      |               |                 |      |               |                |      |               |
| Never   | 579                                   | 62   | (58.7 - 65.3) | 726             | 72.7 | (69.7 - 75.6) | 1305           | 67.5 | (65.2 - 69.7) |
| 1 wave  | 230                                   | 24.6 | (21.4 - 27.8) | 212             | 21.2 | (18.5 - 23.9) | 442            | 22.8 | (20.7 - 25.0) |
| 2+ waves  | 125                                   | 13.4 | (10.9 - 15.9) | 62              | 6.2  | (4.60 - 7.70) | 187            | 9.7  | (8.20 - 11.1) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                       |      |               |                 |      |               |                |      |               |
| None in either phase  | 508                                   | 54.4 | (50.9 - 57.8) | 638             | 63.8 | (60.7 - 66.9) | 1146           | 59.2 | (56.9 - 61.6) |
| Incident in young adulthood   | 247                                   | 26.4 | (23.3 - 29.5) | 209             | 20.9 | (18.3 - 23.5) | 456            | 23.6 | (21.5 - 25.6) |
| Remitted by young adulthood (adolescence only)  | 71                                    | 7.6  | (5.80 - 9.50) | 88              | 8.8  | (7.00 - 10.7) | 160            | 8.2  | (6.90 - 9.60) |
| Continuing in young adulthood (both phases)   | 109                                   | 11.6 | (9.30 - 14.0) | 64              | 6.4  | (4.80 - 8.10) | 173            | 9.0  | (7.60 - 10.3) |

Note: *Persistent "heavy binge" drinking* in adolescence defined as heavy binge drinking in the past week on two or more waves across the adolescent waves (waves 2 to 6).

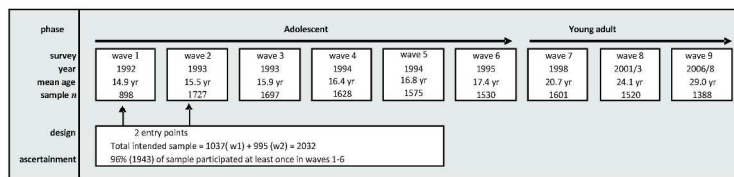
**Table 2: Predictors of binge alcohol use in young adulthood among adolescent “binge” alcohol drinkers****(i.e. those who had past-week binge drinking on at least one wave during adolescence, waves 2-6; n=821)**

| Adolescent predictors among adolescent ‘binge’ drinkers, n=821: | Young adult ‘binge’ drinking |               |          |               | Young adult ‘heavy binge’ drinking |               |          |               |
|---|------------------------------|---------------|----------|---------------|------------------------------------|---------------|----------|---------------|
|   | Univariate                   |               | Adjusted |               | Univariate                         |               | Adjusted |               |
|   | OR                           | (95% CI)      | OR       | (95% CI)      | OR                                 | (95% CI)      | OR       | (95% CI)      |
| <b>Female</b>   | 0.24                         | (0.15 - 0.39) | 0.23     | (0.13 - 0.40) | 0.67                               | (0.49 - 0.92) | 0.63     | (0.43 - 0.92) |
| <b>Daily smoking</b>  | 1.20                         | (0.79 - 1.81) | 1.12     | (0.69 - 1.82) | 1.29                               | (0.94 - 1.77) | 1.01     | (0.70 - 1.46) |
| <b>Weekly/daily cannabis use</b>                                | 1.65                         | (0.96 - 2.82) | 1.05     | (0.54 - 2.03) | 1.57                               | (1.11 - 2.24) | 1.06     | (0.71 - 1.60) |
| <b>Antisocial behaviour</b>                                     | 1.70                         | (1.12 - 2.59) | 0.99     | (0.60 - 1.63) | 1.59                               | (1.16 - 2.18) | 1.06     | (0.74 - 1.52) |
| <b>Early onset sexual activity (&lt;16 years)</b>               | 1.46                         | (0.92 - 2.33) | 1.04     | (0.60 - 1.83) | 1.53                               | (1.09 - 2.14) | 1.02     | (0.69 - 1.49) |
| <b>Adolescent mental health problems</b>                        |                              |               |          |               |                                    |               |          |               |
| CIS >11, 0 waves  | 1                            |               | 1        |               | 1                                  |               | 1        |               |
| CIS >11, 1 wave   | 0.81                         | (0.42 - 1.57) | 0.90     | (0.44 - 1.81) | 1.23                               | (0.81 - 1.87) | 1.15     | (0.74 - 1.77) |
| CIS >11, 2+ waves   | 0.60                         | (0.37 - 0.97) | 0.83     | (0.48 - 1.46) | 1.05                               | (0.74 - 1.49) | 0.99     | (0.64 - 1.52) |
| <b>Adolescent consequences attributed to alcohol use</b>        |                              |               |          |               |                                    |               |          |               |
| Intense drinking <sup>1</sup>                                   | 1.54                         | (1.00 - 2.36) | 1.45     | (0.84 - 2.50) | 1.77                               | (1.28 - 2.43) | 1.41     | (0.99 - 2.00) |
| Social problems <sup>2</sup>                                    | 1.34                         | (0.85 - 2.10) | 1.25     | (0.72 - 2.18) | 1.63                               | (1.16 - 2.31) | 1.23     | (0.83 - 1.83) |
| Physical harm <sup>3</sup>                                      | 1.92                         | (1.13 - 3.26) | 1.25     | (0.64 - 2.44) | 1.96                               | (1.37 - 2.81) | 1.29     | (0.84 - 1.96) |
| Sexual risk taking <sup>4</sup>                                 | 1.75                         | (1.01 - 3.03) | 1.51     | (0.77 - 2.97) | 2.09                               | (1.44 - 3.03) | 1.64     | (1.07 - 2.53) |

<sup>1</sup> Couldn't remember what said or did the night before as a result of alcohol use<sup>2</sup> Lost friends, school trouble, argued with family as a result of alcohol use<sup>3</sup> Injuries, accidents, violence attributed to their alcohol use<sup>4</sup> Regretted having sex, or had sex without protection or contraceptives as a result of alcohol use



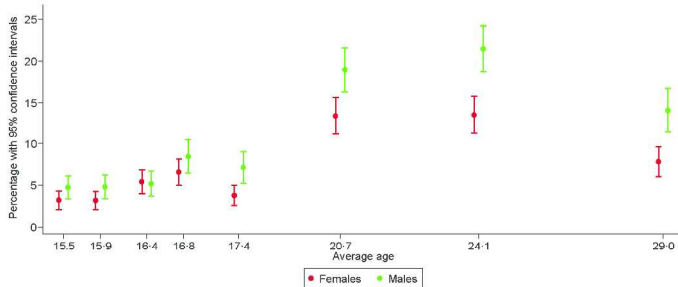
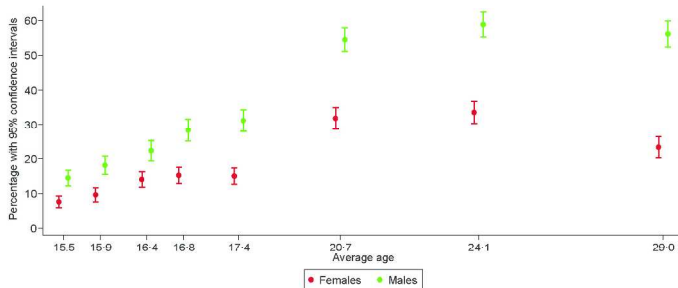
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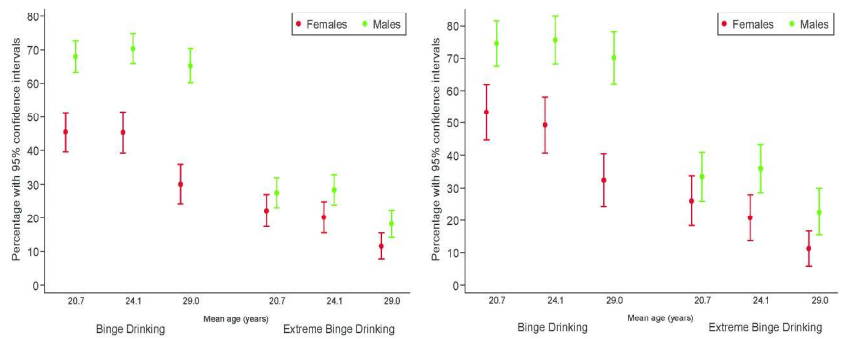
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Note: Binge drinking defined as 5 or more drinks in one day in the past week. Heavy binge drinking defined as 11+ drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

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## Online appendix: Approach to multiple imputation

Missing data were handled using multiple imputation<sup>1</sup>. We imputed 20 complete datasets separately for males and females, under a multivariate normal model, incorporating all the analysis and auxiliary variables at each wave, except age and sexual risk-taking in adolescence, which was imputed as a binary summary measure. Wave 1 was omitted as it contained observations from only 46% of the cohort. Wave 1 responses were used to fill in wave 2 data, for any participant not seen at wave 2 as the same measures had been collected at the earlier wave. Waves 2 to 9 were imputed for all participants (N=1943) who completed the survey at least once in adolescence (waves 2-6). The imputation model contained 49 key variables used in the analysis and 8 auxiliary variables. Of 57 variables included in the imputation model, 18% of the variables had <10% missing values, 46% had ≥10% to <20% missing, 28% had ≥20% to <30% missing and only 5 variables (9%) had ≥45% to <55% missing values. A maximum level of drinking variable was created at each wave, with three levels: *no binge drinking*, *binge drinking* and *extreme binge drinking*. These variables and alcohol consequences variables were log transformed before imputation. Smoking, cannabis use, antisocial behaviour, mental health and summary measures of sexual risk-taking were imputed as binary variables at each wave. Age was imputed as a normal variable. After imputation, transformed variables were converted back to their original scale and all were categorised for analysis, with adaptive rounding used for binary measures<sup>2</sup>. Nine deceased participants were excluded from the imputed datasets. Frequencies and odds ratios were obtained by averaging results across the imputed datasets; inferences under multiple imputation were made using Rubin's rules<sup>1</sup>.

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**The persistence of adolescent binge drinking into adulthood: Findings from a 15-year prospective cohort study**

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# The persistence of adolescent binge drinking into adulthood: Findings from a 15-year prospective cohort study

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## Article summary

### Article focus

- Alcohol is a major source of preventable disease burden among young people.
- Although young people drink less often than adults, they may consume large amounts in a single session ('binge' drinking).
- We know little about the persistence of binge drinking in adolescence into young adulthood. We aimed to: 1) Examine the persistence of adolescent "binge" and "heavy binge" drinking from adolescence to young adulthood; 2) Examine which characteristics of adolescent binge drinkers predict the persistence of "binge" and "heavy binge" alcohol use into young adulthood.

### Key messages

- Half of the males and a third of females in a cohort of young Australians: reported past-week binge drinking in adolescence.
- The overwhelming majority of these adolescent binge drinkers continued to binge drink in young adulthood.
- Past-week binge drinking was reported in at least one young adulthood wave by around 70% of males and 48% of females who had not reported past-week binge drinking in adolescence.
- The high rate of persistence of binge drinking into adulthood indicates the need for policies to reduce its onset in adolescence such as limiting availability, increasing costs and discouraging drinking to intoxication.

### Strengths and limitations

- This well-conducted prospective study, with very high retention, has provided unique prospective data on the persistence of a prevalent and hazardous drinking pattern into adulthood.
- The following limitations do need to be acknowledged. First, non-response in longitudinal studies is often associated with alcohol and drug use. We used multiple imputation to minimise the impact of this potential bias. Second, our data do not capture the full extent of binge drinking in this cohort because not all binge alcohol use will have been captured within the one week reference period. Both of these limitations mean that if anything our findings on levels of binge drinking are conservative in estimating total exposure to these levels of drinking overall and over time.
- Third, all data were based on self-report, however there is reasonable evidence that young people's reports of alcohol use are both reliable and valid when reports are made in a confidential manner, and without any consequences for disclosing.
- Fourth, we used the same definition of binge and heavy binge drinking in adolescent and young adults. It is likely that the same amount of alcohol will have a greater adverse impact on adolescents than on adults.

## Abstract

*Objectives:* Binge drinking in adolescence has become common in many countries but we know little about whether it persists into adulthood.

*Methods:* A 15-year prospective cohort study in Victoria, Australia. 1943 adolescents were recruited from secondary schools at age 14-15 years. Levels of past-week “binge” drinking (5+ standard drinks (SD) on a day, each 10g alcohol) and “heavy binge” drinking (20+ SD on a day for males, 11+ for females) were assessed during six adolescent waves, and across three adult waves up to age 29 years.

*Results:* Half of males (52%) and a third of females (34%) reported past-week binge drinking in adolescence. 90% of male and 70% of female adolescent-onset binge drinkers continued to binge drink into young adulthood. Seventy percent of males and 48% of females who were not adolescent-onset binge drinkers reported binge drinking in young adulthood. Past-week “heavy binge drinking”, reported by 19% of males and 15% females in adolescence, increased substantially in the young adult waves (38% males, 27% females in any adult wave). There was some evidence of a decline at 29 years. Among adolescent binge drinkers (n=821), young adult binge and heavy binge drinking were predicted by being male, adolescent antisocial behaviour, and adverse consequences of drinking in adolescence (intense drinking, physical harm, and sexual risk taking related to alcohol consumption).

*Conclusions:* Binge alcohol use is common and has a greater degree of persistence than other health risk behaviours that commonly arise in adolescence. Efforts to prevent the onset of binge drinking during adolescence may substantially reduce harmful patterns of alcohol use in young adulthood.



## Introduction

Alcohol is a major source of preventable disease burden among young people(1): it is thought to contribute to 320,000 deaths globally among 15-29 year olds each year, comprising 9% of all deaths in this group(2). The burden attributable to alcohol use as a risk factor among young people aged 15-29 years (20 million disability adjusted life years (DALYs)) is thought to account for one third of all global alcohol attributable burden (59 million DALYs)(3).

Alcohol use typically begins in adolescence(4, 5). Although young people drink less often than adults(4), they may consume larger amounts in a single session(6-8). Among school students across 14 European countries in 2011, 41% reported past-month “binge” drinking (5+ standard alcoholic drinks(9)); levels in the United Kingdom were 54%(9). Similar drinking levels occur in young Australians(10). One in five Australian males and females 16-24 years report drinking 20+ and 11+ standard drinks in a session (each 10g alcohol), respectively, at least monthly in the past year(11).

There have been many studies examining alcohol use among adolescents(12, 13), risk factors for young adult consumption and alcohol use disorders(14-19), and the impact of adolescent use upon health in young adulthood(13). However, there has been little study of the strength of persistence of binge alcohol use from adolescence into young adulthood (20). There are also few longitudinal data to inform clinicians about on the predictors of persistence of binge alcohol use into young adulthood for adolescent binge drinkers who they may see in their practice. We investigated the persistence of binge drinking into adulthood using a 15-year prospective cohort study of young Australians that assessed alcohol use during adolescence and up to age 29 years.

We aimed to:

1. Examine the persistence of adolescent “binge” and “heavy binge” drinking from adolescence to young adulthood;
2. Examine which characteristics of adolescent binge drinkers predict the persistence of “binge” and “heavy binge” alcohol use into young adulthood.

## Methods

### Sample

Between August 1992 and 2007, we conducted nine waves of interviews with a cohort then resident in the state of Victoria, Australia (for more details see(21, 22)). At the beginning of the adolescent phase (waves 1-2) parental consent was obtained; in adult waves participants were informed in writing and gave verbal consent.

At baseline, a representative sample of the Victorian population of school pupils aged 14-15 years (year 9) was recruited. Retention in school to year 9 among Victorian young people in 1992-3 was 98%. A two-stage cluster sampling procedure was used, with two classes selected at random. At stage one, 45 schools were randomly chosen from a stratified frame of government, Catholic and independent private schools. At stage two, one class was selected at random from each participating school, entering in the last part of year 9 (wave 1), followed by a second class in the second wave six months later (wave 2). Participants were interviewed at 6-month intervals from 14-19 years (waves 3-6) with three waves in young adulthood: 20-21 years (wave 7), 24-25 years (wave 8), and 28-29 years (wave 9). In waves 1-6, participants self-administered the questionnaire on laptops, with telephone follow-up of those absent from school; waves 7-9 involved computer-assisted telephone interviews(23). From a total of 2032 students, 1943 (95.6%) participated at least once in adolescence (Figure 1); 1756 (53% female) participated in at least one adult wave and were known to be alive at wave 9; 1282 completed all three adult waves; 293 completed two, and 181 completed one. By the end of wave 9, nine participants were known to have died, 108 lost to follow-up and 319 refused participation; 1501 participants were interviewed, 1407 of whom did the full (1383) or part (24) interview schedule, and 94 a paper questionnaire. In this paper, we only used adolescent data from waves 2-6 as over half of the adolescents did not participate in wave 1.

**Figure 1 about here**

### Measures

#### *Alcohol consumption*

Alcohol consumption was recorded at all adolescent and adult phases in an alcohol diary by any participants who reporting drinking in the previous week. In the adolescent phase, respondents completed a seven-day alcohol diary. In the adult phase, in order to minimise

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3 respondent burden, participants were only asked to complete a four-day diary including all  
4 weekend days (Friday to Sunday) and the most recent weekday. Types of alcohol (beer,  
5 cider, spirits, mixed drinks, wine etc.), brand names, and the amounts consumed (glass, pint,  
6 bottle, can, etc.) were recorded. We calculated the number of standard drink units (10g  
7 alcohol) consumed on each day/occasion, and at each wave. Two measures of binge  
8 drinking were estimated (using the same definition in adolescent and adult phases).  
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14 (1) *'Binge' drinking*: Defined (at each wave) as having drunk 5 or more standard drinks (each  
15 10g alcohol) on at least one day during the diary week. *Any binge drinking* was defined  
16 in adolescence and adulthood as binge drinking on one or more waves during the  
17 respective phase. For each phase, we identified the number of waves in which binge  
18 drinking occurred: none, one wave and two or more waves (in adolescence, 2+ of five  
19 assessment waves; in adulthood; 2+ of three waves). *Persistent binge drinking* was  
20 defined as binge drinking on two or more waves.  
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28 (2) *'Heavy' binge drinking*: Defined as having drunk >20 standard drinks for males and  $\geq 11$   
29 standard drinks for females on any day over the diary week (11). These levels were  
30 taken from a previous study of young people (11), using Australian National Health and  
31 Medical Research Council definitions of "high risk" drinking for males and females. *Any*  
32 *'heavy' binge drinking* in adolescence and adulthood was defined as having done so on  
33 any wave. The number of waves in each phase was identified as above. *Persistence of*  
34 *'heavy' binge drinking* was defined as drinking to this level on two or more waves  
35 (adolescence, 2+ of five waves; adulthood; 2+ of three waves).  
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43 *Incident* binge drinking was defined as first reporting binge or heavy binge drinking in young  
44 adulthood. *Continuity of binge drinking* and of *heavy binge drinking* was defined as the same  
45 pattern of drinking in adolescence and also adulthood. *Discontinuity* was defined as  
46 adolescent binge or heavy binge drinking without binge/heavy binge drinking in young  
47 adulthood.  
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### 51 **Prognostic factors**

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53 *Adolescent tobacco smoking* was assessed at each adolescent wave. Participants who  
54 reported smoking daily in the week prior to survey at any one adolescent wave were  
55 classified as daily smokers during adolescence.  
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3 *Adolescent cannabis use* was assessed using reported frequency of use in the previous six  
4 months at each wave. Maximal cannabis use during the adolescent phases (i.e. most  
5 frequent level reported across any wave) was categorised as *none/occasional* and  
6 *daily/weekly*.  
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11 *Adolescent antisocial behaviour* was assessed using 10 items from the Moffitt and Silva self-  
12 report early delinquency scale(24), which assessed property damage, interpersonal conflict  
13 and theft. Participants were asked if they had engaged in any of these behaviours *never*,  
14 *once*, or *more than once* in the last 6 months. *Antisocial behaviour* was defined as any  
15 antisocial behaviour on more than one adolescent wave, and/or 2+ behaviours in the same  
16 wave.  
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21 *Early onset sexual behaviour:* participants were asked if they had ever had sex (“gone all the  
22 way” or had sexual intercourse) at each adolescent wave and their age of first sex at each  
23 young adulthood wave. Those reporting sexual activity before 16 years were classified as  
24 *early onset sexually active*.  
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30 *Adolescent mental health* was assessed using the Clinical Interview Schedule (CIS-R)(25),  
31 which assesses depression and anxiety in non-clinical populations; a cut-off of >11 defines a  
32 mixed depression-anxiety state requiring clinical intervention . Mental health problems  
33 were summarised as having occurred: never, in one, or 2+ adolescent waves.  
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38 *Adolescent alcohol-related consequences:* Eight questions were asked about problems  
39 related to alcohol over the past six months in all adolescent waves. These were categorised  
40 into four types of consequences: *intense drinking* (drank so much that the next day couldn’t  
41 remember what you said/did); *alcohol-related social problems* (lost friends, had trouble at  
42 school, or argued with family, because of drinking); *alcohol-related injury, accident or*  
43 *violence* (violent and had a fight, or had an injury or an accident, because of drinking); and  
44 *alcohol-related sexual risk taking* (had sex without using contraceptives, had sex without  
45 using protection, or had sex and regretted it, because of drinking). For each of the four types  
46 of consequences, persistence in adolescence was defined as engaging in the behaviour  
47 either across multiple waves or more than once on one wave.  
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## 55 56 57 **Statistical Analysis** 58 59 60

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3 We calculated the prevalence of binge drinking at each wave and the number of waves on  
4 which each type of binge drinking occurred in adolescence and adulthood. We also  
5 estimated the continuity and discontinuity of binge and heavy binge drinking between the  
6 two phases. Among those reporting adolescent binge drinking (n=821), logistic regression  
7 was used to examine the prognosis for this group in terms of binge drinking. We  
8 investigated associations between adolescent predictors and any binge and heavy binge  
9 drinking in young adulthood. These associations were initially examined separately and then  
10 jointly in multivariable models. Interactions between the adolescent predictors and sex  
11 were examined in the multivariable models but evidence for differential sex effects was  
12 weak. In order to retain information from individuals with incomplete data (and thereby  
13 minimise the effects of participation bias), the prevalence of binge and heavy binge drinking  
14 during both adolescent and young adult phases was estimated using multiple  
15 imputation(26, 27) (see online appendix). All data analysis was undertaken using Stata  
16 12(28).  
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### 28 **Ethics**

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30 The Ethics in Human Research Committee of the Royal Children's Hospital, Melbourne  
31 approved all data collection protocols.  
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### 35 **Role of the funding source**

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37 Data collection for this study was supported by the National Health and Medical Research  
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40 interpretation, writing of the article or decision to publish. The corresponding author had  
41 full access to all the data in the study and had final responsibility for the decision to submit  
42 for publication.  
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## Results

The analysis utilised data from waves 2 to 9 for all participants (n=1934) who completed the survey at least once in adolescence (waves 2-6) and were alive at wave 9, with multiple imputation used for incomplete records. The results from available case analyses are presented in the **online appendix**; the pattern of results was broadly similar compared to the imputed data.

### Past-week Binge Drinking

Almost seven in eight males and two thirds of females reported binge drinking in the last week on at least one wave in adolescence and young adulthood. Nearly half of males and a quarter of females reported binge drinking both in adolescence *and* young adulthood. The overwhelming majority of adolescent-onset binge drinkers (nine in ten male and seven in ten female adolescent-onset binge drinkers) continued to binge drink in young adulthood (Table 1a). The number of young adult binge drinkers was increased by incident binge drinking among those who did not report binge drinking in adolescence: one third of males and females. Only 4.4% of males and 9.5% females who were adolescent binge drinkers did not report binge drinking in adulthood.

Past-week binge drinking (5+ standard drinks of 10g alcohol on a day) across adolescence (Figure 2a) increased in males from 14.4% in wave 2 (mean age 15.5years) to 31.1% in wave 6 (17.4yrs) and in females from 7.6% to 15.0%. Persistent adolescent past-week binge drinking (across 2+ adolescent waves) was reported by one in three males (31.8%) and one in seven females (15.3%; Table 1a). In the adult waves, the prevalence of binge drinking was higher for males and females than in the adolescent phase and levels consumed for males were higher than females. In adulthood (Table 1a, Figure 2a), over eighty per cent of males reported binge drinking on at least one adult wave and more than half of females did so. Six in ten (59.1%) males and one in four (24.5%) females reported binge drinking across multiple adult waves (Table 1a).

**Figure 2a and 2b about here**

### Past-week Heavy Binge Drinking

Just under half of the males (45.6%) and a third of females (36.2%) reported past-week heavy binge drinking at least once during adolescence or young adulthood (Table 1b). Sixty one percent of males and 42% of females who reported heavy binge drinking in adolescence continued into young adulthood. Of those who engaged in heavy binge drinking at any wave, 58% first reported doing so in young adulthood.

During adolescence, males and females reported similar levels of heavy binge use at each wave but males (7.9%) were more likely to report heavy binge drinking on multiple adolescent waves than females (4.7%; Table 1b). Past-week heavy binge drinking did not increase substantially until the young adult waves (Figure 2b). Around two in five males and one in four females reported past-week heavy binge drinking on at least one adult wave (Table 1b). At ages 20 and 24 years, around 20% of males and 13% of females reported heavy binge drinking. There was a decline in past-week heavy binge drinking by age 29 years.

#### Table 1a and 1b about here

#### *Young adult binge and heavy binge alcohol use among adolescent-onset binge drinkers*

Levels of past-week binge and heavy binge drinking in adulthood, among adolescent-onset binge and heavy binge drinkers, are presented in Figure 3. Males with adolescent-onset binge drinking were more likely to continue binge drinking in adulthood than females (Figure 3a): around seven in ten males reported doing so, compared to fewer than half of females. By 29 years, female adolescent-onset binge drinkers had substantially lower levels of binge drinking than in earlier waves, and much lower levels than males. Levels of adult heavy binge drinking did not differ markedly by sex among adolescent-onset binge drinkers; around 20-30% reported past-week heavy binge drinking at ages 20 and 24, with lower levels at 29 years (wave 9; Figure 3a). Among adolescent-onset heavy binge drinkers, the patterns and levels followed a similar sex pattern to that in adolescent-onset binge drinkers (Figure 3b).

#### Figure 3a and 3b about here

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3 Table 2 reports associations between adolescent characteristics and binge and heavy binge  
4 drinking at any adult wave in adolescent-onset binge drinkers (n=821). At a univariate level,  
5 being male, and reporting adolescent antisocial behaviour or negative consequences of  
6 alcohol use in adolescence were associated with the reporting of young adult binge and  
7 heavy binge drinking in the past week. In multivariable analyses that included all covariates,  
8 the associations between adult bingeing and female gender were substantially unchanged  
9 (for young adult binge OR 0.23, 95%CI 0.13-0.40; for young adult heavy binge use OR 0.63,  
10 95%CI 0.43-0.92). Associations with behavioural characteristics were substantially  
11 attenuated when adjusted for sex and other characteristics, with the strongest independent  
12 effect being an increased risk if sexual risk taking had occurred in adolescence.  
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**Table 2 about here**



## Discussion

To our knowledge this is one of few longitudinal studies charting the persistence of binge use of alcohol from adolescence into young adulthood (20). Consistent with cross-sectional surveys in England(29), the USA, and Europe(5, 9), binge drinking was highly prevalent in both sexes and normative in young Australian males. A substantial minority also engaged in heavy binge drinking (drinking more than 20 drinks on an occasion). Over half of males and a third of females reported binge drinking in the past week at some time during adolescence, and one in five males and one in seven females reported what we defined as "heavy binge drinking".

The overwhelming majority of those who reported binge drinking in adolescence continued to do so in young adulthood. Even if past-week binge drinking was not reported in the teens, it was reported in at least one wave in young adulthood by 70% of males and 48% of females who did not report binge drinking at any time in adolescence.

Among those who reported binge drinking in adolescence, variables that predicted binge and heavy binge drinking in young adulthood included: regular (weekly+) cannabis use, antisocial behaviour, and early onset sexual activity. The most consistent predictors of both adult binge and heavy binge drinking were reporting adverse consequences of alcohol use in adolescence, namely "intense drinking" (could not remember the night before because of drinking), social problems, sexual risk taking and physical harm. Adolescent binge drinkers who engaged in other risky behaviours, and who had experienced negative consequences of alcohol use, were most likely to continue drinking at these levels in adulthood. In multivariable regression analysis, the strongest independent predictor of adult binge drinking among adolescent binge drinkers was being male.

## Limitations

The following limitations need to be acknowledged. First, non-response in longitudinal studies is often associated with alcohol and drug use. We used multiple imputation to minimise the impact of this potential bias, but this method carries its own assumptions and it is difficult to assess exactly how much residual bias might remain. The method of multiple imputation also assumes that data were missing at random. This is unlikely to be strictly true

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3 but the method is strengthened by the inclusion of auxiliary variables in the imputation  
4 model.  
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8 Second, our data do not capture the full extent of binge drinking in this cohort because not  
9 all binge alcohol use will have been captured within the one week reference period. Both of  
10 these limitations mean that our findings on levels of binge drinking may underestimate total  
11 exposure to these levels of drinking overall and over time.  
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15 Third, all data were based on self-report. There is reasonable evidence that young people's  
16 reports of alcohol use are both reliable and valid when reports are made in a confidential  
17 manner, and without any consequences for disclosing use (as was the case here) (30, 31).  
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21 Fourth, we used the same definition of binge and heavy binge drinking in adolescents and  
22 young adults. It is likely that the same amount of alcohol will have a greater adverse impact  
23 on adolescents than on adults. Notwithstanding these limitations, this study has provided  
24 unique prospective data on the persistence of a prevalent and hazardous drinking pattern  
25 from adolescence into adulthood.  
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31 We have clearly identified that binge alcohol use is a common behaviour among  
32 adolescents, and that it is likely to persist into young adulthood. These patterns of binge  
33 drinking in adolescence are a public health concern for two reasons. First, heavy alcohol use  
34 substantially increases the risks of: motor vehicle accidents, other injuries, alcohol-related  
35 assaults, and suicides in young people(32). Second, the longer-term health effects of  
36 persistent binge drinking during adulthood include alcohol dependence, liver disease and  
37 cancer. In most adolescent binge drinkers, binge drinking was clearly not just an "adolescent  
38 phase"; it was a pattern that persisted into young adulthood. There is an urgent need to  
39 understand why such high levels of alcohol use in adolescence continue into young  
40 adulthood.  
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50 Social acceptability, ready availability and low cost of alcohol are likely to be important  
51 drivers of early initiation into binge drinking and continuing high levels of consumption.  
52 Both the taste (33) and packaging (34) of pre-mixed drinks are particularly attractive to  
53 young people; exposure to some forms of advertising is also associated with increased  
54 consumption (35), as are increased numbers of outlets selling alcohol (36-38), extended  
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3 opening hours(39, 40), and reduced alcohol taxes (39, 41) (though only applied similarly  
4 across products(42)). The *persistence* of binge drinking into young adulthood may also be  
5 related to a delay in 'maturing out' of drinking as a result of the postponement in recent  
6 cohorts of major social role transitions such as marriage and parenthood into later  
7 adulthood(43).  
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### 11 12 13 **Conclusions**

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15 Alcohol is one of the biggest risk factors for disease burden among young people. Heavy  
16 consumption in young people is common and persistence into young adulthood is much  
17 more likely than not. There is a need to develop interventions that explicitly acknowledge  
18 that prevention confined to adolescence alone is insufficient. Clearly there is much work still  
19 to be done in that area, given the incredibly high exposure not only to *any* alcohol use, but  
20 to binge alcohol use, across the adolescent years, often repeatedly. It is also apparent that  
21 there is work to be done in young adulthood since most of the heavy binge drinking began  
22 then, once participants were legally allowed to drink, and past the age at which most  
23 prevention messages are targeted. There is an increasingly delayed uptake of social role  
24 transitions; it is unclear whether such shifts are related to the patterns of alcohol  
25 consumption we observed here. The adoption of policies and interventions including those  
26 to reduce alcohol availability (via shortened trading hours, and fewer outlets), increase cost  
27 (via taxation) and discourage drinking to intoxication, may assist in reducing binge alcohol  
28 use in future cohorts of young people.  
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### Author contributions

LD, GP, WS and CO'L conceived of the study. CO'L and HR conducted the analyses. LD led the writing of the manuscript. All authors commented on the analytic plan, interpretation, and contributed to the editing and final approval of the manuscript.

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**Figure legends**

**Figure 1: Sampling and ascertainment in the Victorian Adolescent Health Cohort, 1992 to 2008**

**Figure 2a: Levels of past week binge alcohol use among males and females (5 or more standard drinks on a day in the past week) by age**

**Figure 2b: Levels of past week "heavy binge" alcohol use among males and females (11 or more standard drinks on a day in the past week for females, 20 or more for males) by age**

**Figure 3a: Levels of past week binge and "heavy binge" drinking for males and females who reported binge drinking at one or more waves in adolescence, by age**

**Figure 3b: Levels of past week binge and "heavy binge" drinking for males and females who reported "heavy binge" drinking at one or more wave in adolescence, by age**

For Peer review only



Table 1a. Past week binge drinking during adolescence and young adulthood, by sex

|   | Binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                   |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                               | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 135                             | 14.4 | (12.1 - 16.7) | 76              | 7.6  | (5.90 - 9.30) | 211            | 10.9 | (9.50 - 12.3) |
| Wave 3 (mean age 15.9 years)  | 170                             | 18.1 | (15.5 - 20.7) | 96              | 9.6  | (7.50 - 11.7) | 265            | 13.7 | (12.1 - 15.4) |
| Wave 4 (mean age 16.4 years)  | 208                             | 22.3 | (19.3 - 25.3) | 140             | 14.1 | (11.8 - 16.3) | 349            | 18.0 | (16.2 - 19.9) |
| Wave 5 (mean age 16.8 years)  | 265                             | 28.3 | (25.1 - 31.5) | 152             | 15.2 | (12.9 - 17.6) | 417            | 21.6 | (19.6 - 23.5) |
| Wave 6 (mean age 17.4 years)  | 291                             | 31.1 | (28.0 - 34.3) | 150             | 15.0 | (12.6 - 17.4) | 441            | 22.8 | (20.8 - 24.8) |
| <b>Number of adolescent waves of any binge drinking</b>   |                                 |      |               |                 |      |               |                |      |               |
| Never   | 453                             | 48.5 | (45.0 - 52.0) | 660             | 66.1 | (63.0 - 69.1) | 1113           | 57.6 | (55.2 - 60.0) |
| 1 wave  | 184                             | 19.7 | (16.8 - 22.6) | 186             | 18.6 | (16.0 - 21.2) | 370            | 19.1 | (17.1 - 21.1) |
| 2+ waves  | 297                             | 31.8 | (28.5 - 35.1) | 153             | 15.3 | (13.0 - 17.7) | 451            | 23.3 | (21.3 - 25.3) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 509                             | 54.5 | (51.1 - 57.9) | 318             | 31.8 | (28.7 - 34.9) | 827            | 42.8 | (40.4 - 45.1) |
| Wave 8 (mean age 24.1 years)  | 550                             | 58.8 | (55.2 - 62.4) | 335             | 33.5 | (30.3 - 36.7) | 885            | 45.8 | (43.3 - 48.2) |
| Wave 9 (mean age 29.0 years)  | 524                             | 56.1 | (52.3 - 59.8) | 233             | 23.3 | (20.2 - 26.4) | 757            | 39.2 | (36.6 - 41.8) |
| <b>Number of adult waves of any binge drinking</b>  |                                 |      |               |                 |      |               |                |      |               |
| Never   | 178                             | 19.1 | (16.2 - 21.9) | 437             | 43.8 | (40.4 - 47.1) | 616            | 31.8 | (29.6 - 34.1) |
| 1 wave  | 204                             | 21.8 | (18.9 - 24.8) | 316             | 31.7 | (28.4 - 35.0) | 521            | 26.9 | (24.7 - 29.1) |
| 2+ waves  | 552                             | 59.1 | (55.7 - 62.5) | 245             | 24.5 | (21.5 - 27.6) | 798            | 41.2 | (38.8 - 43.7) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                 |      |               |                 |      |               |                |      |               |
| None in either phase  | 137                             | 14.7 | (12.2 - 17.2) | 342             | 34.2 | (31.0 - 37.5) | 479            | 24.8 | (22.7 - 26.9) |
| Incident in young adulthood   | 316                             | 33.8 | (30.3 - 37.3) | 318             | 31.9 | (28.7 - 35.0) | 634            | 32.8 | (30.4 - 35.2) |
| Remitted by young adulthood (adolescence only)  | 41                              | 4.4  | (2.80 - 6.00) | 95              | 9.5  | (7.50 - 11.6) | 136            | 7.1  | (5.80 - 8.30) |
| Continuing in young adulthood (both phases)   | 441                             | 47.1 | (43.5 - 50.7) | 244             | 24.4 | (21.6 - 27.2) | 684            | 35.4 | (33.1 - 37.7) |

Note: 'Binge' drinking defined as 5 or more drinks in one day in the past week.

Table 1b. Past week heavy binge drinking during adolescence and young adulthood, by sex

|   | Heavy binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                         |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                                     | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 44                                    | 4.8  | (3.40 - 6.10) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.80) |
| Wave 3 (mean age 15.9 years)  | 45                                    | 4.8  | (3.40 - 6.20) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.90) |
| Wave 4 (mean age 16.4 years)  | 49                                    | 5.2  | (3.70 - 6.70) | 54              | 5.4  | (4.00 - 6.90) | 103            | 5.3  | (4.30 - 6.30) |
| Wave 5 (mean age 16.8 years)  | 79                                    | 8.5  | (6.40 - 10.5) | 66              | 6.6  | (5.00 - 8.10) | 145            | 7.5  | (6.20 - 8.80) |
| Wave 6 (mean age 17.4 years)  | 67                                    | 7.1  | (5.20 - 9.00) | 38              | 3.8  | (2.60 - 5.00) | 105            | 5.4  | (4.30 - 6.50) |
| <b>Number of adolescent waves of any heavy binge drinking</b>                                   |                                       |      |               |                 |      |               |                |      |               |
| Never   | 755                                   | 80.7 | (78.1 - 83.4) | 847             | 84.7 | (82.5 - 87.0) | 1601           | 82.8 | (81.1 - 84.5) |
| 1 wave  | 106                                   | 11.4 | (9.10 - 13.6) | 106             | 10.6 | (8.60 - 12.5) | 212            | 11.0 | (9.50 - 12.4) |
| 2+ waves  | 74                                    | 7.9  | (6.10 - 9.70) | 47              | 4.7  | (3.30 - 6.00) | 121            | 6.2  | (5.10 - 7.30) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 177                                   | 18.9 | (16.3 - 21.6) | 134             | 13.4 | (11.2 - 15.6) | 311            | 16.1 | (14.4 - 17.8) |
| Wave 8 (mean age 24.1 years)  | 201                                   | 21.4 | (18.7 - 24.2) | 135             | 13.5 | (11.3 - 15.8) | 336            | 17.4 | (15.6 - 19.1) |
| Wave 9 (mean age 29.0 years)  | 132                                   | 14.1 | (11.4 - 16.7) | 78              | 7.8  | (6.10 - 9.60) | 210            | 10.8 | (9.30 - 12.4) |
| <b>Number of adult waves of any heavy binge drinking</b>  |                                       |      |               |                 |      |               |                |      |               |
| Never   | 579                                   | 62   | (58.7 - 65.3) | 726             | 72.7 | (69.7 - 75.6) | 1305           | 67.5 | (65.2 - 69.7) |
| 1 wave  | 230                                   | 24.6 | (21.4 - 27.8) | 212             | 21.2 | (18.5 - 23.9) | 442            | 22.8 | (20.7 - 25.0) |
| 2+ waves  | 125                                   | 13.4 | (10.9 - 15.9) | 62              | 6.2  | (4.60 - 7.70) | 187            | 9.7  | (8.20 - 11.1) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                       |      |               |                 |      |               |                |      |               |
| None in either phase  | 508                                   | 54.4 | (50.9 - 57.8) | 638             | 63.8 | (60.7 - 66.9) | 1146           | 59.2 | (56.9 - 61.6) |
| Incident in young adulthood   | 247                                   | 26.4 | (23.3 - 29.5) | 209             | 20.9 | (18.3 - 23.5) | 456            | 23.6 | (21.5 - 25.6) |
| Remitted by young adulthood (adolescence only)  | 71                                    | 7.6  | (5.80 - 9.50) | 88              | 8.8  | (7.00 - 10.7) | 160            | 8.2  | (6.90 - 9.60) |
| Continuing in young adulthood (both phases)   | 109                                   | 11.6 | (9.30 - 14.0) | 64              | 6.4  | (4.80 - 8.10) | 173            | 9.0  | (7.60 - 10.3) |

Note: 'Heavy binge' drinking defined as >11 drinks on a day in the past week for females, >20 for males. Persistent 'heavy binge' drinking in adolescence defined as heavy binge drinking in the past week on two or more waves across the adolescent waves (waves 2 to 6).

**Table 2: Predictors of binge alcohol use in young adulthood among adolescent ‘binge’ alcohol drinkers**

(i.e. those who had past-week binge drinking on at least one wave during adolescence, waves 2-6; n=821)

| Adolescent predictors among adolescent ‘binge’ drinkers, n=821: | Young adult ‘binge’ drinking |               |                  |               | Young adult ‘heavy binge’ drinking |               |                  |               |
|---|------------------------------|---------------|------------------|---------------|------------------------------------|---------------|------------------|---------------|
|   | Modelled separately          |               | Modelled jointly |               | Modelled separately                |               | Modelled jointly |               |
|   | OR                           | (95% CI)      | OR               | (95% CI)      | OR                                 | (95% CI)      | OR               | (95% CI)      |
| <b>Female</b>   | 0.24                         | (0.15 - 0.39) | 0.23             | (0.13 - 0.40) | 0.67                               | (0.49 - 0.92) | 0.63             | (0.43 - 0.92) |
| <b>Daily smoking</b>  | 1.20                         | (0.79 - 1.81) | 1.12             | (0.69 - 1.82) | 1.29                               | (0.94 - 1.77) | 1.01             | (0.70 - 1.46) |
| <b>Weekly/daily cannabis use</b>                                | 1.65                         | (0.96 - 2.82) | 1.05             | (0.54 - 2.03) | 1.57                               | (1.11 - 2.24) | 1.06             | (0.71 - 1.60) |
| <b>Antisocial behaviour</b>                                     | 1.70                         | (1.12 - 2.59) | 0.99             | (0.60 - 1.63) | 1.59                               | (1.16 - 2.18) | 1.06             | (0.74 - 1.52) |
| <b>Early onset sexual activity (&lt;16 years)</b>               | 1.46                         | (0.92 - 2.33) | 1.04             | (0.60 - 1.83) | 1.53                               | (1.09 - 2.14) | 1.02             | (0.69 - 1.49) |
| <b>Adolescent mental health problems</b>                        |                              |               |                  |               |                                    |               |                  |               |
| CIS >11, 0 waves  | 1                            |               | 1                |               | 1                                  |               | 1                |               |
| CIS >11, 1 wave   | 0.81                         | (0.42 - 1.57) | 0.90             | (0.44 - 1.81) | 1.23                               | (0.81 - 1.87) | 1.15             | (0.74 - 1.77) |
| CIS >11, 2+ waves   | 0.60                         | (0.37 - 0.97) | 0.83             | (0.48 - 1.46) | 1.05                               | (0.74 - 1.49) | 0.99             | (0.64 - 1.52) |
| <b>Adolescent consequences attributed to alcohol use</b>        |                              |               |                  |               |                                    |               |                  |               |
| Intense drinking <sup>1</sup>                                   | 1.54                         | (1.00 - 2.36) | 1.45             | (0.84 - 2.50) | 1.77                               | (1.28 - 2.43) | 1.41             | (0.99 - 2.00) |
| Social problems <sup>2</sup>                                    | 1.34                         | (0.85 - 2.10) | 1.25             | (0.72 - 2.18) | 1.63                               | (1.16 - 2.31) | 1.23             | (0.83 - 1.83) |
| Physical harm <sup>3</sup>                                      | 1.92                         | (1.13 - 3.26) | 1.25             | (0.64 - 2.44) | 1.96                               | (1.37 - 2.81) | 1.29             | (0.84 - 1.96) |
| Sexual risk taking <sup>4</sup>                                 | 1.75                         | (1.01 - 3.03) | 1.51             | (0.77 - 2.97) | 2.09                               | (1.44 - 3.03) | 1.64             | (1.07 - 2.53) |

Note: ‘Binge’ drinking defined as 5 or more drinks in one day in the past week. ‘Heavy binge’ drinking defined as >11 drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

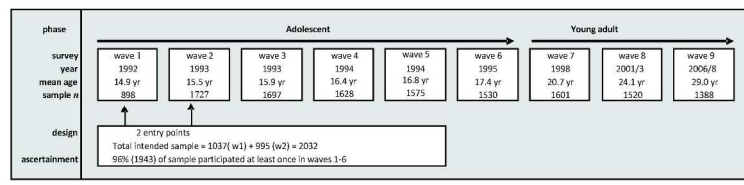
<sup>1</sup> Couldn’t remember what said or did the night before as a result of alcohol use

<sup>2</sup> Lost friends, school trouble, argued with family as a result of alcohol use

<sup>3</sup> Injuries, accidents, violence attributed to their alcohol use

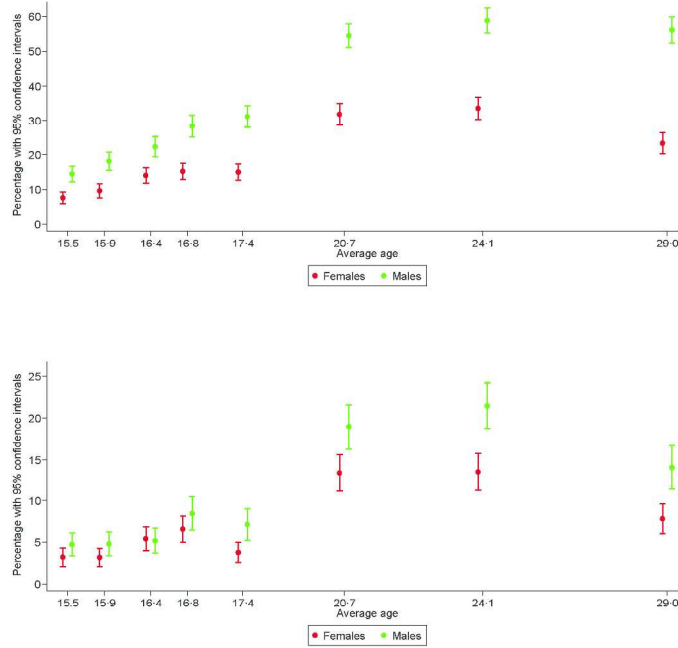
<sup>4</sup> Regretted having sex, or had sex without protection or contraceptives as a result of alcohol use

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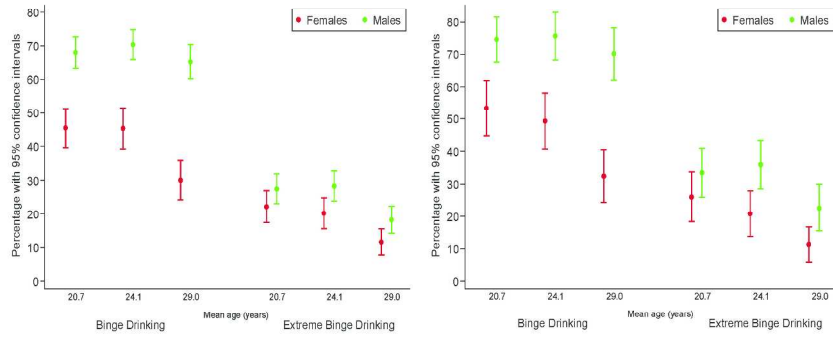
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Note: Binge drinking defined as 5 or more drinks in one day in the past week. Heavy binge drinking defined as 11+ drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

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## The persistence of adolescent binge drinking into adulthood: Findings from a 15-year prospective cohort study

|                              |     |  |
|------------------------------|-----|--|
|                              | 1   | (a) Indicate the study's design with a commonly used term in the title or the abstract:<br><b>This addressed in both title and abstract</b>  |
|                              |     | (b) Provide in the abstract an informative and balanced summary of what was done and what was found:<br><b>We have done so.</b>  |
| <b>Introduction</b>          |     |  |
| Background/rationale         | 2   | Explain the scientific background and rationale for the investigation being reported:<br><b>This is covered in the introduction</b>  |
| Objectives                   | 3   | State specific objectives, including any prespecified hypotheses:<br><b>The objectives were to examine the natural history of binge alcohol use during adolescence and young adulthood, and examine predictors of binge alcohol use during young adulthood among adolescent onset binge drinkers years. These objectives are summarised at the end of the introduction.</b>  |
| <b>Methods</b>               |     |  |
| Study design                 | 4   | Present key elements of study design early in the paper:<br><b>We have presented key design elements in the methods.</b>   |
| Setting                      | 5   | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection:<br><b>These are included in the text and in figure 1.</b>   |
| Participants                 | 6   | (a) <i>Cohort study?</i> Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.<br><b>These are described in the methods section and in figure 1 including rates of attrition and reasons for attrition.</b><br><br>(b) <i>Cohort study?</i> For matched studies, give matching criteria and number of exposed and unexposed. <i>Case-control study?</i> For matched studies, give matching criteria and the number of controls per case. <b>Not applicable</b>   |
| Variables                    | 7   | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.<br><b>We have covered this in the methods section on pages 5-7. There were two main exposures of interest: past week binge alcohol use (5 or more standard drinks in a day) and past week "heavy" binge drinking (more than 20 standard drinks on a day for males, 11 or more on a day for females).</b>   |
| Data sources/<br>measurement | 8*  | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. <b>These are provided on page 5</b>  |
| Bias                         | 9   | Describe any efforts to address potential sources of bias.<br><b>The main sources of selection bias are discussed on page 13 and relate to differential attrition. Further sources of selection bias are unlikely to make a major contribution to the findings but potentially include the following:</b><br><b>1 non-participation in the sampling frame: 2% of the Victorian adolescent population were not registered at school at the time of sampling with some small possibility that the sample did not reflect that of Victorian adolescents at that time.</b><br><b>2 Non-participation in the adolescent wave; 4% of the original sample did not participate in any adolescent wave and were therefore not included in the cohort to be follow-up. Given the high participation rate we believe the potential for bias is small.</b> |
| Study size                   | 10  | Explain how the study size was arrived at.<br><b>The study was designed to examine common adolescent health exposures and common young adult outcomes. Based on the known and relatively common exposure and assuming conservatively a prevalence of 10% (higher prevalences would have led to higher power) for these exposures, the study was expected to have 80% power at the two-sided 0.05 significance level for relative risks in the range 1.6 - 1.9, corresponding to outcomes with a prevalence of 10% to 20%. These are roughly the ranges we are dealing with in these analyses.</b>  |
| Quantitative variables       | 11  | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why.<br><b>This explained in methods, results and in the tables.</b>  |
| Statistical methods          | 12  | (a) Describe all statistical methods, including those used to control for confounding.<br><b>Where relevant this is explained in the methods and results sections.</b><br><br>(b) Describe any methods used to examine subgroups and interactions.<br><b>We examined for first-order interactions where appropriate in the models.</b><br><br>(c) Explain how missing data were addressed. <b>This is described in the analysis sections and in the appendix.</b><br><br>(d) <i>Cohort study?</i> If applicable, explain how loss to follow-up was addressed. <b>This was described in analysis section.</b><br><br>(e) Describe any sensitivity analyses <b>We present available case analyses in the online appendix to allow the reader to examine the impact of multiple imputation.</b>   |
| <b>Results</b>               |     |  |
| Participants                 | 13* | (a) Report numbers of individuals at each stage of study? eg numbers potentially eligible, examined for eligibility, confirmed eligible.   |

|                          |     |  |
|--------------------------|-----|--|
|                          |     | included in the study, completing follow-up, and analysed: <b>This is shown in figure 1 and described in the results.</b>  |
|                          |     | (b) Give reasons for non-participation at each stage.<br><b>Reasons for non-completion are provided on page 5. Dealing with these potential sources of bias was a reason for using multiple imputation in the data analysis.</b>   |
|                          |     | (c) Consider use of a flow diagram <b>See figure 1.</b>  |
| Descriptive data         | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. <b>This information is contained in the description of the recruitment methods and in the data in the Tables especially Table 3. Space does not allow more detailed descriptive summaries.</b><br><br>(b) Indicate number of participants with missing data for each variable of interest.<br><b>This study had very low levels of missing data for variables where the participant completed a wave.</b><br><br>(c) <i>Cohort study?</i> Summarise follow-up time (eg average and total amount). <b>See figure 1.</b> |
| Outcome data             | 15* | <i>Cohort study?</i> Report numbers of outcome events or summary measures over time.<br><b>See table 1. Summary measures and numbers are shown in the other tables.</b><br><br><i>Case-control study?</i> Report numbers in each exposure category, or summary measures of exposure. <b>N/A</b><br><br><i>Cross sectional study?</i> Report numbers of outcome events or summary measures <b>N/A</b>   |
| Main results             | 16  | (a) Report the numbers of individuals at each stage of the study? eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. <b>This is summarised in figure 1.</b><br><br>(b) Give reasons for non-participation at each stage. <b>See above.</b><br><br>(c) Consider use of a flow diagram <b>See figure 1.</b>   |
| Other analyses           | 17  | Report other analyses done? eg analyses of subgroups and interactions, and sensitivity analyses <b>N/A</b>   |
| <b>Discussion</b>        |     |  |
| Key results              | 18  | Summarise key results with reference to study objectives <b>This is undertaken on pages 9-11</b>   |
| Limitations              | 19  | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <b>See pages 13-14</b>  |
| Interpretation           | 20  | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>We have done so.</b>   |
| Generalisability         | 21  | Discuss the generalisability (external validity) of the study results<br><b>This has not been explicitly addressed in the paper, because of space limitations, but we believe is really implicit in the detail given of the recruitment of the cohort from a representative sample of schools in Victoria. Thus we believe the results are clearly generalisable to other Australian communities and likely to be highly relevant to most other high income countries.</b>   |
| <b>Other information</b> |     |  |
| Funding                  | 22  | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based. <b>Given at the end of the discussion.</b>  |



## Online appendix: Approach to multiple imputation

Missing data were handled using multiple imputation<sup>1</sup>. We imputed 20 complete datasets separately for males and females, under a multivariate normal model, incorporating all the analysis and auxiliary variables at each wave, except age and sexual risk-taking in adolescence, which was imputed as a binary summary measure. Wave 1 was omitted as it contained observations from only 46% of the cohort. Wave 1 responses were used to fill in wave 2 data, for any participant not seen at wave 2 as the same measures had been collected at the earlier wave. Waves 2 to 9 were imputed for all participants (N=1943) who completed the survey at least once in adolescence (waves 2-6). The imputation model contained 49 key variables used in the analysis and 8 auxiliary variables. Of 57 variables included in the imputation model, 18% of the variables had <10% missing values, 46% had ≥10% to <20% missing, 28% had ≥20% to <30% missing and only 5 variables (9%) had ≥45% to <55% missing values. A maximum level of drinking variable was created at each wave, with three levels: *no binge drinking*, *binge drinking* and *extreme binge drinking*. These variables and alcohol consequences variables were log transformed before imputation. Smoking, cannabis use, antisocial behaviour, mental health and summary measures of sexual risk-taking were imputed as binary variables at each wave. Age was imputed as a normal variable. After imputation, transformed variables were converted back to their original scale and all were categorised for analysis, with adaptive rounding used for binary measures<sup>2</sup>. Nine deceased participants were excluded from the imputed datasets. Frequencies and odds ratios were obtained by averaging results across the imputed datasets; inferences under multiple imputation were made using Rubin's rules<sup>1</sup>.

Table 1a. Available case analysis: Prevalence of adolescent and young adult binge drinking by wave and sex

|                                      | Binge drinking in the past week |     |      |               |         |     |      |               |       |     |      |               |
|--------------------------------------|---------------------------------|-----|------|---------------|---------|-----|------|---------------|-------|-----|------|---------------|
|                                      | Males                           |     |      |               | Females |     |      |               | Total |     |      |               |
|                                      | N                               | n   | %    | (95% CI)      | N       | n   | %    | (95% CI)      | N     | n   | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>  |                                 |     |      |               |         |     |      |               |       |     |      |               |
| <b>Binge drinking by wave</b>        |                                 |     |      |               |         |     |      |               |       |     |      |               |
| Wave 2 (mean age 15.5 yr)            | 892                             | 127 | 14.2 | (11.9 - 16.5) | 950     | 72  | 7.6  | (5.90 - 9.30) | 1842  | 199 | 10.8 | (9.40 - 12.2) |
| Wave 3 (mean age 15.9 yr)            | 805                             | 137 | 17.0 | (14.4 - 19.6) | 887     | 79  | 8.9  | (7.00 - 10.8) | 1692  | 216 | 12.8 | (11.2 - 14.4) |
| Wave 4 (mean age 16.4 yr)            | 750                             | 151 | 20.1 | (17.3 - 23.0) | 874     | 112 | 12.8 | (10.6 - 15.0) | 1624  | 263 | 16.2 | (14.4 - 18.0) |
| Wave 5 (mean age 16.8 yr)            | 718                             | 186 | 25.9 | (22.7 - 29.1) | 853     | 117 | 13.7 | (11.4 - 16.0) | 1571  | 303 | 19.3 | (17.3 - 21.2) |
| Wave 6 (mean age 17.4 yr)            | 679                             | 195 | 28.7 | (25.3 - 32.1) | 847     | 122 | 14.4 | (12.0 - 16.8) | 1526  | 317 | 20.8 | (18.7 - 22.8) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b> |                                 |     |      |               |         |     |      |               |       |     |      |               |
| <b>Binge drinking by wave</b>        |                                 |     |      |               |         |     |      |               |       |     |      |               |
| Wave 7 (mean age 20.7 yr)            | 732                             | 401 | 54.8 | (51.2 - 58.4) | 865     | 266 | 30.8 | (27.7 - 33.8) | 1597  | 667 | 41.8 | (39.3 - 44.2) |
| Wave 8 (mean age 24.1 yr)            | 693                             | 409 | 59.0 | (55.4 - 62.7) | 824     | 265 | 32.2 | (29.0 - 35.4) | 1517  | 674 | 44.4 | (41.9 - 46.9) |
| Wave 9 (mean age 29.1 yr)            | 631                             | 359 | 56.9 | (53.0 - 60.8) | 764     | 168 | 22.0 | (19.1 - 24.9) | 1395  | 527 | 37.8 | (35.2 - 40.3) |

Note: "Binge" drinking defined as 5 or more drinks in one day in the past week.

Table 1b. Available case analysis: Prevalence of adolescent and young adult extreme binge drinking by wave by sex

|                                      | Extreme binge drinking in the past week |     |      |               |         |     |      |               |       |     |      |               |
|--------------------------------------|---|-----|------|---------------|---------|-----|------|---------------|-------|-----|------|---------------|
|                                      | Males                                   |     |      |               | Females |     |      |               | Total |     |      |               |
|                                      | N                                       | n   | %    | (95% CI)      | N       | n   | %    | (95% CI)      | N     | n   | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>  |   |     |      |               |         |     |      |               |       |     |      |               |
| <b>Binge drinking by wave</b>        |   |     |      |               |         |     |      |               |       |     |      |               |
| Wave 2 (mean age 15.5 yr)            | 892                                     | 44  | 4.9  | (3.50 - 6.40) | 950     | 32  | 3.4  | (2.20 - 4.50) | 1842  | 76  | 4.1  | (3.20 - 5.00) |
| Wave 3 (mean age 15.9 yr)            | 805                                     | 42  | 5.2  | (3.70 - 6.80) | 887     | 31  | 3.5  | (2.30 - 4.70) | 1692  | 73  | 4.3  | (3.30 - 5.30) |
| Wave 4 (mean age 16.4 yr)            | 750                                     | 41  | 5.5  | (3.80 - 7.10) | 874     | 52  | 5.9  | (4.40 - 7.50) | 1624  | 93  | 5.7  | (4.60 - 6.90) |
| Wave 5 (mean age 16.8 yr)            | 718                                     | 63  | 8.8  | (6.70 - 10.8) | 853     | 62  | 7.3  | (5.50 - 9.00) | 1571  | 125 | 8.0  | (6.60 - 9.30) |
| Wave 6 (mean age 17.4 yr)            | 892                                     | 44  | 4.9  | (3.50 - 6.40) | 847     | 36  | 4.3  | (2.90 - 5.60) | 1526  | 85  | 5.6  | (4.40 - 6.70) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b> |   |     |      |               |         |     |      |               |       |     |      |               |
| <b>Binge drinking by wave</b>        |   |     |      |               |         |     |      |               |       |     |      |               |
| Wave 7 (mean age 20.7 yr)            | 732                                     | 141 | 19.3 | (16.4 - 22.1) | 865     | 121 | 14.0 | (11.7 - 16.3) | 1597  | 262 | 16.4 | (14.6 - 18.2) |
| Wave 8 (mean age 24.1 yr)            | 693                                     | 153 | 22.1 | (19.0 - 25.2) | 824     | 120 | 14.6 | (12.2 - 17.0) | 1517  | 273 | 18.0 | (16.1 - 19.9) |
| Wave 9 (mean age 29.1 yr)            | 631                                     | 85  | 13.5 | (10.8 - 16.1) | 764     | 70  | 9.2  | (7.10 - 11.2) | 1395  | 155 | 11.1 | (9.50 - 12.8) |

Note: "Extreme binge" drinking defined as >11 drinks on a day in the past week for females, >20 for males.

## References

1. Rubin DB. Multiple Imputation for Nonresponse in Surveys. New York: John Wiley and Sons; 2004.
2. Bernaards CA, Belin TR, Schafer JL. Robustness of a multivariate normal approximation for imputation of incomplete binary data. *Statistics in Medicine*. 2007; 26: 1368-82.

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7 **The persistence of adolescent binge drinking into adulthood: Findings from a**  
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9 **15-year prospective cohort study**

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11 **Louisa Degenhardt<sup>1,2</sup>, Christina O'Loughlin<sup>3</sup>, Wendy Swift<sup>1</sup>, Helena Romaniuk<sup>3,5,6</sup>, John**  
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## Article summary

### Article focus

- Alcohol is a major source of preventable disease burden among young people.
- Although young people drink less often than adults, they may consume large amounts in a single session (~~“binge”~~ **‘binge’** drinking).
- We know little about the persistence of binge drinking in adolescence into young adulthood. We aimed to: 1) Examine the persistence of adolescent “binge” and “heavy binge” drinking from adolescence to young adulthood; 2) Examine which characteristics of adolescent binge drinkers predict the persistence of “binge” and “heavy binge” alcohol use into young adulthood.

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### Key messages

- Half of the males and a third of females in a cohort of young Australians: reported past-week binge drinking in adolescence.
- The overwhelming majority of these adolescent binge drinkers continued to binge drink in young adulthood.
- Past-week binge drinking was reported in at least one young adulthood wave by around 70% of males and 48% of females who had not reported past-week binge drinking in adolescence.
- The high rate of persistence of binge drinking into adulthood indicates the need for policies to reduce its onset in adolescence such as limiting availability, increasing costs and discouraging drinking to intoxication.

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### Strengths and limitations

- This well-conducted prospective study, with very high retention, has provided unique prospective data on the persistence of a prevalent and hazardous drinking pattern into adulthood.
- The following limitations do need to be acknowledged. First, non-response in longitudinal studies is often associated with alcohol and drug use. We used multiple imputation to minimise the impact of this potential bias. Second, our data do not capture the full extent of binge drinking in this cohort because not all binge alcohol use will have been captured within the one week reference period. Both of these limitations mean that if anything our findings on levels of binge drinking are conservative in estimating total exposure to these levels of drinking overall and over time.
- Third, all data were based on self-report, however there is reasonable evidence that young people’s reports of alcohol use are both reliable and valid when reports are made in a confidential manner, and without any consequences for disclosing.
- Fourth, we used the same definition of binge and heavy binge drinking in adolescent and young adults. It is likely that the same amount of alcohol will have a greater adverse impact on adolescents than on adults.

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## Abstract

**Background Objectives:** Binge drinking in adolescence has become common in many countries but we know little about whether it persists into adulthood.

**Methods:** A 15-year prospective cohort study in Victoria, Australia. 1943 adolescents were recruited from secondary schools at age 14-15 years. Levels of past-week “binge” drinking (5+ standard drinks (SD) on a day, each 10g alcohol) and “heavy binge” drinking (20+ SD on a day for males, 11+ for females) were assessed during six adolescent waves, and across three adult waves up to age 29 years.

**Results:** Half of males (52%) and a third of females (34%) reported past-week binge drinking in adolescence. 90% of male and 70% of female adolescent-onset binge drinkers continued to binge drink into young adulthood. Seventy percent of males and 48% of females who were not adolescent-onset binge drinkers reported binge drinking in young adulthood. Past-week “heavy binge drinking”, reported by 19% of males and 15% females in adolescence, increased substantially in the young adult waves (38% males, 27% females in any adult wave). There was some evidence of a decline at 29 years. Among adolescent binge drinkers (n=821), young adult binge and heavy binge drinking were predicted by being male, adolescent antisocial behaviour, and adverse consequences of drinking in adolescence (intense drinking, physical harm, and sexual risk taking related to alcohol consumption).

**Conclusions:** Binge alcohol use is common and ~~persistent among young Australians~~ has a greater degree of persistence than other health risk behaviours that commonly arise in adolescence.

Efforts to prevent the onset of binge drinking during adolescence may substantially reduce harmful patterns of alcohol use in young adulthood.

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## Introduction

Alcohol is a major source of preventable disease burden among young people<sup>(1)(1)</sup>: it is thought to contribute to 320,000 deaths globally among 15-29 year olds each year, comprising 9% of all deaths in this group<sup>(2)</sup>; ~~the~~<sup>(2)</sup>. The burden attributable to alcohol use as a risk factor among young people aged 15-29 years (20 million disability adjusted life years (DALYs)) is thought to account for one third of all global alcohol attributable burden (59 million DALYs)<sup>(3)</sup>.

Alcohol use typically begins in adolescence<sup>(4, 5)</sup>. Although young people drink less often than adults<sup>(4)</sup>, they may consume larger amounts in a single session<sup>(6-8)</sup>. Among school students across 14 European countries in 2011, 41% reported past-month “binge” drinking (5+ standard alcoholic drinks<sup>(9)</sup>); levels in the United Kingdom were 54%<sup>(9)</sup>. Similar drinking levels occur in young Australians<sup>(10)</sup>. One in five Australian males and females 16-24 years report drinking 20+ and 11+ standard drinks in a session (each 10g alcohol), respectively, at least monthly in the past year<sup>(11)</sup>.

~~We do not know a great deal about how persistent binge alcohol use in adolescence is because few longitudinal studies have examined its natural history from adolescence into adulthood<sup>(12)</sup>. There have been many studies examining alcohol use among adolescents<sup>(12, 13)</sup>, risk factors for young adult consumption and alcohol use disorders<sup>(14-19)</sup>, and the impact of adolescent use upon health in young adulthood<sup>(13)</sup>. However, there has been little study of the strength of persistence of binge alcohol use from adolescence into young adulthood<sup>(20)</sup>. There are also few longitudinal data to inform clinicians about on the predictors of persistence of binge alcohol use into young adulthood for adolescent binge drinkers who they may see in their practice.~~ We investigated the persistence of binge drinking into adulthood using a 15-year prospective cohort study of young Australians that assessed alcohol use during adolescence and up to age 29 years.

We aimed to:

1. Examine the persistence of adolescent “binge” and “heavy binge” drinking from adolescence to young adulthood;
2. Examine which characteristics of adolescent binge drinkers predict the persistence of “binge” and “heavy binge” alcohol use into young adulthood.



## Methods

### Sample

Between August 1992 and 2007, we conducted nine waves of interviews with a cohort then resident in the state of Victoria, Australia (for more details see [\(13, 14\)](#), [\(21, 22\)](#)). At the beginning of the adolescent phase (waves 1-2) parental consent was obtained; in adult waves participants were informed in writing and gave verbal consent.

At baseline, a representative sample of the Victorian population of school pupils aged 14-15 years (year 9) was recruited. Retention in school to year 9 among Victorian young people in 1992-3 was 98%. A two-stage cluster sampling procedure was used, with two classes selected at random. [StageAt stage](#) one, 45 schools were randomly chosen from a stratified frame of government, Catholic and independent private schools. [StageAt stage](#) two, one class was selected at random from each participating school, entering in the last part of year 9 (wave 1), followed by a second class in the second wave six months later (wave 2). Participants were interviewed at 6-month intervals from 14-19 years (waves 3-6) with three waves in young adulthood: 20-21 years (wave 7), 24-25 years (wave 8), and 28-29 years (wave 9). In waves 1-6, participants self-administered the questionnaire on laptops, with telephone follow-up of those absent from school; waves 7-9 involved computer-assisted telephone interviews [\(15\)](#), [\(23\)](#). From a total of 2032 students, 1943 (95.6%) participated at least once in adolescence (Figure 1); 1756 (53% female) participated in at least one adult wave and were known to be alive at wave 9; 1282 completed all three adult waves; 293 completed two, and 181 completed one. By the end of wave 9, nine participants were known to have died, 108 lost to follow-up and 319 refused participation; 1501 participants were interviewed, 1407 of whom did the full (1383) or part (24) interview schedule, and 94 a paper questionnaire. In this paper, we only used adolescent data from waves 2-6 as over half of the adolescents did not participate in wave 1.

Figure 1 about here

### Measures

#### *Alcohol consumption*

Alcohol consumption was recorded at all adolescent and adult phases in an alcohol diary by any participants who reporting drinking in the previous week. In the adolescent phase, respondents completed a seven-day alcohol diary. In the adult phase, in order to minimise

respondent burden, participants were only asked to complete a four-day diary including all weekend days (Friday to Sunday) and the most recent weekday. Types of alcohol (beer, cider, spirits, mixed drinks, wine etc.), brand names, and the amounts consumed (glass, pint, bottle, can, etc.) were recorded. We calculated the number of standard drink (SD) units (10g alcohol) consumed on each day/occasion, and at each wave. Two measures of binge drinking were estimated (using the same definition in adolescent and adult phases).

(1) *'Binge' drinking*: Defined (at each wave) as having drunk 5 or more SDs standard drinks (each 10g alcohol) on at least one day during the diary week. Any *binge drinking* was defined in adolescence and adulthood as binge drinking on one or more adolescent waves during the respective phase. For each phase, we identified the number of waves in which binge drinking never occurred: none, one wave and ~~on~~ two or more waves (in adolescence, 2+ of five assessment waves; in adulthood; 2+ of three waves). *Persistent binge drinking* was defined as binge drinking on two or more waves.

(2) *'Heavy' binge drinking*: Defined as having drunk >20 SDs standard drinks for males and  $\geq 11$  SDs standard drinks for females on any day over the diary week (11). These levels were taken from a previous study of young people (11), using Australian National Health and Medical Research Council levels for definitions of "high risk" drinking for males and females. Any *'heavy' binge drinking* in adolescence and adulthood was defined as having done so on any wave. The number of waves in each phase was identified as above. *Persistence of 'heavy' binge drinking* was defined as drinking to this level on two or more waves (adolescence, 2+ of five waves; adulthood; 2+ of three waves).

*Incident binge drinking* was defined as first reporting binge or heavy binge drinking in young adulthood. *Continuity of binge drinking* and of *heavy binge drinking* was defined as the same pattern of drinking in adolescence and also adulthood. *Discontinuity* was defined as adolescent binge or heavy binge drinking without binge/heavy binge drinking in young adulthood.

### **Prognostic factors**

*Adolescent tobacco smoking* was assessed at each adolescent wave. Participants who reported smoking daily in the week prior to survey at any one adolescent wave were classified as daily smokers during adolescence.

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7 *Adolescent cannabis use* was assessed using reported frequency of use in the previous six  
8 months at each wave. Maximal cannabis use during the adolescent phases (i.e. most  
9 frequent level reported across any wave) was categorised as *none/occasional* and  
10 *daily/weekly*.

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13 *Adolescent antisocial behaviour* was assessed using 10 items from the Moffitt and Silva self-  
14 report early delinquency scale (16) that (24), which assessed property damage, interpersonal  
15 conflict and theft. Participants were asked if they had engaged in any of these behaviours  
16 *never, once, or more than once* in the last 6 months. *Antisocial behaviour* was defined as any  
17 antisocial behaviour on more than one adolescent wave, and/or 2+ behaviours in the same  
18 wave.  
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23 *Early onset sexual behaviour*: participants were asked if they had ever had sex (“gone all the  
24 way” or had sexual intercourse) at each ~~adolescence~~ adolescent wave and their age of first  
25 sex at each young adulthood wave. Those reporting sexual activity before 16 years were  
26 classified as *early onset sexually active*.  
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30 *Adolescent mental health* was assessed using the Clinical Interview Schedule (CIS-R) (17),  
31 ~~which assesses depression and anxiety in non-clinical populations; a cut-off of >11~~  
32 ~~defined~~ (25), which assesses depression and anxiety in non-clinical populations; a cut-off of  
33 >11 defines a mixed depression-anxiety state requiring clinical intervention. Mental health  
34 problems were summarised as having occurred: never, in one, or 2+ adolescent waves.  
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38 *Adolescent alcohol-related consequences*: Eight questions were asked about problems  
39 related to alcohol over the past six months in all adolescent waves. These were categorised  
40 into four types of consequences: *intense drinking*, (drank so much that the next day couldn't  
41 remember what you said/did); *alcohol-related social problems* (lost friends, had trouble at  
42 school, or argued with family, because of drinking); *alcohol-related injury, accident or*  
43 *violence* (violent and had a fight, or had an injury or an accident, because of drinking); and  
44 *alcohol-related sexual risk taking* (had sex without using contraceptives, had sex without  
45 using protection, or had sex and regretted it, because of drinking). For each of the four types  
46 of consequences, persistence in adolescence was defined as engaging in the behaviour  
47 either across multiple waves or more than once on one wave.  
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### Statistical Analysis

We calculated the prevalence of binge drinking at each wave and the number of waves on which each type of binge drinking occurred in adolescence and adulthood. We also estimated the continuity and discontinuity of binge and heavy binge drinking between the two phases. Among those reporting adolescent binge drinking, (n=821), logistic regression was used to investigate examine the prognosis for this group in terms of binge drinking. We investigated associations between adolescent predictors and any binge and heavy binge drinking in young adulthood. These associations were initially examined separately and then jointly in multivariable models. Interactions between the adolescent predictors and sex were examined in the multivariable models but evidence for differential sex effects was weak. In order to retain information from individuals with incomplete data (and thereby minimise the effects of participation bias), the prevalence of binge and heavy binge drinking during both adolescent and young adult phases was estimated using multiple imputation (18, 19) (26, 27) (see online appendix). All data analysis was undertaken using Stata 12 (2028).

### Ethics

The Ethics in Human Research Committee of the Royal Children's Hospital, Melbourne approved all data collection protocols.

### Role of the funding source

Funding to support the work for this manuscript was provided by Australian Rotary Health. Data collection for this study was supported by the National Health and Medical Research Council, Australia and the operational infrastructure support programme, Government of Victoria, Australia. The funders had no role in design, data collection or analysis, data interpretation, writing of the article or decision to publish. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

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## Results

The analysis utilised data from waves 2 to 9 for all participants (n=1934) who completed the survey at least once in adolescence (waves 2-6) and were alive at wave 9, with multiple imputation used for incomplete records. The results from ~~complete available~~ case analyses are presented in the **online appendix** ~~to show that there were no appreciable differences in;~~ the pattern of results was broadly similar compared to the imputed data.

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### Past-week Binge Drinking

Almost seven in eight males and two thirds of females reported binge drinking in the last week on at least one wave in adolescence and young adulthood. Nearly half of males and a quarter of females reported binge drinking both in adolescence and young adulthood. The overwhelming majority of adolescent-onset binge drinkers (nine in ten male and seven in ten female adolescent-onset binge drinkers) continued to binge drink in young adulthood (Table 1a). The number of young adult binge drinkers was increased by incident binge drinking among those who did not report binge drinking in adolescence: one third of males and females. Only 4.4% of males and 9.5% females who were adolescent binge drinkers did not report binge drinking in adulthood.

Past-week binge drinking (5+ ~~SDs~~standard drinks of 10g alcohol on a day) across adolescence (Figure 2a) increased ~~for in~~ males from 14.4% in wave 2 (mean age 15.5years) to 31.1% in wave 6 (17.4yrs) and ~~for in~~ females from 7.6% to 15.0%. Persistent adolescent past-week binge drinking (across 2+ adolescent waves) was reported by one in three males (31.8%) and one in seven females (15.3%; Table 1a). In the ~~adulthood~~adult waves, the prevalence of binge drinking was higher for males and females than in the adolescent phase and levels consumed for males were higher than females. In adulthood (Table 1a, Figure 2a), over eighty per cent of males reported binge drinking on at least one adult wave and more than half of females did so. Six in ten (59.1%) males and one in four (24.5%) females reported binge drinking across multiple adult waves (Table 1a).

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~~Only 15% of males and a third of females reported that they did not binge drink during adolescence or young adulthood. Almost seven in eight males and two thirds of females reported binge drinking in the last week on at least one wave in adolescence and young~~

~~adulthood. Nearly half of males and a quarter of females did so in adolescence and young adulthood. The overwhelming majority of adolescent-onset binge drinkers (nine in ten male and seven in ten female adolescent-onset binge drinkers) continued to binge drink in young adulthood (Table 1a). The number of binge drinkers was increased by incident binge drinking young adults who did not report binge drinking in adolescence: one third of males and females. Only 4.4% of males and 9.5% females who were adolescent binge drinkers did not report binge drinking in adulthood.~~

Figure 2a and 2b about here

### Past-week Heavy Binge Drinking

Just under half of the males (45.6%) and a third of females (36.2%) reported past-week heavy binge drinking at least once during adolescence or young adulthood (Table 1b). Sixty one percent of males and 42% of females who reported heavy binge drinking in adolescence continued into young adulthood. Of those who engaged in heavy binge drinking at any wave, 58% first reported doing so in young adulthood.

During adolescence, males and females reported similar levels of heavy binge use at each wave but males (7.9%) were more likely to ~~persist in report~~ heavy binge drinking on multiple adolescent waves than females (4.7%; Table 1b). Past-week heavy binge drinking did not increase substantially until the young adult waves (Figure 2b). Around two in five males and one in four females reported past-week heavy binge drinking on at least one adult wave (Table 1b). At ages 20 and 24 years, around 20% of males and 13% of females reported heavy binge drinking. There was a decline in past-week heavy binge drinking by age 29 years.

~~Just under half of the males (45.6%) and a third of females (36.2%) reported past-week heavy binge drinking at least once during adolescence or young adulthood (Table 1b). Sixty one percent of males and 42% of females who reported heavy binge drinking in adolescence, continued into young adulthood (Table 1b). Of those who engaged in heavy binge drinking at some point, 58% first reported doing so in young adulthood.~~

Table 1a and 1b about here

*Young adult binge and heavy binge alcohol use among adolescent-onset binge drinkers*

Levels of past-week binge and heavy binge drinking in adulthood, among adolescent-onset binge and heavy binge drinkers, are presented in Figure 3. Males with adolescent-onset binge drinking were more likely to continue binge drinking in adulthood than females (Figure 3a): around seven in ten males reported doing so, compared to fewer than half of females. By 29 years, female adolescent-onset binge drinkers had substantially lower levels of binge drinking than in earlier waves, and much lower levels than males. Levels of adult heavy binge drinking did not differ markedly by sex among adolescent-onset binge drinkers; around 20-30% reported past-week heavy binge drinking at ages 20 and 24, with lower levels at 29 years (wave 9; Figure 3a). Among adolescent-onset heavy binge drinkers, the patterns and levels followed a similar sex pattern to that in adolescent-onset binge drinkers (Figure 3b).

**Figure 3a and 3b about here**

Table 2 ~~presents the reports associations between adolescent~~ characteristics ~~that predicted and~~ binge and heavy binge drinking at any adult wave in adolescent-onset binge drinkers (n=821). At a univariate level, ~~among adolescent-onset binge drinkers, those who were being~~ male, ~~and with reporting~~ adolescent antisocial behaviour ~~were more likely to report or negative consequences of alcohol use in adolescence were associated with the reporting of~~ young adult binge and heavy binge drinking in the past week. ~~Among adolescent binge drinkers, those who reported negative consequences of alcohol use in adolescence were more likely to report adult binge and heavy binge alcohol use. Adolescent binge drinkers who reported early onset sexual activity and weekly/daily adolescent cannabis use also had higher odds of adult heavy binge drinking.~~ In multivariable analyses that included all covariates, ~~the associations between adult bingeing and~~ female ~~binge drinkers had lower odds than males of~~ gender were substantially unchanged (for young adult binge (OR 0.23, 95%CI 0.13-0.40) ~~and; for young adult~~ heavy binge use (OR 0.63, 95%CI 0.43-0.92). ~~Additionally, for heavy binge use, there was~~ Associations with behavioural characteristics were substantially attenuated when adjusted for sex and other characteristics, with the strongest independent effect being an increased risk if sexual risk taking had occurred in adolescence.

**Table 2 about here**

## Discussion

To our knowledge this is one of few longitudinal studies charting the persistence of binge use of alcohol from adolescence into young adulthood<sup>(12), (20)</sup>. Consistent with cross-sectional surveys in England<sup>(21)(29)</sup>, the USA, and Europe<sup>(5, 9)</sup>, ~~we found~~ binge drinking was highly prevalent in both sexes and normative in young Australian males. A substantial minority also engaged in ~~a~~ heavy binge drinking (drinking more than 20 drinks on an occasion). Over half of males and a third of females reported binge drinking in the past week at some time during adolescence, and one in five males and one in seven females reported what we defined as "heavy binge drinking".

The overwhelming majority of those who reported binge drinking in adolescence continued to do so in young adulthood. Even if past-week binge drinking was not reported in the teens, it was reported in at least one wave in young adulthood by 70% of males and 48% of females who did not report binge drinking at any time in adolescence.

Among those who reported binge drinking in adolescence, variables that predicted binge and heavy binge drinking in young adulthood included: regular (weekly+) cannabis use, antisocial behaviour, and early onset sexual activity. The most consistent predictors of both adult binge and heavy binge drinking were reporting adverse consequences of alcohol use in adolescence, namely "intense drinking" (could not remember the night before because of drinking), social problems, sexual risk taking and physical harm. Adolescent binge drinkers who engaged in other risky behaviours, and who had experienced negative consequences of alcohol use, were most likely to continue drinking at these levels in adulthood. ~~At a~~ ~~multivariate level~~<sup>In multivariable regression analysis</sup>, the strongest independent predictor of adult binge drinking among adolescent binge drinkers was being male.

### Limitations

The following limitations need to be acknowledged. First, non-response in longitudinal studies is often associated with alcohol and drug use. We used multiple imputation to minimise the impact of this potential bias, but this method carries its own assumptions and it is difficult to assess exactly how much residual bias might remain. The method of multiple imputation also assumes that data were missing at random. This is unlikely to be strictly true



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7 but the method is strengthened by the inclusion of auxiliary variables in the imputation  
8 model.

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10 Second, our data do not capture the full extent of binge drinking in this cohort because not  
11 all binge alcohol use will have been captured within the one week reference period. Both of  
12 these limitations mean that our findings on levels of binge drinking may underestimate total  
13 exposure to these levels of drinking overall and over time.

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17 Third, all data were based on self-report. There is reasonable evidence that young people's  
18 reports of alcohol use are both reliable and valid when reports are made in a confidential  
19 manner, and without any consequences for disclosing use (as was the case here) (30, 31).

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23 Fourth, we used the same definition of binge and heavy binge drinking in adolescents and  
24 young adults. It is likely that the same amount of alcohol will have a greater adverse impact  
25 on adolescents than on adults. Notwithstanding these limitations, this study has provided  
26 unique prospective data on the persistence of a prevalent and hazardous drinking pattern  
27 from adolescence into adulthood.

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31 We have clearly identified that binge alcohol use is a common behaviour among  
32 adolescents, and that it is likely to persist into young adulthood. These patterns of binge  
33 drinking in adolescence are a public health concern for two reasons. First, heavy alcohol use  
34 substantially increases the risks of: motor vehicle accidents, other injuries, alcohol-related  
35 assaults, and suicides in young people(22). ~~Secondly the longer-term health effects of~~  
36 ~~persistent binge drinking include:(32). Second, the longer-term health effects of persistent~~  
37 ~~binge drinking during adulthood include~~ alcohol dependence, liver disease and cancer. In  
38 most adolescent binge drinkers, binge drinking was clearly not just an "adolescent phase"; it  
39 was a pattern that persisted into young adulthood. There is an urgent need to understand  
40 why such high levels of alcohol use in adolescence continue into young adulthood.

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48 ~~early initiation and continuing high levels of consumption. Both the taste(23) and~~  
49 ~~packaging(24) of pre-mixed drinks are particularly attractive to young people; exposure to~~  
50 ~~some forms of advertising is also associated with increased consumption(25), as are~~  
51 ~~increased numbers of outlets selling alcohol~~  
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9 drinks are particularly attractive to young people; exposure to some forms of advertising is  
10 also associated with increased consumption (35), as are increased numbers of outlets selling  
11 alcohol (26-28)(36-38), extended opening hours(29, 30), and reduced alcohol taxes(29, 31)  
12 (though only applied similarly across products(32)). The persistence of binge drinking into  
13 young adulthood may also be related to a delay in 'maturing out' of drinking as a result of  
14 the postponement of major social role transitions such as marriage and parenthood into  
15 later adulthood, extended opening hours(39, 40), and reduced alcohol taxes (39, 41)  
16 (though only applied similarly across products(42)). The persistence of binge drinking into  
17 young adulthood may also be related to a delay in 'maturing out' of drinking as a result of  
18 the postponement in recent cohorts of major social role transitions such as marriage and  
19 parenthood into later adulthood(33)(43).

### 27 **Limitations**

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30 ~~studies is often associated with alcohol and drug use. We used multiple imputation to~~  
31 ~~minimise the impact of this potential bias, but this method carries its own assumptions and~~  
32 ~~it is difficult to assess exactly how much residual bias might remain. The method of multiple~~  
33 ~~imputation assumes that data were missing at random, an assumption that is strengthened~~  
34 ~~by the inclusion of auxiliary variables in the imputation model, but this assumption is~~  
35 ~~unlikely to be true.~~

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44 ~~conservative in estimating total exposure to these levels of drinking overall and over time.~~

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51 ~~here)(34, 35).~~

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8 young adults. It is likely that the same amount of alcohol will have a greater adverse impact  
9 on adolescents than on adults. Notwithstanding these limitations, this study has provided  
10 unique prospective data on the persistence of a prevalent and hazardous drinking pattern  
11 into adulthood.  
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## 14 Conclusions

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16 Alcohol is one of the biggest risk factors for disease burden among young people. Heavy  
17 consumption in young people is common and persistence into young adulthood is much  
18 more likely than not. ~~The adoption of policies and interventions to reduce availability,~~  
19 ~~increase costs and discourage drinking to intoxication are urgently needed~~ There is a need to  
20 develop interventions that explicitly acknowledge that prevention confined to adolescence  
21 alone is insufficient. Clearly there is much work still to be done in that area, given the  
22 incredibly high exposure not only to any alcohol use, but to binge alcohol use, across the  
23 adolescent years, often repeatedly. It is also apparent that there is work to be done in  
24 young adulthood since most of the heavy binge drinking began then, once participants were  
25 legally allowed to drink, and past the age at which most prevention messages are targeted.  
26 There is an increasingly delayed uptake of social role transitions; it is unclear whether such  
27 shifts are related to the patterns of alcohol consumption we observed here. The adoption of  
28 policies and interventions including those to reduce alcohol availability (via shortened  
29 trading hours, and fewer outlets), increase cost (via taxation) and discourage drinking to  
30 intoxication, may assist in reducing binge alcohol use in future cohorts of young people.  
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**Author contributions**

LD, GP, WS and CO'L conceived of the study. CO'L and HR conducted the analyses. LD led the writing of the manuscript. All authors commented on the analytic plan, interpretation, and contributed to the editing and final approval of the manuscript.

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8 **Figure legends**  
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10 **Figure 1: Sampling and ascertainment in the Victorian Adolescent Health Cohort, 1992 to 2008**

11  
12 **Figure 2a: Levels of past week binge alcohol use among males and females (5 or more standard drinks on a day in the past week) by age**

13  
14 **Figure 2b: Levels of past week "heavy binge" alcohol use among males and females (11 or more standard drinks on a day in the past week for females, 20 or more for males) by age**

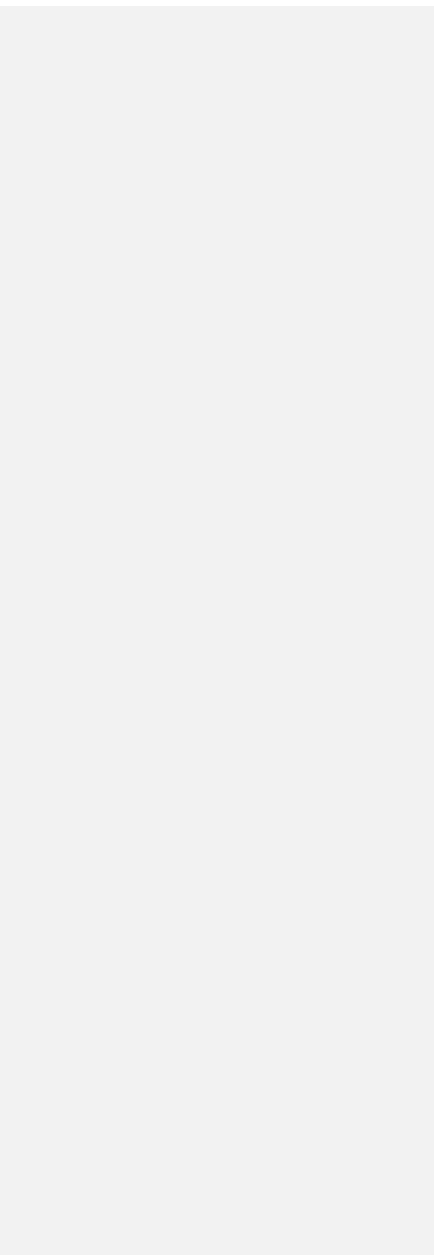
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17 **Figure 3a: Levels of past week binge and "heavy binge" drinking for males and females who reported binge drinking at one or more waves in adolescence, by age**

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19  
20 **Figure 3b: Levels of past week binge and "heavy binge" drinking for males and females who reported "heavy binge" drinking at one or more wave in adolescence, by age**  
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Table 1a. Past week binge drinking during adolescence and young adulthood, by sex

|   | Binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                   |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                               | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 135                             | 14.4 | (12.1 - 16.7) | 76              | 7.6  | (5.90 - 9.30) | 211            | 10.9 | (9.50 - 12.3) |
| Wave 3 (mean age 15.9 years)  | 170                             | 18.1 | (15.5 - 20.7) | 96              | 9.6  | (7.50 - 11.7) | 265            | 13.7 | (12.1 - 15.4) |
| Wave 4 (mean age 16.4 years)  | 208                             | 22.3 | (19.3 - 25.3) | 140             | 14.1 | (11.8 - 16.3) | 349            | 18.0 | (16.2 - 19.9) |
| Wave 5 (mean age 16.8 years)  | 265                             | 28.3 | (25.1 - 31.5) | 152             | 15.2 | (12.9 - 17.6) | 417            | 21.6 | (19.6 - 23.5) |
| Wave 6 (mean age 17.4 years)  | 291                             | 31.1 | (28.0 - 34.3) | 150             | 15.0 | (12.6 - 17.4) | 441            | 22.8 | (20.8 - 24.8) |
| <b>Number of adolescent waves of any binge drinking</b>   |                                 |      |               |                 |      |               |                |      |               |
| Never   | 453                             | 48.5 | (45.0 - 52.0) | 660             | 66.1 | (63.0 - 69.1) | 1113           | 57.6 | (55.2 - 60.0) |
| 1 wave  | 184                             | 19.7 | (16.8 - 22.6) | 186             | 18.6 | (16.0 - 21.2) | 370            | 19.1 | (17.1 - 21.1) |
| 2+ waves  | 297                             | 31.8 | (28.5 - 35.1) | 153             | 15.3 | (13.0 - 17.7) | 451            | 23.3 | (21.3 - 25.3) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 509                             | 54.5 | (51.1 - 57.9) | 318             | 31.8 | (28.7 - 34.9) | 827            | 42.8 | (40.4 - 45.1) |
| Wave 8 (mean age 24.1 years)  | 550                             | 58.8 | (55.2 - 62.4) | 335             | 33.5 | (30.3 - 36.7) | 885            | 45.8 | (43.3 - 48.2) |
| Wave 9 (mean age 29.0 years)  | 524                             | 56.1 | (52.3 - 59.8) | 233             | 23.3 | (20.2 - 26.4) | 757            | 39.2 | (36.6 - 41.8) |
| <b>Number of adult waves of any binge drinking</b>  |                                 |      |               |                 |      |               |                |      |               |
| Never   | 178                             | 19.1 | (16.2 - 21.9) | 437             | 43.8 | (40.4 - 47.1) | 616            | 31.8 | (29.6 - 34.1) |
| 1 wave  | 204                             | 21.8 | (18.9 - 24.8) | 316             | 31.7 | (28.4 - 35.0) | 521            | 26.9 | (24.7 - 29.1) |
| 2+ waves  | 552                             | 59.1 | (55.7 - 62.5) | 245             | 24.5 | (21.5 - 27.6) | 798            | 41.2 | (38.8 - 43.7) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                 |      |               |                 |      |               |                |      |               |
| None in either phase  | 137                             | 14.7 | (12.2 - 17.2) | 342             | 34.2 | (31.0 - 37.5) | 479            | 24.8 | (22.7 - 26.9) |
| Incident in young adulthood   | 316                             | 33.8 | (30.3 - 37.3) | 318             | 31.9 | (28.7 - 35.0) | 634            | 32.8 | (30.4 - 35.2) |
| Remitted by young adulthood (adolescence only)  | 41                              | 4.4  | (2.80 - 6.00) | 95              | 9.5  | (7.50 - 11.6) | 136            | 7.1  | (5.80 - 8.30) |
| Continuing in young adulthood (both phases)   | 441                             | 47.1 | (43.5 - 50.7) | 244             | 24.4 | (21.6 - 27.2) | 684            | 35.4 | (33.1 - 37.7) |

Note: <sup>a</sup>Binge drinking defined as 5 or more drinks in one day in the past week.

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Table 1b. Past week heavy binge drinking during adolescence and young adulthood, by sex

|   | Heavy binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                         |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                                     | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 44                                    | 4.8  | (3.40 - 6.10) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.80) |
| Wave 3 (mean age 15.9 years)  | 45                                    | 4.8  | (3.40 - 6.20) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.90) |
| Wave 4 (mean age 16.4 years)  | 49                                    | 5.2  | (3.70 - 6.70) | 54              | 5.4  | (4.00 - 6.90) | 103            | 5.3  | (4.30 - 6.30) |
| Wave 5 (mean age 16.8 years)  | 79                                    | 8.5  | (6.40 - 10.5) | 66              | 6.6  | (5.00 - 8.10) | 145            | 7.5  | (6.20 - 8.80) |
| Wave 6 (mean age 17.4 years)  | 67                                    | 7.1  | (5.20 - 9.00) | 38              | 3.8  | (2.60 - 5.00) | 105            | 5.4  | (4.30 - 6.50) |
| <b>Number of adolescent waves of any heavy binge drinking</b>                                   |                                       |      |               |                 |      |               |                |      |               |
| Never   | 755                                   | 80.7 | (78.1 - 83.4) | 847             | 84.7 | (82.5 - 87.0) | 1601           | 82.8 | (81.1 - 84.5) |
| 1 wave  | 106                                   | 11.4 | (9.10 - 13.6) | 106             | 10.6 | (8.60 - 12.5) | 212            | 11.0 | (9.50 - 12.4) |
| 2+ waves  | 74                                    | 7.9  | (6.10 - 9.70) | 47              | 4.7  | (3.30 - 6.00) | 121            | 6.2  | (5.10 - 7.30) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 177                                   | 18.9 | (16.3 - 21.6) | 134             | 13.4 | (11.2 - 15.6) | 311            | 16.1 | (14.4 - 17.8) |
| Wave 8 (mean age 24.1 years)  | 201                                   | 21.4 | (18.7 - 24.2) | 135             | 13.5 | (11.3 - 15.8) | 336            | 17.4 | (15.6 - 19.1) |
| Wave 9 (mean age 29.0 years)  | 132                                   | 14.1 | (11.4 - 16.7) | 78              | 7.8  | (6.10 - 9.60) | 210            | 10.8 | (9.30 - 12.4) |
| <b>Number of adult waves of any heavy binge drinking</b>  |                                       |      |               |                 |      |               |                |      |               |
| Never   | 579                                   | 62   | (58.7 - 65.3) | 726             | 72.7 | (69.7 - 75.6) | 1305           | 67.5 | (65.2 - 69.7) |
| 1 wave  | 230                                   | 24.6 | (21.4 - 27.8) | 212             | 21.2 | (18.5 - 23.9) | 442            | 22.8 | (20.7 - 25.0) |
| 2+ waves  | 125                                   | 13.4 | (10.9 - 15.9) | 62              | 6.2  | (4.60 - 7.70) | 187            | 9.7  | (8.20 - 11.1) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                       |      |               |                 |      |               |                |      |               |
| None in either phase  | 508                                   | 54.4 | (50.9 - 57.8) | 638             | 63.8 | (60.7 - 66.9) | 1146           | 59.2 | (56.9 - 61.6) |
| Incident in young adulthood   | 247                                   | 26.4 | (23.3 - 29.5) | 209             | 20.9 | (18.3 - 23.5) | 456            | 23.6 | (21.5 - 25.6) |
| Remitted by young adulthood (adolescence only)  | 71                                    | 7.6  | (5.80 - 9.50) | 88              | 8.8  | (7.00 - 10.7) | 160            | 8.2  | (6.90 - 9.60) |
| Continuing in young adulthood (both phases)   | 109                                   | 11.6 | (9.30 - 14.0) | 64              | 6.4  | (4.80 - 8.10) | 173            | 9.0  | (7.60 - 10.3) |

Note: *'Heavy binge' drinking defined as >11 drinks on a day in the past week for females, >20 for males. Persistent "heavy binge" drinking in adolescence defined as heavy binge drinking in the past week on two or more waves across the adolescent waves (waves 2 to 6).*

**Table 2: Predictors of binge alcohol use in young adulthood among adolescent “binge”/“binge’ alcohol drinkers (i.e. those who had past-week binge drinking on at least one wave during adolescence, waves 2-6; n=821)**

| Adolescent predictors among adolescent ‘binge’ drinkers, n=821: | Young adult ‘binge’ drinking   |               |                           |               | Young adult ‘heavy binge’ drinking |               |                           |               |
|---|--------------------------------|---------------|---------------------------|---------------|------------------------------------|---------------|---------------------------|---------------|
|   | Univariate Modelled separately |               | Adjusted Modelled jointly |               | Univariate Modelled separately     |               | Adjusted Modelled jointly |               |
|   | OR                             | (95% CI)      | OR                        | (95% CI)      | OR                                 | (95% CI)      | OR                        | (95% CI)      |
| Female  | 0.24                           | (0.15 - 0.39) | 0.23                      | (0.13 - 0.40) | 0.67                               | (0.49 - 0.92) | 0.63                      | (0.43 - 0.92) |
| Daily smoking   | 1.20                           | (0.79 - 1.81) | 1.12                      | (0.69 - 1.82) | 1.29                               | (0.94 - 1.77) | 1.01                      | (0.70 - 1.46) |
| Weekly/daily cannabis use                                       | 1.65                           | (0.96 - 2.82) | 1.05                      | (0.54 - 2.03) | 1.57                               | (1.11 - 2.24) | 1.06                      | (0.71 - 1.60) |
| Antisocial behaviour  | 1.70                           | (1.12 - 2.59) | 0.99                      | (0.60 - 1.63) | 1.59                               | (1.16 - 2.18) | 1.06                      | (0.74 - 1.52) |
| Early onset sexual activity (<16 years)                         | 1.46                           | (0.92 - 2.33) | 1.04                      | (0.60 - 1.83) | 1.53                               | (1.09 - 2.14) | 1.02                      | (0.69 - 1.49) |
| <b>Adolescent mental health problems</b>                        |                                |               |                           |               |                                    |               |                           |               |
| CIS >11, 0 waves  | 1                              |               | 1                         |               | 1                                  |               | 1                         |               |
| CIS >11, 1 wave   | 0.81                           | (0.42 - 1.57) | 0.90                      | (0.44 - 1.81) | 1.23                               | (0.81 - 1.87) | 1.15                      | (0.74 - 1.77) |
| CIS >11, 2+ waves   | 0.60                           | (0.37 - 0.97) | 0.83                      | (0.48 - 1.46) | 1.05                               | (0.74 - 1.49) | 0.99                      | (0.64 - 1.52) |
| <b>Adolescent consequences attributed to alcohol use</b>        |                                |               |                           |               |                                    |               |                           |               |
| Intense drinking <sup>1</sup>                                   | 1.54                           | (1.00 - 2.36) | 1.45                      | (0.84 - 2.50) | 1.77                               | (1.28 - 2.43) | 1.41                      | (0.99 - 2.00) |
| Social problems <sup>2</sup>                                    | 1.34                           | (0.85 - 2.10) | 1.25                      | (0.72 - 2.18) | 1.63                               | (1.16 - 2.31) | 1.23                      | (0.83 - 1.83) |
| Physical harm <sup>3</sup>                                      | 1.92                           | (1.13 - 3.26) | 1.25                      | (0.64 - 2.44) | 1.96                               | (1.37 - 2.81) | 1.29                      | (0.84 - 1.96) |
| Sexual risk taking <sup>4</sup>                                 | 1.75                           | (1.01 - 3.03) | 1.51                      | (0.77 - 2.97) | 2.09                               | (1.44 - 3.03) | 1.64                      | (1.07 - 2.53) |

Note: ‘Binge’ drinking defined as 5 or more drinks in one day in the past week. ‘Heavy binge’ drinking defined as >11 drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

<sup>1</sup> Couldn’t remember what said or did the night before as a result of alcohol use

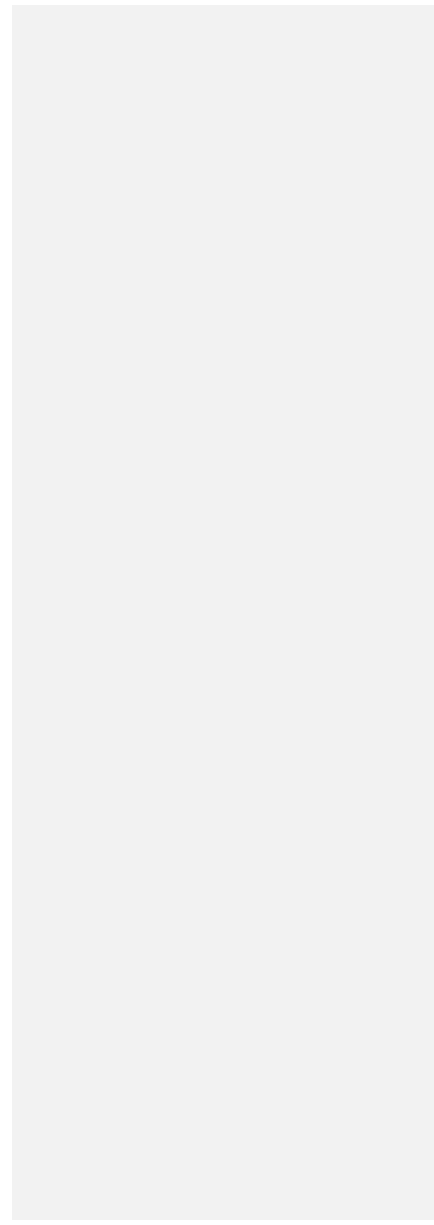
<sup>2</sup> Lost friends, school trouble, argued with family as a result of alcohol use

<sup>3</sup> Injuries, accidents, violence attributed to their alcohol use

<sup>4</sup> Regretted having sex, or had sex without protection or contraceptives as a result of alcohol use

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## Online appendix: Approach to multiple imputation

Missing data were handled using multiple imputation<sup>1</sup>. We imputed 20 complete datasets separately for males and females, under a multivariate normal model, incorporating all the analysis and auxiliary variables at each wave, except age and sexual risk-taking in adolescence, which was imputed as a binary summary measure. Wave 1 was omitted as it contained observations from only 46% of the cohort. Wave 1 responses were used to fill in wave 2 data, for any participant not seen at wave 2 as the same measures had been collected at the earlier wave. Waves 2 to 9 were imputed for all participants (N=1943) who completed the survey at least once in adolescence (waves 2-6). The imputation model contained 49 key variables used in the analysis and 8 auxiliary variables. Of 57 variables included in the imputation model, 18% of the variables had <10% missing values, 46% had ≥10% to <20% missing, 28% had ≥20% to <30% missing and only 5 variables (9%) had ≥45% to <55% missing values. A maximum level of drinking variable was created at each wave, with three levels: *no binge drinking*, *binge drinking* and *extreme binge drinking*. These variables and alcohol consequences variables were log transformed before imputation. Smoking, cannabis use, antisocial behaviour, mental health and summary measures of sexual risk-taking were imputed as binary variables at each wave. Age was imputed as a normal variable. After imputation, transformed variables were converted back to their original scale and all were categorised for analysis, with adaptive rounding used for binary measures<sup>2</sup>. Nine deceased participants were excluded from the imputed datasets. Frequencies and odds ratios were obtained by averaging results across the imputed datasets; inferences under multiple imputation were made using Rubin's rules<sup>1</sup>.

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**The persistence of adolescent binge drinking into adulthood: Findings from a 15-year prospective cohort study**

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# The persistence of adolescent binge drinking into adulthood: Findings from a 15-year prospective cohort study

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## Article summary

### Article focus

- Alcohol is a major source of preventable disease burden among young people.
- Although young people drink less often than adults, they may consume large amounts in a single session ('binge' drinking).
- We aimed to: 1) Examine the persistence of adolescent "binge" and "heavy binge" drinking from adolescence to young adulthood; 2) Examine which characteristics of adolescent binge drinkers predict the persistence of "binge" and "heavy binge" alcohol use into young adulthood.

### Key messages

- Half of the males and a third of females in a cohort of young Australians: reported past-week binge drinking in adolescence.
- The overwhelming majority of these adolescent binge drinkers continued to binge drink in young adulthood.
- Past-week binge drinking was reported in at least one young adulthood wave by around 70% of males and 48% of females who had not reported past-week binge drinking in adolescence.
- The high rate of persistence of binge drinking into adulthood indicates the need for policies to reduce its onset in adolescence such as limiting availability, increasing costs and discouraging drinking to intoxication.

### Strengths and limitations

- This well-conducted prospective study, with very high retention, has provided unique prospective data on the persistence of a prevalent and hazardous drinking pattern into adulthood.
- The following limitations do need to be acknowledged. First, non-response in longitudinal studies is often associated with alcohol and drug use. We used multiple imputation to minimise the impact of this potential bias. Second, our data do not capture the full extent of binge drinking in this cohort because not all binge alcohol use will have been captured within the one week reference period. Both of these limitations mean that if anything our findings on levels of binge drinking are conservative in estimating total exposure to these levels of drinking overall and over time.
- Third, all data were based on self-report, however there is reasonable evidence that young people's reports of alcohol use are both reliable and valid when reports are made in a confidential manner, and without any consequences for disclosing.
- Fourth, we used the same definition of binge and heavy binge drinking in adolescent and young adults. It is likely that the same amount of alcohol will have a greater adverse impact on adolescents than on adults.

## Abstract

Objectives: To examine the prevalence of binge drinking in adolescence and its persistence into adulthood in an Australian cohort.

Design: 15-year prospective cohort study.

Setting: Victoria, Australia.

Participants: 1943 adolescents were recruited from secondary schools at age 14-15 years.

Primary outcome measures: Levels of past-week "binge" drinking (5+ standard drinks (SD) on a day, each 10g alcohol) and "heavy binge" drinking (20+ SD on a day for males, 11+ for females) were assessed during six adolescent waves, and across three adult waves up to age 29 years.

Results: Half of males (52%) and a third of females (34%) reported past-week adolescent binge drinking. 90% of male and 70% of female adolescent-onset binge drinkers continued to binge in young adulthood; 70% of males and 48% of females who were not adolescent-onset binge drinkers reported young adult binge drinking. Past-week heavy bingeing was less common in adolescence than adulthood. Overall, 35% of the sample (95%CI 33-38%) reported past-week binge drinking in both adolescence and young adulthood and one third (33%; 30-35%) first reported binge drinking in young adulthood; only 7% of the sample (6-8%) had binge drinking in adolescence but not young adulthood. "Heavy binge" drinking occurred in both adolescence and young adulthood for 9% (8-10%); 8% (7-10%) reported it in adolescence but no longer in young adulthood; and 24% (22-26%) began "heavy binge" drinking in young adulthood. Among adolescent binge drinkers (n=821), young adult binge and heavy binge drinking were predicted by being male, adolescent antisocial behaviour, and adverse consequences of drinking in adolescence.

Conclusions: Binge alcohol use is common and persistent among young Australians. Efforts to prevent the onset of binge drinking during adolescence may substantially reduce harmful patterns of alcohol use in young adulthood.

## Introduction

Alcohol is a major source of preventable disease burden among young people(1): it is thought to contribute to 320,000 deaths globally among 15-29 year olds each year, comprising 9% of all deaths in this group(2). The burden attributable to alcohol use as a risk factor among young people aged 15-29 years (20 million disability adjusted life years (DALYs)) is thought to account for one third of all global alcohol attributable burden (59 million DALYs)(3).

Alcohol use typically begins in adolescence(4, 5). Although young people drink less often than adults(4), they may consume larger amounts in a single session(6-8). Among school students across 14 European countries in 2011, 41% reported past-month “binge” drinking (5+ standard alcoholic drinks(9)); levels in the United Kingdom were 54%(9). Similar drinking levels occur in young Australians(10). One in five Australian males and females 16-24 years report drinking 20+ and 11+ standard drinks in a session (each 10g alcohol), respectively, at least monthly in the past year(11).

There have been many studies examining alcohol use among adolescents(12, 13), risk factors for young adult consumption and alcohol use disorders(14-19), and the impact of adolescent use upon health in young adulthood(13). However to our knowledge there has not been a study of the course of adolescent binge drinking in a cohort study of young Australians(20). We investigated the persistence of binge drinking into adulthood among Australian young people using a 15-year prospective cohort study of young Australians that assessed alcohol use during adolescence and up to age 29 years. We also examined the predictors of persistence of binge alcohol use into young adulthood among adolescent binge drinkers.

We aimed to:

1. Examine the persistence of adolescent “binge” and “heavy binge” drinking from adolescence to young adulthood;
2. Examine which characteristics of adolescent binge drinkers predict the persistence of “binge” and “heavy binge” alcohol use into young adulthood.

## Methods

### Sample

Between August 1992 and 2007, we conducted nine waves of interviews with a cohort then resident in the state of Victoria, Australia (for more details see(21, 22)). At the beginning of the adolescent phase (waves 1-2) parental consent was obtained; in adult waves participants were informed in writing and gave verbal consent.

At baseline, a representative sample of the Victorian population of school pupils aged 14-15 years (year 9) was recruited. Retention in school to year 9 among Victorian young people in 1992-3 was 98%. A two-stage cluster sampling procedure was used, with two classes selected at random. At stage one, 45 schools were randomly chosen from a stratified frame of government, Catholic and independent private schools. At stage two, one class was selected at random from each participating school, entering in the last part of year 9 (wave 1), followed by a second class in the second wave six months later (wave 2). Participants were interviewed at 6-month intervals from 14-19 years (waves 3-6) with three waves in young adulthood: 20-21 years (wave 7), 24-25 years (wave 8), and 28-29 years (wave 9). In waves 1-6, participants self-administered the questionnaire on laptops, with telephone follow-up of those absent from school; waves 7-9 involved computer-assisted telephone interviews(23).

Figure 1 about here

### Measures

#### *Alcohol consumption*

Alcohol consumption was recorded at all adolescent and adult phases in an alcohol diary by any participants who reporting drinking in the previous week. In the adolescent phase, respondents completed a seven-day alcohol diary. In the adult phase, in order to minimise respondent burden, participants were only asked to complete a four-day diary including all weekend days (Friday to Sunday) and the most recent weekday. Types of alcohol (beer, cider, spirits, mixed drinks, wine etc.), brand names, and the amounts consumed (glass, pint, bottle, can, etc.) were recorded. We calculated the number of standard drink units (10g alcohol) consumed on each day/occasion, and at each wave. Two measures of binge drinking were estimated (using the same definition in adolescent and adult phases).

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3 (1) *'Binge' drinking*: Defined (at each wave) as having drunk 5 or more standard drinks (each  
4 10g alcohol) on at least one day during the diary week. *Any binge drinking* was defined  
5 in adolescence and adulthood as binge drinking on one or more waves during the  
6 respective phase. For each phase, we identified the number of waves in which binge  
7 drinking occurred: none, one wave and two or more waves (in adolescence, 2+ of five  
8 assessment waves; in adulthood; 2+ of three waves). *Persistent binge drinking* was  
9 defined as binge drinking on two or more waves.
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12 (2) *'Heavy' binge drinking*: Defined as having drunk >20 standard drinks for males and  $\geq 11$   
13 standard drinks for females on any day over the diary week (11). These levels were  
14 taken from a previous study of young people (11), using Australian National Health and  
15 Medical Research Council definitions of "high risk" drinking for males and females. *Any*  
16 *'heavy' binge drinking* in adolescence and adulthood was defined as having done so on  
17 any wave. The number of waves in each phase was identified as above. *Persistence of*  
18 *'heavy' binge drinking* was defined as drinking to this level on two or more waves  
19 (adolescence, 2+ of five waves; adulthood; 2+ of three waves).

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22 *Incident binge drinking* was defined as first reporting binge or heavy binge drinking in young  
23 adulthood. *Continuity of binge drinking* and of *heavy binge drinking* was defined as the same  
24 pattern of drinking in adolescence and also adulthood. *Discontinuity* was defined as  
25 adolescent binge or heavy binge drinking without binge/heavy binge drinking in young  
26 adulthood.

### 27 **Prognostic factors**

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30 *Adolescent tobacco smoking* was assessed at each adolescent wave. Participants who  
31 reported smoking daily in the week prior to survey at any one adolescent wave were  
32 classified as daily smokers during adolescence.

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35 *Adolescent cannabis use* was assessed using reported frequency of use in the previous six  
36 months at each wave. Maximal cannabis use during the adolescent phases (i.e. most  
37 frequent level reported across any wave) was categorised as *none/occasional* and  
38 *daily/weekly*.

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3 *Adolescent antisocial behaviour* was assessed using 10 items from the Moffitt and Silva self-report early delinquency scale(24), which assessed property damage, interpersonal conflict and theft. Participants were asked if they had engaged in any of these behaviours *never*,  
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13 *once*, or *more than once* in the last 6 months. *Antisocial behaviour* was defined as any antisocial behaviour on more than one adolescent wave, and/or 2+ behaviours in the same wave.

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15 *Early onset sexual behaviour*: participants were asked if they had ever had sex (“gone all the way” or had sexual intercourse) at each adolescent wave and their age of first sex at each  
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*young adulthood wave*. Those reporting sexual activity before 16 years were classified as *early onset sexually active*.

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*Adolescent mental health* was assessed using the Clinical Interview Schedule (CIS-R)(25), which assesses depression and anxiety in non-clinical populations; a cut-off of >11 defines a mixed depression-anxiety state requiring clinical intervention . Mental health problems were summarised as having occurred: never, in one, or 2+ adolescent waves.

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*Adolescent alcohol-related consequences*: Eight questions were asked about problems related to alcohol over the past six months in all adolescent waves. These were categorised into four types of consequences: *intense drinking* (drank so much that the next day couldn’t remember what you said/did); *alcohol-related social problems* (lost friends, had trouble at school, or argued with family, because of drinking); *alcohol-related injury, accident or violence* (violent and had a fight, or had an injury or an accident, because of drinking); and *alcohol-related sexual risk taking* (had sex without using contraceptives, had sex without using protection, or had sex and regretted it, because of drinking). For each of the four types of consequences, persistence in adolescence was defined as engaging in the behaviour either across multiple waves or more than once on one wave.

### Statistical Analysis

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We calculated the prevalence of binge drinking at each wave and the number of waves on which each type of binge drinking occurred in adolescence and adulthood. We also estimated the continuity and discontinuity of binge and heavy binge drinking between the two phases. Among those reporting adolescent binge drinking (n=821), logistic regression was used to examine the prognosis for this group in terms of binge drinking. We

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3 investigated associations between adolescent predictors and any binge and heavy binge  
4 drinking in young adulthood. These associations were initially examined separately and then  
5 jointly in multivariable models. Interactions between the adolescent predictors and sex  
6 were examined in the multivariable models but evidence for differential sex effects was  
7 weak. In order to retain information from individuals with incomplete data (and thereby  
8 minimise the effects of participation bias), the prevalence of binge and heavy binge drinking  
9 during both adolescent and young adult phases was estimated using multiple  
10 imputation(26, 27) (see online appendix). All data analysis was undertaken using Stata  
11 12(28).  
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### 20 Ethics

21 The Ethics in Human Research Committee of the Royal Children's Hospital, Melbourne  
22 approved all data collection protocols.  
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27 Data collection for this study was supported by the National Health and Medical Research  
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29 Victoria, Australia. The funders had no role in design, data collection or analysis, data  
30 interpretation, writing of the article or decision to publish. The corresponding author had  
31 full access to all the data in the study and had final responsibility for the decision to submit  
32 for publication.  
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## Results

From a total of 2032 students, 1943 (95.6%) participated at least once in adolescence (Figure 1); 1756 (53% female) participated in at least one adult wave and were known to be alive at wave 9; 1282 completed all three adult waves; 293 completed two, and 181 completed one. By the end of wave 9, nine participants were known to have died, 108 lost to follow-up and 319 refused participation; 1501 participants were interviewed, 1407 of whom did the full (1383) or part (24) interview schedule, and 94 a paper questionnaire. In this paper, we only used adolescent data from waves 2-6 as over half of the adolescents did not participate in wave 1.

The analysis utilised data from waves 2 to 9 for all participants (n=1934) who completed the survey at least once in adolescence (waves 2-6) and were alive at wave 9, with multiple imputation used for incomplete records. The results from available case analyses are presented in the **online appendix**; the pattern of results was broadly similar compared to the imputed data.

### Past-week Binge Drinking

Almost seven in eight males and two thirds of females reported binge drinking in the last week on at least one wave in adolescence and young adulthood. Nearly half of males and a quarter of females reported binge drinking both in adolescence *and* young adulthood. The overwhelming majority of adolescent-onset binge drinkers (nine in ten male and seven in ten female adolescent-onset binge drinkers) continued to binge drink in young adulthood (Table 1a). The number of young adult binge drinkers was increased by incident binge drinking among those who did not report binge drinking in adolescence: one third of males and females. Only 4.4% of males and 9.5% females who were adolescent binge drinkers did not report binge drinking in adulthood.

Past-week binge drinking (5+ standard drinks of 10g alcohol on a day) across adolescence (Figure 2a) increased in males from 14.4% in wave 2 (mean age 15.5years) to 31.1% in wave 6 (17.4yrs) and in females from 7.6% to 15.0%. Persistent adolescent past-week binge drinking (across 2+ adolescent waves) was reported by one in three males (31.8%) and one in seven females (15.3%; Table 1a). In the adult waves, the prevalence of binge drinking was

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3 higher for males and females than in the adolescent phase and levels consumed for males  
4 were higher than females. In adulthood (Table 1a, Figure 2a), over eighty per cent of males  
5 reported binge drinking on at least one adult wave and more than half of females did so. Six  
6 in ten (59.1%) males and one in four (24.5%) females reported binge drinking across  
7 multiple adult waves (Table 1a).  
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13 **Figure 2a and 2b about here**  
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### 15 16 17 18 **Past-week Heavy Binge Drinking** 19

20 Just under half of the males (45.6%) and a third of females (36.2%) reported past-week  
21 heavy binge drinking at least once during adolescence or young adulthood (Table 1b). Sixty  
22 one percent of males and 42% of females who reported heavy binge drinking in adolescence  
23 continued into young adulthood. Of those who engaged in heavy binge drinking at any  
24 wave, 58% first reported doing so in young adulthood.  
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31 During adolescence, males and females reported similar levels of heavy binge use at each  
32 wave but males (7.9%) were more likely to report heavy binge drinking on multiple  
33 adolescent waves than females (4.7%; Table 1b). Past-week heavy binge drinking did not  
34 increase substantially until the young adult waves (Figure 2b). Around two in five males and  
35 one in four females reported past-week heavy binge drinking on at least one adult wave  
36 (Table 1b). At ages 20 and 24 years, around 20% of males and 13% of females reported  
37 heavy binge drinking. There was a decline in past-week heavy binge drinking by age 29  
38 years.  
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46 **Table 1a and 1b about here**  
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### 48 *Young adult binge and heavy binge alcohol use among adolescent-onset binge drinkers* 49

50 Levels of past-week binge and heavy binge drinking in adulthood, among adolescent-onset  
51 binge and heavy binge drinkers, are presented in Figure 3. Males with adolescent-onset  
52 binge drinking were more likely to continue binge drinking in adulthood than females  
53 (Figure 3a): around seven in ten males reported doing so, compared to fewer than half of  
54 females. By 29 years, female adolescent-onset binge drinkers had substantially lower levels  
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3 of binge drinking than in earlier waves, and much lower levels than males. Levels of adult  
4 heavy binge drinking did not differ markedly by sex among adolescent-onset binge drinkers;  
5 around 20-30% reported past-week heavy binge drinking at ages 20 and 24, with lower  
6 levels at 29 years (wave 9; Figure 3a). Among adolescent-onset heavy binge drinkers, the  
7 patterns and levels followed a similar sex pattern to that in adolescent-onset binge drinkers  
8 (Figure 3b).  
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15 **Figure 3a and 3b about here**

16 Table 2 reports associations between adolescent characteristics and binge and heavy binge  
17 drinking at any adult wave in adolescent-onset binge drinkers (n=821). At a univariate level,  
18 being male, and reporting adolescent antisocial behaviour or negative consequences of  
19 alcohol use in adolescence were associated with the reporting of young adult binge and  
20 heavy binge drinking in the past week. In multivariable analyses that included all covariates,  
21 the associations between adult bingeing and female gender were substantially unchanged  
22 (for young adult binge OR 0.23, 95%CI 0.13-0.40; for young adult heavy binge use OR 0.63,  
23 95%CI 0.43-0.92). Associations with behavioural characteristics were substantially  
24 attenuated when adjusted for sex and other characteristics, with the strongest independent  
25 effect being an increased the odds of young adult binge drinking if sexual risk taking had  
26 occurred in adolescence.  
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36 **Table 2 about here**  
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## Discussion

Consistent with cross-sectional surveys in England(29), the USA, and Europe(5, 9), binge drinking was highly prevalent in both sexes and normative in young Australian males. A substantial minority also engaged in heavy binge drinking (drinking more than 20 drinks on an occasion). Over half of males and a third of females reported binge drinking in the past week at some time during adolescence, and one in five males and one in seven females reported what we defined as "heavy binge drinking".

The overwhelming majority of those who reported binge drinking in adolescence continued to do so in young adulthood. Even if past-week binge drinking was not reported in the teens, it was reported in at least one wave in young adulthood by 70% of males and 48% of females who did not report binge drinking at any time in adolescence. Interestingly, our findings about the continuity of past-week binge drinking from adolescence to young adulthood contrasted somewhat with the findings of a Norwegian cohort study, where considerable discontinuity was observed, and where they estimated that eliminating all adolescent hazardous drinking would only reduce adult hazardous drinking by 10%(30).

Among those who reported binge drinking in adolescence, variables that predicted binge and heavy binge drinking in young adulthood included: regular (weekly+) cannabis use, antisocial behaviour, and early onset sexual activity. The most consistent predictors of both adult binge and heavy binge drinking were reporting adverse consequences of alcohol use in adolescence, namely "intense drinking" (could not remember the night before because of drinking), social problems, sexual risk taking and physical harm. Adolescent binge drinkers who engaged in other risky behaviours, and who had experienced negative consequences of alcohol use, were most likely to continue drinking at these levels in adulthood. In multivariable regression analysis, the strongest independent predictor of adult binge drinking among adolescent binge drinkers was being male.

## Limitations

The following limitations need to be acknowledged. First, non-response in longitudinal studies is often associated with alcohol and drug use. We used multiple imputation to minimise the impact of this potential bias, but this method carries its own assumptions and

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3 it is difficult to assess exactly how much residual bias might remain. The method of multiple  
4 imputation also assumes that data were missing at random. This is unlikely to be strictly true  
5 but the method is strengthened by the inclusion of auxiliary variables in the imputation  
6 model.  
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11 Second, our data do not capture the full extent of binge drinking in this cohort because not  
12 all binge alcohol use will have been captured within the one week reference period. Both of  
13 these limitations mean that our findings on levels of binge drinking may underestimate total  
14 exposure to these levels of drinking overall and over time.  
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19 Third, all data were based on self-report. There is reasonable evidence that young people's  
20 reports of alcohol use are both reliable and valid when reports are made in a confidential  
21 manner, and without any consequences for disclosing use (as was the case here) (31, 32).  
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26 Fourth, we used the same definition of binge and heavy binge drinking in adolescents and  
27 young adults. It is likely that the same amount of alcohol will have a greater adverse impact  
28 on adolescents than on adults. Notwithstanding these limitations, this study has provided  
29 unique prospective data on the persistence of a prevalent and hazardous drinking pattern  
30 from adolescence into adulthood.  
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35 We have clearly identified that binge alcohol use is a common behaviour among  
36 adolescents, and that it is likely to persist into young adulthood. These patterns of binge  
37 drinking in adolescence are a public health concern for two reasons. First, heavy alcohol use  
38 substantially increases the risks of: motor vehicle accidents, other injuries, alcohol-related  
39 assaults, and suicides in young people(33). Second, the longer-term health effects of  
40 persistent binge drinking during adulthood include alcohol dependence, liver disease and  
41 cancer. In most adolescent binge drinkers, binge drinking was clearly not just an "adolescent  
42 phase"; it was a pattern that persisted into young adulthood. There is an urgent need to  
43 understand why such high levels of alcohol use in adolescence continue into young  
44 adulthood.  
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53 Social acceptability, ready availability and low cost of alcohol are likely to be important  
54 drivers of early initiation into binge drinking and continuing high levels of consumption.  
55 Both the taste (34) and packaging (35) of pre-mixed drinks are particularly attractive to  
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3 young people; exposure to some forms of advertising is also associated with increased  
4 consumption (36), as are increased numbers of outlets selling alcohol (37-39), extended  
5 opening hours(40, 41), and reduced alcohol taxes (40, 42) (though only applied similarly  
6 across products(43)). The *persistence* of binge drinking into young adulthood may also be  
7 related to a delay in 'maturing out' of drinking as a result of the postponement in recent  
8 cohorts of major social role transitions such as marriage and parenthood into later  
9 adulthood(44).

## 16 Conclusions

18 Alcohol is one of the biggest risk factors for disease burden among young people. Heavy  
19 consumption in young people is common and persistence into young adulthood is much  
20 more likely than not. There is a need to develop interventions that explicitly acknowledge  
21 that prevention confined to adolescence alone is insufficient. Clearly there is much work still  
22 to be done in that area, given the incredibly high exposure not only to *any* alcohol use, but  
23 to binge alcohol use, across the adolescent years, often repeatedly. It is also apparent that  
24 there is work to be done in young adulthood since most of the heavy binge drinking began  
25 then, once participants were legally allowed to drink, and past the age at which most  
26 prevention messages are targeted. There is an increasingly delayed uptake of social role  
27 transitions; it is unclear whether such shifts are related to the patterns of alcohol  
28 consumption we observed here. The adoption of policies and interventions including those  
29 to reduce alcohol availability (via shortened trading hours, and fewer outlets), increase cost  
30 (via taxation) and discourage drinking to intoxication, may assist in reducing binge alcohol  
31 use in future cohorts of young people.  
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## Author contributions

LD, GP, WS and CO'L conceived of the study. CO'L and HR conducted the analyses. LD led the writing of the manuscript. All authors commented on the analytic plan, interpretation, and contributed to the editing and final approval of the manuscript.

## Competing Interests

None

## Data sharing

No additional data are available.

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**Figure legends**

**Figure 1: Sampling and ascertainment in the Victorian Adolescent Health Cohort, 1992 to 2008**

**Figure 2a: Levels of past week binge alcohol use among males and females (5 or more standard drinks on a day in the past week) by age**

**Figure 2b: Levels of past week "heavy binge" alcohol use among males and females (11 or more standard drinks on a day in the past week for females, 20 or more for males) by age**

**Figure 3a: Levels of past week binge and "heavy binge" drinking for males and females who reported binge drinking at one or more waves in adolescence, by age**

**Figure 3b: Levels of past week binge and "heavy binge" drinking for males and females who reported "heavy binge" drinking at one or more wave in adolescence, by age**

For Peer review only

Table 1a. Past week binge drinking during adolescence and young adulthood, by sex

|   | Binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                   |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                               | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 135                             | 14.4 | (12.1 - 16.7) | 76              | 7.6  | (5.90 - 9.30) | 211            | 10.9 | (9.50 - 12.3) |
| Wave 3 (mean age 15.9 years)  | 170                             | 18.1 | (15.5 - 20.7) | 96              | 9.6  | (7.50 - 11.7) | 265            | 13.7 | (12.1 - 15.4) |
| Wave 4 (mean age 16.4 years)  | 208                             | 22.3 | (19.3 - 25.3) | 140             | 14.1 | (11.8 - 16.3) | 349            | 18.0 | (16.2 - 19.9) |
| Wave 5 (mean age 16.8 years)  | 265                             | 28.3 | (25.1 - 31.5) | 152             | 15.2 | (12.9 - 17.6) | 417            | 21.6 | (19.6 - 23.5) |
| Wave 6 (mean age 17.4 years)  | 291                             | 31.1 | (28.0 - 34.3) | 150             | 15.0 | (12.6 - 17.4) | 441            | 22.8 | (20.8 - 24.8) |
| <b>Number of adolescent waves of any binge drinking</b>   |                                 |      |               |                 |      |               |                |      |               |
| Never   | 453                             | 48.5 | (45.0 - 52.0) | 660             | 66.1 | (63.0 - 69.1) | 1113           | 57.6 | (55.2 - 60.0) |
| 1 wave  | 184                             | 19.7 | (16.8 - 22.6) | 186             | 18.6 | (16.0 - 21.2) | 370            | 19.1 | (17.1 - 21.1) |
| 2+ waves  | 297                             | 31.8 | (28.5 - 35.1) | 153             | 15.3 | (13.0 - 17.7) | 451            | 23.3 | (21.3 - 25.3) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 509                             | 54.5 | (51.1 - 57.9) | 318             | 31.8 | (28.7 - 34.9) | 827            | 42.8 | (40.4 - 45.1) |
| Wave 8 (mean age 24.1 years)  | 550                             | 58.8 | (55.2 - 62.4) | 335             | 33.5 | (30.3 - 36.7) | 885            | 45.8 | (43.3 - 48.2) |
| Wave 9 (mean age 29.0 years)  | 524                             | 56.1 | (52.3 - 59.8) | 233             | 23.3 | (20.2 - 26.4) | 757            | 39.2 | (36.6 - 41.8) |
| <b>Number of adult waves of any binge drinking</b>  |                                 |      |               |                 |      |               |                |      |               |
| Never   | 178                             | 19.1 | (16.2 - 21.9) | 437             | 43.8 | (40.4 - 47.1) | 616            | 31.8 | (29.6 - 34.1) |
| 1 wave  | 204                             | 21.8 | (18.9 - 24.8) | 316             | 31.7 | (28.4 - 35.0) | 521            | 26.9 | (24.7 - 29.1) |
| 2+ waves  | 552                             | 59.1 | (55.7 - 62.5) | 245             | 24.5 | (21.5 - 27.6) | 798            | 41.2 | (38.8 - 43.7) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                 |      |               |                 |      |               |                |      |               |
| None in either phase  | 137                             | 14.7 | (12.2 - 17.2) | 342             | 34.2 | (31.0 - 37.5) | 479            | 24.8 | (22.7 - 26.9) |
| Incident in young adulthood   | 316                             | 33.8 | (30.3 - 37.3) | 318             | 31.9 | (28.7 - 35.0) | 634            | 32.8 | (30.4 - 35.2) |
| Remitted by young adulthood (adolescence only)  | 41                              | 4.4  | (2.80 - 6.00) | 95              | 9.5  | (7.50 - 11.6) | 136            | 7.1  | (5.80 - 8.30) |
| Continuing in young adulthood (both phases)   | 441                             | 47.1 | (43.5 - 50.7) | 244             | 24.4 | (21.6 - 27.2) | 684            | 35.4 | (33.1 - 37.7) |

Note: 'Binge' drinking defined as 5 or more drinks in one day in the past week.

Table 1b. Past week heavy binge drinking during adolescence and young adulthood, by sex

|   | Heavy binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                         |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                                     | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 44                                    | 4.8  | (3.40 - 6.10) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.80) |
| Wave 3 (mean age 15.9 years)  | 45                                    | 4.8  | (3.40 - 6.20) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.90) |
| Wave 4 (mean age 16.4 years)  | 49                                    | 5.2  | (3.70 - 6.70) | 54              | 5.4  | (4.00 - 6.90) | 103            | 5.3  | (4.30 - 6.30) |
| Wave 5 (mean age 16.8 years)  | 79                                    | 8.5  | (6.40 - 10.5) | 66              | 6.6  | (5.00 - 8.10) | 145            | 7.5  | (6.20 - 8.80) |
| Wave 6 (mean age 17.4 years)  | 67                                    | 7.1  | (5.20 - 9.00) | 38              | 3.8  | (2.60 - 5.00) | 105            | 5.4  | (4.30 - 6.50) |
| <b>Number of adolescent waves of any heavy binge drinking</b>                                   |                                       |      |               |                 |      |               |                |      |               |
| Never   | 755                                   | 80.7 | (78.1 - 83.4) | 847             | 84.7 | (82.5 - 87.0) | 1601           | 82.8 | (81.1 - 84.5) |
| 1 wave  | 106                                   | 11.4 | (9.10 - 13.6) | 106             | 10.6 | (8.60 - 12.5) | 212            | 11.0 | (9.50 - 12.4) |
| 2+ waves  | 74                                    | 7.9  | (6.10 - 9.70) | 47              | 4.7  | (3.30 - 6.00) | 121            | 6.2  | (5.10 - 7.30) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 177                                   | 18.9 | (16.3 - 21.6) | 134             | 13.4 | (11.2 - 15.6) | 311            | 16.1 | (14.4 - 17.8) |
| Wave 8 (mean age 24.1 years)  | 201                                   | 21.4 | (18.7 - 24.2) | 135             | 13.5 | (11.3 - 15.8) | 336            | 17.4 | (15.6 - 19.1) |
| Wave 9 (mean age 29.0 years)  | 132                                   | 14.1 | (11.4 - 16.7) | 78              | 7.8  | (6.10 - 9.60) | 210            | 10.8 | (9.30 - 12.4) |
| <b>Number of adult waves of any heavy binge drinking</b>  |                                       |      |               |                 |      |               |                |      |               |
| Never   | 579                                   | 62   | (58.7 - 65.3) | 726             | 72.7 | (69.7 - 75.6) | 1305           | 67.5 | (65.2 - 69.7) |
| 1 wave  | 230                                   | 24.6 | (21.4 - 27.8) | 212             | 21.2 | (18.5 - 23.9) | 442            | 22.8 | (20.7 - 25.0) |
| 2+ waves  | 125                                   | 13.4 | (10.9 - 15.9) | 62              | 6.2  | (4.60 - 7.70) | 187            | 9.7  | (8.20 - 11.1) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                       |      |               |                 |      |               |                |      |               |
| None in either phase  | 508                                   | 54.4 | (50.9 - 57.8) | 638             | 63.8 | (60.7 - 66.9) | 1146           | 59.2 | (56.9 - 61.6) |
| Incident in young adulthood   | 247                                   | 26.4 | (23.3 - 29.5) | 209             | 20.9 | (18.3 - 23.5) | 456            | 23.6 | (21.5 - 25.6) |
| Remitted by young adulthood (adolescence only)  | 71                                    | 7.6  | (5.80 - 9.50) | 88              | 8.8  | (7.00 - 10.7) | 160            | 8.2  | (6.90 - 9.60) |
| Continuing in young adulthood (both phases)   | 109                                   | 11.6 | (9.30 - 14.0) | 64              | 6.4  | (4.80 - 8.10) | 173            | 9.0  | (7.60 - 10.3) |

Note: 'Heavy binge' drinking defined as >11 drinks on a day in the past week for females, >20 for males. Persistent 'heavy binge' drinking in adolescence defined as heavy binge drinking in the past week on two or more waves across the adolescent waves (waves 2 to 6).

**Table 2: Predictors of binge alcohol use in young adulthood among adolescent ‘binge’ alcohol drinkers**

(i.e. those who had past-week binge drinking on at least one wave during adolescence, waves 2-6; n=821)

| Adolescent predictors among adolescent ‘binge’ drinkers, n=821: | Young adult ‘binge’ drinking |               |                  |               | Young adult ‘heavy binge’ drinking |               |                  |               |
|---|------------------------------|---------------|------------------|---------------|------------------------------------|---------------|------------------|---------------|
|   | Modelled separately          |               | Modelled jointly |               | Modelled separately                |               | Modelled jointly |               |
|   | OR                           | (95% CI)      | OR               | (95% CI)      | OR                                 | (95% CI)      | OR               | (95% CI)      |
| <b>Female</b>   | 0.24                         | (0.15 - 0.39) | 0.23             | (0.13 - 0.40) | 0.67                               | (0.49 - 0.92) | 0.63             | (0.43 - 0.92) |
| <b>Daily smoking</b>  | 1.20                         | (0.79 - 1.81) | 1.12             | (0.69 - 1.82) | 1.29                               | (0.94 - 1.77) | 1.01             | (0.70 - 1.46) |
| <b>Weekly/daily cannabis use</b>                                | 1.65                         | (0.96 - 2.82) | 1.05             | (0.54 - 2.03) | 1.57                               | (1.11 - 2.24) | 1.06             | (0.71 - 1.60) |
| <b>Antisocial behaviour</b>                                     | 1.70                         | (1.12 - 2.59) | 0.99             | (0.60 - 1.63) | 1.59                               | (1.16 - 2.18) | 1.06             | (0.74 - 1.52) |
| <b>Early onset sexual activity (&lt;16 years)</b>               | 1.46                         | (0.92 - 2.33) | 1.04             | (0.60 - 1.83) | 1.53                               | (1.09 - 2.14) | 1.02             | (0.69 - 1.49) |
| <b>Adolescent mental health problems</b>                        |                              |               |                  |               |                                    |               |                  |               |
| CIS >11, 0 waves  | 1                            |               | 1                |               | 1                                  |               | 1                |               |
| CIS >11, 1 wave   | 0.81                         | (0.42 - 1.57) | 0.90             | (0.44 - 1.81) | 1.23                               | (0.81 - 1.87) | 1.15             | (0.74 - 1.77) |
| CIS >11, 2+ waves   | 0.60                         | (0.37 - 0.97) | 0.83             | (0.48 - 1.46) | 1.05                               | (0.74 - 1.49) | 0.99             | (0.64 - 1.52) |
| <b>Adolescent consequences attributed to alcohol use</b>        |                              |               |                  |               |                                    |               |                  |               |
| Intense drinking <sup>1</sup>                                   | 1.54                         | (1.00 - 2.36) | 1.45             | (0.84 - 2.50) | 1.77                               | (1.28 - 2.43) | 1.41             | (0.99 - 2.00) |
| Social problems <sup>2</sup>                                    | 1.34                         | (0.85 - 2.10) | 1.25             | (0.72 - 2.18) | 1.63                               | (1.16 - 2.31) | 1.23             | (0.83 - 1.83) |
| Physical harm <sup>3</sup>                                      | 1.92                         | (1.13 - 3.26) | 1.25             | (0.64 - 2.44) | 1.96                               | (1.37 - 2.81) | 1.29             | (0.84 - 1.96) |
| Sexual risk taking <sup>4</sup>                                 | 1.75                         | (1.01 - 3.03) | 1.51             | (0.77 - 2.97) | 2.09                               | (1.44 - 3.03) | 1.64             | (1.07 - 2.53) |

Note: ‘Binge’ drinking defined as 5 or more drinks in one day in the past week. ‘Heavy binge’ drinking defined as >11 drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

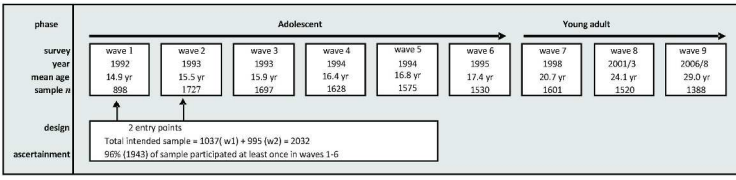
<sup>1</sup> Couldn’t remember what said or did the night before as a result of alcohol use

<sup>2</sup> Lost friends, school trouble, argued with family as a result of alcohol use

<sup>3</sup> Injuries, accidents, violence attributed to their alcohol use

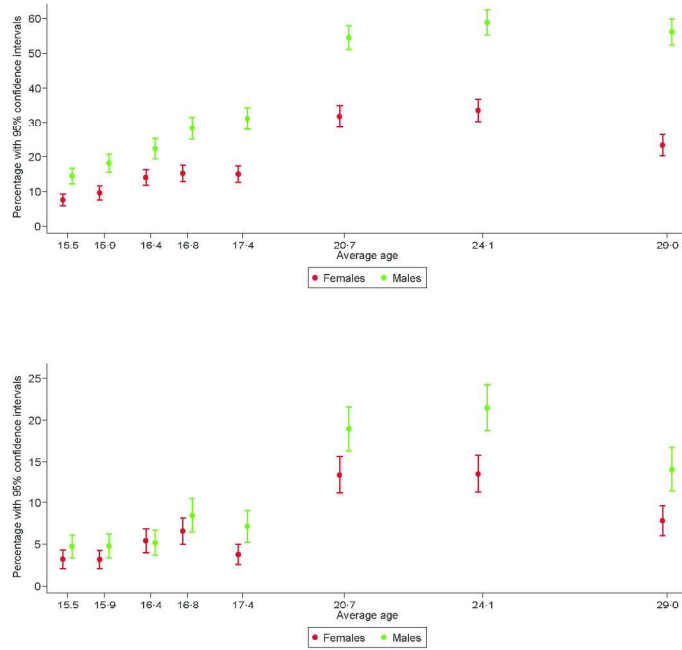
<sup>4</sup> Regretted having sex, or had sex without protection or contraceptives as a result of alcohol use

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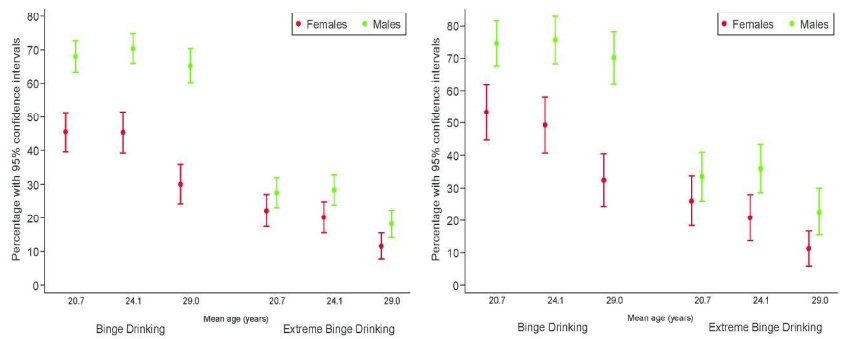


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Note: Binge drinking defined as 5 or more drinks in one day in the past week. Heavy binge drinking defined as 11+ drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

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## The persistence of adolescent binge drinking into adulthood: Findings from a 15-year prospective cohort study

|                              |     |  |
|------------------------------|-----|--|
|                              | 1   | (a) Indicate the study's design with a commonly used term in the title or the abstract:<br><b>This addressed in both title and abstract</b>  |
|                              |     | (b) Provide in the abstract an informative and balanced summary of what was done and what was found:<br><b>We have done so.</b>  |
| <b>Introduction</b>          |     |  |
| Background/rationale         | 2   | Explain the scientific background and rationale for the investigation being reported:<br><b>This is covered in the introduction</b>  |
| Objectives                   | 3   | State specific objectives, including any prespecified hypotheses:<br><b>The objectives were to examine the natural history of binge alcohol use during adolescence and young adulthood, and examine predictors of binge alcohol use during young adulthood among adolescent onset binge drinkers years. These objectives are summarised at the end of the introduction.</b>  |
| <b>Methods</b>               |     |  |
| Study design                 | 4   | Present key elements of study design early in the paper:<br><b>We have presented key design elements in the methods.</b>   |
| Setting                      | 5   | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection:<br><b>These are included in the text and in figure 1.</b>   |
| Participants                 | 6   | (a) <i>Cohort study?</i> Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.<br><b>These are described in the methods section and in figure 1 including rates of attrition and reasons for attrition.</b><br><br>(b) <i>Cohort study?</i> For matched studies, give matching criteria and number of exposed and unexposed. <i>Case-control study?</i> For matched studies, give matching criteria and the number of controls per case. <b>Not applicable</b>   |
| Variables                    | 7   | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.<br><b>We have covered this in the methods section on pages 5-7. There were two main exposures of interest: past week binge alcohol use (5 or more standard drinks in a day) and past week "heavy" binge drinking (more than 20 standard drinks on a day for males, 11 or more on a day for females).</b>   |
| Data sources/<br>measurement | 8*  | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. <b>These are provided on page 5</b>  |
| Bias                         | 9   | Describe any efforts to address potential sources of bias.<br><b>The main sources of selection bias are discussed on page 13 and relate to differential attrition. Further sources of selection bias are unlikely to make a major contribution to the findings but potentially include the following:</b><br><b>1 non-participation in the sampling frame: 2% of the Victorian adolescent population were not registered at school at the time of sampling with some small possibility that the sample did not reflect that of Victorian adolescents at that time.</b><br><b>2 Non-participation in the adolescent wave; 4% of the original sample did not participate in any adolescent wave and were therefore not included in the cohort to be follow-up. Given the high participation rate we believe the potential for bias is small.</b> |
| Study size                   | 10  | Explain how the study size was arrived at.<br><b>The study was designed to examine common adolescent health exposures and common young adult outcomes. Based on the known and relatively common exposure and assuming conservatively a prevalence of 10% (higher prevalences would have led to higher power) for these exposures, the study was expected to have 80% power at the two-sided 0.05 significance level for relative risks in the range 1.6 - 1.9, corresponding to outcomes with a prevalence of 10% to 20%. These are roughly the ranges we are dealing with in these analyses.</b>  |
| Quantitative variables       | 11  | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why.<br><b>This explained in methods, results and in the tables.</b>  |
| Statistical methods          | 12  | (a) Describe all statistical methods, including those used to control for confounding.<br><b>Where relevant this is explained in the methods and results sections.</b><br><br>(b) Describe any methods used to examine subgroups and interactions.<br><b>We examined for first-order interactions where appropriate in the models.</b><br><br>(c) Explain how missing data were addressed. <b>This is described in the analysis sections and in the appendix.</b><br><br>(d) <i>Cohort study?</i> If applicable, explain how loss to follow-up was addressed. <b>This was described in analysis section.</b><br><br>(e) Describe any sensitivity analyses <b>We present available case analyses in the online appendix to allow the reader to examine the impact of multiple imputation.</b>   |
| <b>Results</b>               |     |  |
| Participants                 | 13* | (a) Report numbers of individuals at each stage of study? eg numbers potentially eligible, examined for eligibility, confirmed eligible.   |

|                          |     |  |
|--------------------------|-----|--|
|                          |     | included in the study, completing follow-up, and analysed: <b>This is shown in figure 1 and described in the results.</b>  |
|                          |     | (b) Give reasons for non-participation at each stage.<br><b>Reasons for non-completion are provided on page 5. Dealing with these potential sources of bias was a reason for using multiple imputation in the data analysis.</b>   |
|                          |     | (c) Consider use of a flow diagram <b>See figure 1.</b>  |
| Descriptive data         | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. <b>This information is contained in the description of the recruitment methods and in the data in the Tables especially Table 3. Space does not allow more detailed descriptive summaries.</b><br><br>(b) Indicate number of participants with missing data for each variable of interest.<br><b>This study had very low levels of missing data for variables where the participant completed a wave.</b><br><br>(c) <i>Cohort study?</i> Summarise follow-up time (eg average and total amount). <b>See figure 1.</b> |
| Outcome data             | 15* | <i>Cohort study?</i> Report numbers of outcome events or summary measures over time.<br><b>See table 1. Summary measures and numbers are shown in the other tables.</b><br><br><i>Case-control study?</i> Report numbers in each exposure category, or summary measures of exposure. <b>N/A</b><br><br><i>Cross sectional study?</i> Report numbers of outcome events or summary measures <b>N/A</b>   |
| Main results             | 16  | (a) Report the numbers of individuals at each stage of the study?eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. <b>This is summarised in figure 1.</b><br><br>(b) Give reasons for non-participation at each stage. <b>See above.</b><br><br>(c) Consider use of a flow diagram <b>See figure 1.</b>  |
| Other analyses           | 17  | Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses <b>N/A</b>  |
| <b>Discussion</b>        |     |  |
| Key results              | 18  | Summarise key results with reference to study objectives <b>This is undertaken on pages 9-11</b>   |
| Limitations              | 19  | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias <b>See pages 13-14</b>  |
| Interpretation           | 20  | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <b>We have done so.</b>   |
| Generalisability         | 21  | Discuss the generalisability (external validity) of the study results<br><b>This has not been explicitly addressed in the paper, because of space limitations, but we believe is really implicit in the detail given of the recruitment of the cohort from a representative sample of schools in Victoria. Thus we believe the results are clearly generalisable to other Australian communities and likely to be highly relevant to most other high income countries.</b>   |
| <b>Other information</b> |     |  |
| Funding                  | 22  | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based . <b>Given at the end of the discussion.</b>   |

## Online appendix: Approach to multiple imputation

Missing data were handled using multiple imputation<sup>1</sup>. We imputed 20 complete datasets separately for males and females, under a multivariate normal model, incorporating all the analysis and auxiliary variables at each wave, except age and sexual risk-taking in adolescence, which was imputed as a binary summary measure. Wave 1 was omitted as it contained observations from only 46% of the cohort. Wave 1 responses were used to fill in wave 2 data, for any participant not seen at wave 2 as the same measures had been collected at the earlier wave. Waves 2 to 9 were imputed for all participants (N=1943) who completed the survey at least once in adolescence (waves 2-6). The imputation model contained 49 key variables used in the analysis and 8 auxiliary variables. Of 57 variables included in the imputation model, 18% of the variables had <10% missing values, 46% had ≥10% to <20% missing, 28% had ≥20% to <30% missing and only 5 variables (9%) had ≥45% to <55% missing values. A maximum level of drinking variable was created at each wave, with three levels: *no binge drinking*, *binge drinking* and *extreme binge drinking*. These variables and alcohol consequences variables were log transformed before imputation. Smoking, cannabis use, antisocial behaviour, mental health and summary measures of sexual risk-taking were imputed as binary variables at each wave. Age was imputed as a normal variable. After imputation, transformed variables were converted back to their original scale and all were categorised for analysis, with adaptive rounding used for binary measures<sup>2</sup>. Nine deceased participants were excluded from the imputed datasets. Frequencies and odds ratios were obtained by averaging results across the imputed datasets; inferences under multiple imputation were made using Rubin's rules<sup>1</sup>.

Table 1a. Available case analysis: Prevalence of adolescent and young adult binge drinking by wave and sex

|                                      | Binge drinking in the past week |     |      |               |         |     |      |               |       |     |      |               |
|--------------------------------------|---------------------------------|-----|------|---------------|---------|-----|------|---------------|-------|-----|------|---------------|
|                                      | Males                           |     |      |               | Females |     |      |               | Total |     |      |               |
|                                      | N                               | n   | %    | (95% CI)      | N       | n   | %    | (95% CI)      | N     | n   | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>  |                                 |     |      |               |         |     |      |               |       |     |      |               |
| <b>Binge drinking by wave</b>        |                                 |     |      |               |         |     |      |               |       |     |      |               |
| Wave 2 (mean age 15.5 yr)            | 892                             | 127 | 14.2 | (11.9 - 16.5) | 950     | 72  | 7.6  | (5.90 - 9.30) | 1842  | 199 | 10.8 | (9.40 - 12.2) |
| Wave 3 (mean age 15.9 yr)            | 805                             | 137 | 17.0 | (14.4 - 19.6) | 887     | 79  | 8.9  | (7.00 - 10.8) | 1692  | 216 | 12.8 | (11.2 - 14.4) |
| Wave 4 (mean age 16.4 yr)            | 750                             | 151 | 20.1 | (17.3 - 23.0) | 874     | 112 | 12.8 | (10.6 - 15.0) | 1624  | 263 | 16.2 | (14.4 - 18.0) |
| Wave 5 (mean age 16.8 yr)            | 718                             | 186 | 25.9 | (22.7 - 29.1) | 853     | 117 | 13.7 | (11.4 - 16.0) | 1571  | 303 | 19.3 | (17.3 - 21.2) |
| Wave 6 (mean age 17.4 yr)            | 679                             | 195 | 28.7 | (25.3 - 32.1) | 847     | 122 | 14.4 | (12.0 - 16.8) | 1526  | 317 | 20.8 | (18.7 - 22.8) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b> |                                 |     |      |               |         |     |      |               |       |     |      |               |
| <b>Binge drinking by wave</b>        |                                 |     |      |               |         |     |      |               |       |     |      |               |
| Wave 7 (mean age 20.7 yr)            | 732                             | 401 | 54.8 | (51.2 - 58.4) | 865     | 266 | 30.8 | (27.7 - 33.8) | 1597  | 667 | 41.8 | (39.3 - 44.2) |
| Wave 8 (mean age 24.1 yr)            | 693                             | 409 | 59.0 | (55.4 - 62.7) | 824     | 265 | 32.2 | (29.0 - 35.4) | 1517  | 674 | 44.4 | (41.9 - 46.9) |
| Wave 9 (mean age 29.1 yr)            | 631                             | 359 | 56.9 | (53.0 - 60.8) | 764     | 168 | 22.0 | (19.1 - 24.9) | 1395  | 527 | 37.8 | (35.2 - 40.3) |

Note: "Binge" drinking defined as 5 or more drinks in one day in the past week.

Table 1b. Available case analysis: Prevalence of adolescent and young adult extreme binge drinking by wave by sex

|                                      | Extreme binge drinking in the past week |     |      |               |         |     |      |               |       |     |      |               |
|--------------------------------------|---|-----|------|---------------|---------|-----|------|---------------|-------|-----|------|---------------|
|                                      | Males                                   |     |      |               | Females |     |      |               | Total |     |      |               |
|                                      | N                                       | n   | %    | (95% CI)      | N       | n   | %    | (95% CI)      | N     | n   | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>  |   |     |      |               |         |     |      |               |       |     |      |               |
| <b>Binge drinking by wave</b>        |   |     |      |               |         |     |      |               |       |     |      |               |
| Wave 2 (mean age 15.5 yr)            | 892                                     | 44  | 4.9  | (3.50 - 6.40) | 950     | 32  | 3.4  | (2.20 - 4.50) | 1842  | 76  | 4.1  | (3.20 - 5.00) |
| Wave 3 (mean age 15.9 yr)            | 805                                     | 42  | 5.2  | (3.70 - 6.80) | 887     | 31  | 3.5  | (2.30 - 4.70) | 1692  | 73  | 4.3  | (3.30 - 5.30) |
| Wave 4 (mean age 16.4 yr)            | 750                                     | 41  | 5.5  | (3.80 - 7.10) | 874     | 52  | 5.9  | (4.40 - 7.50) | 1624  | 93  | 5.7  | (4.60 - 6.90) |
| Wave 5 (mean age 16.8 yr)            | 718                                     | 63  | 8.8  | (6.70 - 10.8) | 853     | 62  | 7.3  | (5.50 - 9.00) | 1571  | 125 | 8.0  | (6.60 - 9.30) |
| Wave 6 (mean age 17.4 yr)            | 892                                     | 44  | 4.9  | (3.50 - 6.40) | 847     | 36  | 4.3  | (2.90 - 5.60) | 1526  | 85  | 5.6  | (4.40 - 6.70) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b> |   |     |      |               |         |     |      |               |       |     |      |               |
| <b>Binge drinking by wave</b>        |   |     |      |               |         |     |      |               |       |     |      |               |
| Wave 7 (mean age 20.7 yr)            | 732                                     | 141 | 19.3 | (16.4 - 22.1) | 865     | 121 | 14.0 | (11.7 - 16.3) | 1597  | 262 | 16.4 | (14.6 - 18.2) |
| Wave 8 (mean age 24.1 yr)            | 693                                     | 153 | 22.1 | (19.0 - 25.2) | 824     | 120 | 14.6 | (12.2 - 17.0) | 1517  | 273 | 18.0 | (16.1 - 19.9) |
| Wave 9 (mean age 29.1 yr)            | 631                                     | 85  | 13.5 | (10.8 - 16.1) | 764     | 70  | 9.2  | (7.10 - 11.2) | 1395  | 155 | 11.1 | (9.50 - 12.8) |

Note: "Extreme binge" drinking defined as >11 drinks on a day in the past week for females, >20 for males.

## References

1. Rubin DB. Multiple Imputation for Nonresponse in Surveys. New York: John Wiley and Sons; 2004.
2. Bernaards CA, Belin TR, Schafer JL. Robustness of a multivariate normal approximation for imputation of incomplete binary data. *Statistics in Medicine*. 2007; 26: 1368-82.

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7 **The persistence of adolescent binge drinking into adulthood: Findings from a**  
8 **15-year prospective cohort study**  
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11 **Louisa Degenhardt<sup>1,2</sup>, Christina O'Loughlin<sup>3</sup>, Wendy Swift<sup>1</sup>, Helena Romaniuk<sup>3,5,6</sup>, John**  
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46 Running head: Adolescent binge drinking  
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48 Word count (text only): 3,240; Abstract 250  
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50 Conflict of interest: None.  
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## Article summary

### Article focus

- Alcohol is a major source of preventable disease burden among young people.
- Although young people drink less often than adults, they may consume large amounts in a single session ('binge' drinking).
- ~~We know little about the persistence of binge drinking in adolescence into young adulthood.~~ We aimed to: 1) Examine the persistence of adolescent "binge" and "heavy binge" drinking from adolescence to young adulthood; 2) Examine which characteristics of adolescent binge drinkers predict the persistence of "binge" and "heavy binge" alcohol use into young adulthood.

### Key messages

- Half of the males and a third of females in a cohort of young Australians: reported past-week binge drinking in adolescence.
- The overwhelming majority of these adolescent binge drinkers continued to binge drink in young adulthood.
- Past-week binge drinking was reported in at least one young adulthood wave by around 70% of males and 48% of females who had not reported past-week binge drinking in adolescence.
- The high rate of persistence of binge drinking into adulthood indicates the need for policies to reduce its onset in adolescence such as limiting availability, increasing costs and discouraging drinking to intoxication.

### Strengths and limitations

- This well-conducted prospective study, with very high retention, has provided unique prospective data on the persistence of a prevalent and hazardous drinking pattern into adulthood.
- The following limitations do need to be acknowledged. First, non-response in longitudinal studies is often associated with alcohol and drug use. We used multiple imputation to minimise the impact of this potential bias. Second, our data do not capture the full extent of binge drinking in this cohort because not all binge alcohol use will have been captured within the one week reference period. Both of these limitations mean that if anything our findings on levels of binge drinking are conservative in estimating total exposure to these levels of drinking overall and over time.
- Third, all data were based on self-report, however there is reasonable evidence that young people's reports of alcohol use are both reliable and valid when reports are made in a confidential manner, and without any consequences for disclosing.
- Fourth, we used the same definition of binge and heavy binge drinking in adolescent and young adults. It is likely that the same amount of alcohol will have a greater adverse impact on adolescents than on adults.



## Abstract

Objectives: To examine the prevalence of binge drinking in adolescence and its persistence into adulthood in an Australian cohort.

Design: 15-year prospective cohort study.

Setting: Victoria, Australia.

Participants: 1943 adolescents were recruited from secondary schools at age 14-15 years.

Primary outcome measures: Levels of past-week "binge" drinking (5+ standard drinks (SD) on a day, each 10g alcohol) and "heavy binge" drinking (20+ SD on a day for males, 11+ for females) were assessed during six adolescent waves, and across three adult waves up to age 29 years.

Results: Half of males (52%) and a third of females (34%) reported past-week adolescent binge drinking. 90% of male and 70% of female adolescent-onset binge drinkers continued to binge in young adulthood; 70% of males and 48% of females who were not adolescent-onset binge drinkers reported young adult binge drinking. Past-week heavy bingeing was less common in adolescence than adulthood. Overall, 35% of the sample (95%CI 33-38%) reported past-week binge drinking in both adolescence and young adulthood and one third (33%; 30-35%) first reported binge drinking in young adulthood; only 7% of the sample (6-8%) had binge drinking in adolescence but not young adulthood. "Heavy binge" drinking occurred in both adolescence and young adulthood for 9% (8-10%); 8% (7-10%) reported it in adolescence but no longer in young adulthood; and 24% (22-26%) began "heavy binge" drinking in young adulthood. Among adolescent binge drinkers (n=821), young adult binge and heavy binge drinking were predicted by being male, adolescent antisocial behaviour, and adverse consequences of drinking in adolescence.

Conclusions: Binge alcohol use is common and persistent among young Australians. Efforts to prevent the onset of binge drinking during adolescence may substantially reduce harmful patterns of alcohol use in young adulthood.

Objectives: Binge drinking in adolescence has become common in many countries but we know little about whether it persists into adulthood.

Methods: A 15-year prospective cohort study in Victoria, Australia. 1943 adolescents were recruited from secondary schools at age 14-15 years. Levels of past-week "binge" drinking

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(5+ standard drinks (SD) on a day, each 10g alcohol) and “heavy binge” drinking (20+ SD on a day for males, 11+ for females) were assessed during six adolescent waves, and across three adult waves up to age 29 years.

*Results:* Half of males (52%) and a third of females (34%) reported past week adolescent binge drinking. 90% of male and 70% of female adolescent onset binge drinkers continued to binge in young adulthood; 70% of males and 48% of females who were not adolescent onset binge drinkers reported young adult binge drinking. Past week heavy bingeing was less common in adolescence than adulthood. Among adolescent binge drinkers (n=821), young adult binge and heavy binge drinking were predicted by being male, adolescent antisocial behaviour, and adverse consequences of drinking in adolescence.

*Conclusions:* Binge alcohol use is common and has a greater degree of persistence than other health risk behaviours that commonly arise in adolescence. Efforts to prevent the onset of binge drinking during adolescence may substantially reduce harmful patterns of alcohol use in young

## Introduction

Alcohol is a major source of preventable disease burden among young people(1): it is thought to contribute to 320,000 deaths globally among 15-29 year olds each year, comprising 9% of all deaths in this group(2). The burden attributable to alcohol use as a risk factor among young people aged 15-29 years (20 million disability adjusted life years (DALYs)) is thought to account for one third of all global alcohol attributable burden (59 million DALYs)(3).

Alcohol use typically begins in adolescence(4, 5). Although young people drink less often than adults(4), they may consume larger amounts in a single session(6-8). Among school students across 14 European countries in 2011, 41% reported past-month "binge" drinking (5+ standard alcoholic drinks(9); levels in the United Kingdom were 54%(9). Similar drinking levels occur in young Australians(10). One in five Australian males and females 16-24 years report drinking 20+ and 11+ standard drinks in a session (each 10g alcohol), respectively, at least monthly in the past year(11).

There have been many studies examining alcohol use among adolescents(12, 13), risk factors for young adult consumption and alcohol use disorders(14-19), and the impact of adolescent use upon health in young adulthood(13). ~~However, there has been little study of the strength of persistence of binge alcohol use from adolescence into young adulthood (20). There are also few longitudinal data to inform clinicians about on the predictors of persistence of binge alcohol use into young adulthood for adolescent binge drinkers who they may see in their practice. However to our knowledge there has not been a study of the course of adolescent binge drinking in a cohort study of young Australians(20).~~ We investigated the persistence of binge drinking into adulthood among Australian young people using a 15-year prospective cohort study of young Australians that assessed alcohol use during adolescence and up to age 29 years. We also examined the predictors of persistence of binge alcohol use into young adulthood among adolescent binge drinkers.

We aimed to:

1. Examine the persistence of adolescent "binge" and "heavy binge" drinking from adolescence to young adulthood;

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7 2. Examine which characteristics of adolescent binge drinkers predict the persistence of  
8 “binge” and “heavy binge” alcohol use into young adulthood.  
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For peer review only

## Methods

### Sample

Between August 1992 and 2007, we conducted nine waves of interviews with a cohort then resident in the state of Victoria, Australia (for more details see(21, 22)). At the beginning of the adolescent phase (waves 1-2) parental consent was obtained; in adult waves participants were informed in writing and gave verbal consent.

At baseline, a representative sample of the Victorian population of school pupils aged 14-15 years (year 9) was recruited. Retention in school to year 9 among Victorian young people in 1992-3 was 98%. A two-stage cluster sampling procedure was used, with two classes selected at random. At stage one, 45 schools were randomly chosen from a stratified frame of government, Catholic and independent private schools. At stage two, one class was selected at random from each participating school, entering in the last part of year 9 (wave 1), followed by a second class in the second wave six months later (wave 2). Participants were interviewed at 6-month intervals from 14-19 years (waves 3-6) with three waves in young adulthood: 20-21 years (wave 7), 24-25 years (wave 8), and 28-29 years (wave 9). In waves 1-6, participants self-administered the questionnaire on laptops, with telephone follow-up of those absent from school; waves 7-9 involved computer-assisted telephone interviews(23). ~~From a total of 2032 students, 1943 (95.6%) participated at least once in adolescence (Figure 1); 1756 (53% female) participated in at least one adult wave and were known to be alive at wave 9; 1282 completed all three adult waves; 293 completed two, and 181 completed one. By the end of wave 9, nine participants were known to have died, 108 lost to follow-up and 319 refused participation; 1501 participants were interviewed, 1407 of whom did the full (1383) or part (24) interview schedule, and 94 a paper questionnaire. In this paper, we only used adolescent data from waves 2-6 as over half of the adolescents did not participate in wave 1.~~

Figure 1 about here

### Measures

#### *Alcohol consumption*

Alcohol consumption was recorded at all adolescent and adult phases in an alcohol diary by any participants who reporting drinking in the previous week. In the adolescent phase, respondents completed a seven-day alcohol diary. In the adult phase, in order to minimise

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7 respondent burden, participants were only asked to complete a four-day diary including all  
8 weekend days (Friday to Sunday) and the most recent weekday. Types of alcohol (beer,  
9 cider, spirits, mixed drinks, wine etc.), brand names, and the amounts consumed (glass, pint,  
10 bottle, can, etc.) were recorded. We calculated the number of standard drink units (10g  
11 alcohol) consumed on each day/occasion, and at each wave. Two measures of binge  
12 drinking were estimated (using the same definition in adolescent and adult phases).  
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17 (1) *'Binge' drinking*: Defined (at each wave) as having drunk 5 or more standard drinks (each  
18 10g alcohol) on at least one day during the diary week. *Any binge drinking* was defined  
19 in adolescence and adulthood as binge drinking on one or more waves during the  
20 respective phase. For each phase, we identified the number of waves in which binge  
21 drinking occurred: none, one wave and two or more waves (in adolescence, 2+ of five  
22 assessment waves; in adulthood; 2+ of three waves). *Persistent binge drinking* was  
23 defined as binge drinking on two or more waves.  
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28 (2) *'Heavy' binge drinking*: Defined as having drunk >20 standard drinks for males and ≥11  
29 standard drinks for females on any day over the diary week (11). These levels were  
30 taken from a previous study of young people (11), using Australian National Health and  
31 Medical Research Council definitions of "high risk" drinking for males and females. *Any*  
32 *'heavy' binge drinking* in adolescence and adulthood was defined as having done so on  
33 any wave. The number of waves in each phase was identified as above. *Persistence of*  
34 *'heavy' binge drinking* was defined as drinking to this level on two or more waves  
35 (adolescence, 2+ of five waves; adulthood; 2+ of three waves).  
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41 *Incident binge drinking* was defined as first reporting binge or heavy binge drinking in young  
42 adulthood. *Continuity of binge drinking* and of *heavy binge drinking* was defined as the same  
43 pattern of drinking in adolescence and also adulthood. *Discontinuity* was defined as  
44 adolescent binge or heavy binge drinking without binge/heavy binge drinking in young  
45 adulthood.  
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#### 49 **Prognostic factors**

50 *Adolescent tobacco smoking* was assessed at each adolescent wave. Participants who  
51 reported smoking daily in the week prior to survey at any one adolescent wave were  
52 classified as daily smokers during adolescence.  
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7 *Adolescent cannabis use* was assessed using reported frequency of use in the previous six  
8 months at each wave. Maximal cannabis use during the adolescent phases (i.e. most  
9 frequent level reported across any wave) was categorised as *none/occasional* and  
10 *daily/weekly*.

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13 *Adolescent antisocial behaviour* was assessed using 10 items from the Moffitt and Silva self-  
14 report early delinquency scale(24), which assessed property damage, interpersonal conflict  
15 and theft. Participants were asked if they had engaged in any of these behaviours *never*,  
16 *once*, or *more than once* in the last 6 months. *Antisocial behaviour* was defined as any  
17 antisocial behaviour on more than one adolescent wave, and/or 2+ behaviours in the same  
18 wave.

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21 *Early onset sexual behaviour*: participants were asked if they had ever had sex (“gone all the  
22 way” or had sexual intercourse) at each adolescent wave and their age of first sex at each  
23 young adulthood wave. Those reporting sexual activity before 16 years were classified as  
24 *early onset sexually active*.

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27 *Adolescent mental health* was assessed using the Clinical Interview Schedule (CIS-R)(25),  
28 which assesses depression and anxiety in non-clinical populations; a cut-off of >11 defines a  
29 mixed depression-anxiety state requiring clinical intervention . Mental health problems  
30 were summarised as having occurred: never, in one, or 2+ adolescent waves.

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33 *Adolescent alcohol-related consequences*: Eight questions were asked about problems  
34 related to alcohol over the past six months in all adolescent waves. These were categorised  
35 into four types of consequences: *intense drinking* (drank so much that the next day couldn't  
36 remember what you said/did); *alcohol-related social problems* (lost friends, had trouble at  
37 school, or argued with family, because of drinking); *alcohol-related injury, accident or*  
38 *violence* (violent and had a fight, or had an injury or an accident, because of drinking); and  
39 *alcohol-related sexual risk taking* (had sex without using contraceptives, had sex without  
40 using protection, or had sex and regretted it, because of drinking). For each of the four types  
41 of consequences, persistence in adolescence was defined as engaging in the behaviour  
42 either across multiple waves or more than once on one wave.

### 53 **Statistical Analysis**

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7 We calculated the prevalence of binge drinking at each wave and the number of waves on  
8 which each type of binge drinking occurred in adolescence and adulthood. We also  
9 estimated the continuity and discontinuity of binge and heavy binge drinking between the  
10 two phases. Among those reporting adolescent binge drinking (n=821), logistic regression  
11 was used to examine the prognosis for this group in terms of binge drinking. We  
12 investigated associations between adolescent predictors and any binge and heavy binge  
13 drinking in young adulthood. These associations were initially examined separately and then  
14 jointly in multivariable models. Interactions between the adolescent predictors and sex  
15 were examined in the multivariable models but evidence for differential sex effects was  
16 weak. In order to retain information from individuals with incomplete data (and thereby  
17 minimise the effects of participation bias), the prevalence of binge and heavy binge drinking  
18 during both adolescent and young adult phases was estimated using multiple  
19 imputation(26, 27) (see online appendix). All data analysis was undertaken using Stata  
20 12(28).  
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### 28 **Ethics**

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30 The Ethics in Human Research Committee of the Royal Children's Hospital, Melbourne  
31 approved all data collection protocols.  
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35  
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40 interpretation, writing of the article or decision to publish. The corresponding author had  
41 full access to all the data in the study and had final responsibility for the decision to submit  
42 for publication.  
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## Results

From a total of 2032 students, 1943 (95.6%) participated at least once in adolescence (Figure 1); 1756 (53% female) participated in at least one adult wave and were known to be alive at wave 9; 1282 completed all three adult waves; 293 completed two, and 181 completed one. By the end of wave 9, nine participants were known to have died, 108 lost to follow-up and 319 refused participation; 1501 participants were interviewed, 1407 of whom did the full (1383) or part (24) interview schedule, and 94 a paper questionnaire. In this paper, we only used adolescent data from waves 2-6 as over half of the adolescents did not participate in wave 1.

The analysis utilised data from waves 2 to 9 for all participants (n=1934) who completed the survey at least once in adolescence (waves 2-6) and were alive at wave 9, with multiple imputation used for incomplete records. The results from available case analyses are presented in the **online appendix**; the pattern of results was broadly similar compared to the imputed data.

### Past-week Binge Drinking

Almost seven in eight males and two thirds of females reported binge drinking in the last week on at least one wave in adolescence and young adulthood. Nearly half of males and a quarter of females reported binge drinking both in adolescence *and* young adulthood. The overwhelming majority of adolescent-onset binge drinkers (nine in ten male and seven in ten female adolescent-onset binge drinkers) continued to binge drink in young adulthood (Table 1a). The number of young adult binge drinkers was increased by incident binge drinking among those who did not report binge drinking in adolescence: one third of males and females. Only 4.4% of males and 9.5% females who were adolescent binge drinkers did not report binge drinking in adulthood.

Past-week binge drinking (5+ standard drinks of 10g alcohol on a day) across adolescence (Figure 2a) increased in males from 14.4% in wave 2 (mean age 15.5years) to 31.1% in wave 6 (17.4yrs) and in females from 7.6% to 15.0%. Persistent adolescent past-week binge drinking (across 2+ adolescent waves) was reported by one in three males (31.8%) and one in seven females (15.3%; Table 1a). In the adult waves, the prevalence of binge drinking was

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7 higher for males and females than in the adolescent phase and levels consumed for males  
8 were higher than females. In adulthood (Table 1a, Figure 2a), over eighty per cent of males  
9 reported binge drinking on at least one adult wave and more than half of females did so. Six  
10 in ten (59.1%) males and one in four (24.5%) females reported binge drinking across  
11 multiple adult waves (Table 1a).  
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15 **Figure 2a and 2b about here**  
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### 17 18 19 **Past-week Heavy Binge Drinking**

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21 Just under half of the males (45.6%) and a third of females (36.2%) reported past-week  
22 heavy binge drinking at least once during adolescence or young adulthood (Table 1b). Sixty  
23 one percent of males and 42% of females who reported heavy binge drinking in adolescence  
24 continued into young adulthood. Of those who engaged in heavy binge drinking at any  
25 wave, 58% first reported doing so in young adulthood.  
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30 During adolescence, males and females reported similar levels of heavy binge use at each  
31 wave but males (7.9%) were more likely to report heavy binge drinking on multiple  
32 adolescent waves than females (4.7%; Table 1b). Past-week heavy binge drinking did not  
33 increase substantially until the young adult waves (Figure 2b). Around two in five males and  
34 one in four females reported past-week heavy binge drinking on at least one adult wave  
35 (Table 1b). At ages 20 and 24 years, around 20% of males and 13% of females reported  
36 heavy binge drinking. There was a decline in past-week heavy binge drinking by age 29  
37 years.  
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44 **Table 1a and 1b about here**

### 45 *Young adult binge and heavy binge alcohol use among adolescent-onset binge drinkers*

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47 Levels of past-week binge and heavy binge drinking in adulthood, among adolescent-onset  
48 binge and heavy binge drinkers, are presented in Figure 3. Males with adolescent-onset  
49 binge drinking were more likely to continue binge drinking in adulthood than females  
50 (Figure 3a): around seven in ten males reported doing so, compared to fewer than half of  
51 females. By 29 years, female adolescent-onset binge drinkers had substantially lower levels  
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7 of binge drinking than in earlier waves, and much lower levels than males. Levels of adult  
8 heavy binge drinking did not differ markedly by sex among adolescent-onset binge drinkers;  
9 around 20-30% reported past-week heavy binge drinking at ages 20 and 24, with lower  
10 levels at 29 years (wave 9; Figure 3a). Among adolescent-onset heavy binge drinkers, the  
11 patterns and levels followed a similar sex pattern to that in adolescent-onset binge drinkers  
12 (Figure 3b).  
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17 **Figure 3a and 3b about here**

18 Table 2 reports associations between adolescent characteristics and binge and heavy binge  
19 drinking at any adult wave in adolescent-onset binge drinkers (n=821). At a univariate level,  
20 being male, and reporting adolescent antisocial behaviour or negative consequences of  
21 alcohol use in adolescence were associated with the reporting of young adult binge and  
22 heavy binge drinking in the past week. In multivariable analyses that included all covariates,  
23 the associations between adult bingeing and female gender were substantially unchanged  
24 (for young adult binge OR 0.23, 95%CI 0.13-0.40; for young adult heavy binge use OR 0.63,  
25 95%CI 0.43-0.92). Associations with behavioural characteristics were substantially  
26 attenuated when adjusted for sex and other characteristics, with the strongest independent  
27 effect being an increased [the odds of young adult binge drinking risk](#) if sexual risk taking had  
28 occurred in adolescence.  
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35 **Table 2 about here**

## Discussion

~~To our knowledge this is one of few longitudinal studies charting the persistence of binge use of alcohol from adolescence into young adulthood (20).~~ Consistent with cross-sectional surveys in England(29), the USA, and Europe(5, 9), binge drinking was highly prevalent in both sexes and normative in young Australian males. A substantial minority also engaged in heavy binge drinking (drinking more than 20 drinks on an occasion). Over half of males and a third of females reported binge drinking in the past week at some time during adolescence, and one in five males and one in seven females reported what we defined as "heavy binge drinking".

The overwhelming majority of those who reported binge drinking in adolescence continued to do so in young adulthood. Even if past-week binge drinking was not reported in the teens, it was reported in at least one wave in young adulthood by 70% of males and 48% of females who did not report binge drinking at any time in adolescence. Interestingly, our findings about the continuity of past-week binge drinking from adolescence to young adulthood contrasted somewhat with the findings of a Norwegian cohort study, where considerable discontinuity was observed, and where they estimated that eliminating all adolescent hazardous drinking would only reduce adult hazardous drinking by 10%(30).

Among those who reported binge drinking in adolescence, variables that predicted binge and heavy binge drinking in young adulthood included: regular (weekly+) cannabis use, antisocial behaviour, and early onset sexual activity. The most consistent predictors of both adult binge and heavy binge drinking were reporting adverse consequences of alcohol use in adolescence, namely "intense drinking" (could not remember the night before because of drinking), social problems, sexual risk taking and physical harm. Adolescent binge drinkers who engaged in other risky behaviours, and who had experienced negative consequences of alcohol use, were most likely to continue drinking at these levels in adulthood. In multivariable regression analysis, the strongest independent predictor of adult binge drinking among adolescent binge drinkers was being male.

## Limitations

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7 The following limitations need to be acknowledged. First, non-response in longitudinal  
8 studies is often associated with alcohol and drug use. We used multiple imputation to  
9 minimise the impact of this potential bias, but this method carries its own assumptions and  
10 it is difficult to assess exactly how much residual bias might remain. The method of multiple  
11 imputation also assumes that data were missing at random. This is unlikely to be strictly true  
12 but the method is strengthened by the inclusion of auxiliary variables in the imputation  
13 model.  
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18 Second, our data do not capture the full extent of binge drinking in this cohort because not  
19 all binge alcohol use will have been captured within the one week reference period. Both of  
20 these limitations mean that our findings on levels of binge drinking may underestimate total  
21 exposure to these levels of drinking overall and over time.  
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25 Third, all data were based on self-report. There is reasonable evidence that young people's  
26 reports of alcohol use are both reliable and valid when reports are made in a confidential  
27 manner, and without any consequences for disclosing use (as was the case here) (31, 32).  
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30 Fourth, we used the same definition of binge and heavy binge drinking in adolescents and  
31 young adults. It is likely that the same amount of alcohol will have a greater adverse impact  
32 on adolescents than on adults. Notwithstanding these limitations, this study has provided  
33 unique prospective data on the persistence of a prevalent and hazardous drinking pattern  
34 from adolescence into adulthood.  
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38 We have clearly identified that binge alcohol use is a common behaviour among  
39 adolescents, and that it is likely to persist into young adulthood. These patterns of binge  
40 drinking in adolescence are a public health concern for two reasons. First, heavy alcohol use  
41 substantially increases the risks of: motor vehicle accidents, other injuries, alcohol-related  
42 assaults, and suicides in young people(33). Second, the longer-term health effects of  
43 persistent binge drinking during adulthood include alcohol dependence, liver disease and  
44 cancer. In most adolescent binge drinkers, binge drinking was clearly not just an "adolescent  
45 phase"; it was a pattern that persisted into young adulthood. There is an urgent need to  
46 understand why such high levels of alcohol use in adolescence continue into young  
47 adulthood.  
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7 Social acceptability, ready availability and low cost of alcohol are likely to be important  
8 drivers of early initiation into binge drinking and continuing high levels of consumption.  
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10 Both the taste (34) and packaging (35) of pre-mixed drinks are particularly attractive to  
11 young people; exposure to some forms of advertising is also associated with increased  
12 consumption (36), as are increased numbers of outlets selling alcohol (37-39), extended  
13 opening hours(40, 41), and reduced alcohol taxes (40, 42) (though only applied similarly  
14 across products(43)). The *persistence* of binge drinking into young adulthood may also be  
15 related to a delay in 'maturing out' of drinking as a result of the postponement in recent  
16 cohorts of major social role transitions such as marriage and parenthood into later  
17 adulthood(44).  
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## 22 **Conclusions**

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24 Alcohol is one of the biggest risk factors for disease burden among young people. Heavy  
25 consumption in young people is common and persistence into young adulthood is much  
26 more likely than not. There is a need to develop interventions that explicitly acknowledge  
27 that prevention confined to adolescence alone is insufficient. Clearly there is much work still  
28 to be done in that area, given the incredibly high exposure not only to *any* alcohol use, but  
29 to binge alcohol use, across the adolescent years, often repeatedly. It is also apparent that  
30 there is work to be done in young adulthood since most of the heavy binge drinking began  
31 then, once participants were legally allowed to drink, and past the age at which most  
32 prevention messages are targeted. There is an increasingly delayed uptake of social role  
33 transitions; it is unclear whether such shifts are related to the patterns of alcohol  
34 consumption we observed here. The adoption of policies and interventions including those  
35 to reduce alcohol availability (via shortened trading hours, and fewer outlets), increase cost  
36 (via taxation) and discourage drinking to intoxication, may assist in reducing binge alcohol  
37 use in future cohorts of young people.  
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### Author contributions

LD, GP, WS and CO'L conceived of the study. CO'L and HR conducted the analyses. LD led the writing of the manuscript. All authors commented on the analytic plan, interpretation, and contributed to the editing and final approval of the manuscript.

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**Figure legends**

**Figure 1: Sampling and ascertainment in the Victorian Adolescent Health Cohort, 1992 to 2008**

**Figure 2a: Levels of past week binge alcohol use among males and females (5 or more standard drinks on a day in the past week) by age**

**Figure 2b: Levels of past week "heavy binge" alcohol use among males and females (11 or more standard drinks on a day in the past week for females, 20 or more for males) by age**

**Figure 3a: Levels of past week binge and "heavy binge" drinking for males and females who reported binge drinking at one or more waves in adolescence, by age**

**Figure 3b: Levels of past week binge and "heavy binge" drinking for males and females who reported "heavy binge" drinking at one or more wave in adolescence, by age**

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Table 1a. Past week binge drinking during adolescence and young adulthood, by sex

|   | Binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                   |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                               | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 135                             | 14.4 | (12.1 - 16.7) | 76              | 7.6  | (5.90 - 9.30) | 211            | 10.9 | (9.50 - 12.3) |
| Wave 3 (mean age 15.9 years)  | 170                             | 18.1 | (15.5 - 20.7) | 96              | 9.6  | (7.50 - 11.7) | 265            | 13.7 | (12.1 - 15.4) |
| Wave 4 (mean age 16.4 years)  | 208                             | 22.3 | (19.3 - 25.3) | 140             | 14.1 | (11.8 - 16.3) | 349            | 18.0 | (16.2 - 19.9) |
| Wave 5 (mean age 16.8 years)  | 265                             | 28.3 | (25.1 - 31.5) | 152             | 15.2 | (12.9 - 17.6) | 417            | 21.6 | (19.6 - 23.5) |
| Wave 6 (mean age 17.4 years)  | 291                             | 31.1 | (28.0 - 34.3) | 150             | 15.0 | (12.6 - 17.4) | 441            | 22.8 | (20.8 - 24.8) |
| <b>Number of adolescent waves of any binge drinking</b>   |                                 |      |               |                 |      |               |                |      |               |
| Never   | 453                             | 48.5 | (45.0 - 52.0) | 660             | 66.1 | (63.0 - 69.1) | 1113           | 57.6 | (55.2 - 60.0) |
| 1 wave  | 184                             | 19.7 | (16.8 - 22.6) | 186             | 18.6 | (16.0 - 21.2) | 370            | 19.1 | (17.1 - 21.1) |
| 2+ waves  | 297                             | 31.8 | (28.5 - 35.1) | 153             | 15.3 | (13.0 - 17.7) | 451            | 23.3 | (21.3 - 25.3) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                 |      |               |                 |      |               |                |      |               |
| <b>Binge drinking by wave</b>   |                                 |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 509                             | 54.5 | (51.1 - 57.9) | 318             | 31.8 | (28.7 - 34.9) | 827            | 42.8 | (40.4 - 45.1) |
| Wave 8 (mean age 24.1 years)  | 550                             | 58.8 | (55.2 - 62.4) | 335             | 33.5 | (30.3 - 36.7) | 885            | 45.8 | (43.3 - 48.2) |
| Wave 9 (mean age 29.0 years)  | 524                             | 56.1 | (52.3 - 59.8) | 233             | 23.3 | (20.2 - 26.4) | 757            | 39.2 | (36.6 - 41.8) |
| <b>Number of adult waves of any binge drinking</b>  |                                 |      |               |                 |      |               |                |      |               |
| Never   | 178                             | 19.1 | (16.2 - 21.9) | 437             | 43.8 | (40.4 - 47.1) | 616            | 31.8 | (29.6 - 34.1) |
| 1 wave  | 204                             | 21.8 | (18.9 - 24.8) | 316             | 31.7 | (28.4 - 35.0) | 521            | 26.9 | (24.7 - 29.1) |
| 2+ waves  | 552                             | 59.1 | (55.7 - 62.5) | 245             | 24.5 | (21.5 - 27.6) | 798            | 41.2 | (38.8 - 43.7) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                 |      |               |                 |      |               |                |      |               |
| None in either phase  | 137                             | 14.7 | (12.2 - 17.2) | 342             | 34.2 | (31.0 - 37.5) | 479            | 24.8 | (22.7 - 26.9) |
| Incident in young adulthood   | 316                             | 33.8 | (30.3 - 37.3) | 318             | 31.9 | (28.7 - 35.0) | 634            | 32.8 | (30.4 - 35.2) |
| Remitted by young adulthood (adolescence only)  | 41                              | 4.4  | (2.80 - 6.00) | 95              | 9.5  | (7.50 - 11.6) | 136            | 7.1  | (5.80 - 8.30) |
| Continuing in young adulthood (both phases)   | 441                             | 47.1 | (43.5 - 50.7) | 244             | 24.4 | (21.6 - 27.2) | 684            | 35.4 | (33.1 - 37.7) |

Note: 'Binge' drinking defined as 5 or more drinks in one day in the past week.

Table 1b. Past week heavy binge drinking during adolescence and young adulthood, by sex

|   | Heavy binge drinking in the past week |      |               |                 |      |               |                |      |               |
|---|---------------------------------------|------|---------------|-----------------|------|---------------|----------------|------|---------------|
|   | Males (N=935)                         |      |               | Females (N=999) |      |               | Total (N=1934) |      |               |
|   | n                                     | %    | (95% CI)      | n               | %    | (95% CI)      | n              | %    | (95% CI)      |
| <b>ADOLESCENT PHASE (WAVES 2-6)</b>   |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 2 (mean age 15.5 years)  | 44                                    | 4.8  | (3.40 - 6.10) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.80) |
| Wave 3 (mean age 15.9 years)  | 45                                    | 4.8  | (3.40 - 6.20) | 32              | 3.2  | (2.10 - 4.30) | 77             | 4.0  | (3.10 - 4.90) |
| Wave 4 (mean age 16.4 years)  | 49                                    | 5.2  | (3.70 - 6.70) | 54              | 5.4  | (4.00 - 6.90) | 103            | 5.3  | (4.30 - 6.30) |
| Wave 5 (mean age 16.8 years)  | 79                                    | 8.5  | (6.40 - 10.5) | 66              | 6.6  | (5.00 - 8.10) | 145            | 7.5  | (6.20 - 8.80) |
| Wave 6 (mean age 17.4 years)  | 67                                    | 7.1  | (5.20 - 9.00) | 38              | 3.8  | (2.60 - 5.00) | 105            | 5.4  | (4.30 - 6.50) |
| <b>Number of adolescent waves of any heavy binge drinking</b>                                   |                                       |      |               |                 |      |               |                |      |               |
| Never   | 755                                   | 80.7 | (78.1 - 83.4) | 847             | 84.7 | (82.5 - 87.0) | 1601           | 82.8 | (81.1 - 84.5) |
| 1 wave  | 106                                   | 11.4 | (9.10 - 13.6) | 106             | 10.6 | (8.60 - 12.5) | 212            | 11.0 | (9.50 - 12.4) |
| 2+ waves  | 74                                    | 7.9  | (6.10 - 9.70) | 47              | 4.7  | (3.30 - 6.00) | 121            | 6.2  | (5.10 - 7.30) |
| <b>YOUNG ADULT PHASE (WAVES 7-9)</b>  |                                       |      |               |                 |      |               |                |      |               |
| <b>Heavy binge drinking by wave</b>   |                                       |      |               |                 |      |               |                |      |               |
| Wave 7 (mean age 20.7 years)  | 177                                   | 18.9 | (16.3 - 21.6) | 134             | 13.4 | (11.2 - 15.6) | 311            | 16.1 | (14.4 - 17.8) |
| Wave 8 (mean age 24.1 years)  | 201                                   | 21.4 | (18.7 - 24.2) | 135             | 13.5 | (11.3 - 15.8) | 336            | 17.4 | (15.6 - 19.1) |
| Wave 9 (mean age 29.0 years)  | 132                                   | 14.1 | (11.4 - 16.7) | 78              | 7.8  | (6.10 - 9.60) | 210            | 10.8 | (9.30 - 12.4) |
| <b>Number of adult waves of any heavy binge drinking</b>  |                                       |      |               |                 |      |               |                |      |               |
| Never   | 579                                   | 62   | (58.7 - 65.3) | 726             | 72.7 | (69.7 - 75.6) | 1305           | 67.5 | (65.2 - 69.7) |
| 1 wave  | 230                                   | 24.6 | (21.4 - 27.8) | 212             | 21.2 | (18.5 - 23.9) | 442            | 22.8 | (20.7 - 25.0) |
| 2+ waves  | 125                                   | 13.4 | (10.9 - 15.9) | 62              | 6.2  | (4.60 - 7.70) | 187            | 9.7  | (8.20 - 11.1) |
| <b>CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)</b> |                                       |      |               |                 |      |               |                |      |               |
| None in either phase  | 508                                   | 54.4 | (50.9 - 57.8) | 638             | 63.8 | (60.7 - 66.9) | 1146           | 59.2 | (56.9 - 61.6) |
| Incident in young adulthood   | 247                                   | 26.4 | (23.3 - 29.5) | 209             | 20.9 | (18.3 - 23.5) | 456            | 23.6 | (21.5 - 25.6) |
| Remitted by young adulthood (adolescence only)  | 71                                    | 7.6  | (5.80 - 9.50) | 88              | 8.8  | (7.00 - 10.7) | 160            | 8.2  | (6.90 - 9.60) |
| Continuing in young adulthood (both phases)   | 109                                   | 11.6 | (9.30 - 14.0) | 64              | 6.4  | (4.80 - 8.10) | 173            | 9.0  | (7.60 - 10.3) |

Note: 'Heavy binge' drinking defined as >11 drinks on a day in the past week for females, >20 for males. Persistent 'heavy binge' drinking in adolescence defined as heavy binge drinking in the past week on two or more waves across the adolescent waves (waves 2 to 6).

**Table 2: Predictors of binge alcohol use in young adulthood among adolescent 'binge' alcohol drinkers**  
(i.e. those who had past-week binge drinking on at least one wave during adolescence, waves 2-6; n=821)

| Adolescent predictors among adolescent 'binge' drinkers, n=821: | Young adult 'binge' drinking |               |                  |               | Young adult 'heavy binge' drinking |               |                  |               |
|---|------------------------------|---------------|------------------|---------------|------------------------------------|---------------|------------------|---------------|
|   | Modelled separately          |               | Modelled jointly |               | Modelled separately                |               | Modelled jointly |               |
|   | OR                           | (95% CI)      | OR               | (95% CI)      | OR                                 | (95% CI)      | OR               | (95% CI)      |
| <b>Female</b>   | 0.24                         | (0.15 - 0.39) | 0.23             | (0.13 - 0.40) | 0.67                               | (0.49 - 0.92) | 0.63             | (0.43 - 0.92) |
| <b>Daily smoking</b>  | 1.20                         | (0.79 - 1.81) | 1.12             | (0.69 - 1.82) | 1.29                               | (0.94 - 1.77) | 1.01             | (0.70 - 1.46) |
| <b>Weekly/daily cannabis use</b>                                | 1.65                         | (0.96 - 2.82) | 1.05             | (0.54 - 2.03) | 1.57                               | (1.11 - 2.24) | 1.06             | (0.71 - 1.60) |
| <b>Antisocial behaviour</b>                                     | 1.70                         | (1.12 - 2.59) | 0.99             | (0.60 - 1.63) | 1.59                               | (1.16 - 2.18) | 1.06             | (0.74 - 1.52) |
| <b>Early onset sexual activity (&lt;16 years)</b>               | 1.46                         | (0.92 - 2.33) | 1.04             | (0.60 - 1.83) | 1.53                               | (1.09 - 2.14) | 1.02             | (0.69 - 1.49) |
| <b>Adolescent mental health problems</b>                        |                              |               |                  |               |                                    |               |                  |               |
| CIS >11, 0 waves  | 1                            |               | 1                |               | 1                                  |               | 1                |               |
| CIS >11, 1 wave   | 0.81                         | (0.42 - 1.57) | 0.90             | (0.44 - 1.81) | 1.23                               | (0.81 - 1.87) | 1.15             | (0.74 - 1.77) |
| CIS >11, 2+ waves   | 0.60                         | (0.37 - 0.97) | 0.83             | (0.48 - 1.46) | 1.05                               | (0.74 - 1.49) | 0.99             | (0.64 - 1.52) |
| <b>Adolescent consequences attributed to alcohol use</b>        |                              |               |                  |               |                                    |               |                  |               |
| Intense drinking <sup>1</sup>                                   | 1.54                         | (1.00 - 2.36) | 1.45             | (0.84 - 2.50) | 1.77                               | (1.28 - 2.43) | 1.41             | (0.99 - 2.00) |
| Social problems <sup>2</sup>                                    | 1.34                         | (0.85 - 2.10) | 1.25             | (0.72 - 2.18) | 1.63                               | (1.16 - 2.31) | 1.23             | (0.83 - 1.83) |
| Physical harm <sup>3</sup>                                      | 1.92                         | (1.13 - 3.26) | 1.25             | (0.64 - 2.44) | 1.96                               | (1.37 - 2.81) | 1.29             | (0.84 - 1.96) |
| Sexual risk taking <sup>4</sup>                                 | 1.75                         | (1.01 - 3.03) | 1.51             | (0.77 - 2.97) | 2.09                               | (1.44 - 3.03) | 1.64             | (1.07 - 2.53) |

Note: 'Binge' drinking defined as 5 or more drinks in one day in the past week. 'Heavy binge' drinking defined as >11 drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

<sup>1</sup> Couldn't remember what said or did the night before as a result of alcohol use

<sup>2</sup> Lost friends, school trouble, argued with family as a result of alcohol use

<sup>3</sup> Injuries, accidents, violence attributed to their alcohol use

<sup>4</sup> Regretted having sex, or had sex without protection or contraceptives as a result of alcohol use

## Online appendix: Approach to multiple imputation

Missing data were handled using multiple imputation<sup>1</sup>. We imputed 20 complete datasets separately for males and females, under a multivariate normal model, incorporating all the analysis and auxiliary variables at each wave, except age and sexual risk-taking in adolescence, which was imputed as a binary summary measure. Wave 1 was omitted as it contained observations from only 46% of the cohort. Wave 1 responses were used to fill in wave 2 data, for any participant not seen at wave 2 as the same measures had been collected at the earlier wave. Waves 2 to 9 were imputed for all participants (N=1943) who completed the survey at least once in adolescence (waves 2-6). The imputation model contained 49 key variables used in the analysis and 8 auxiliary variables. Of 57 variables included in the imputation model, 18% of the variables had <10% missing values, 46% had ≥10% to <20% missing, 28% had ≥20% to <30% missing and only 5 variables (9%) had ≥45% to <55% missing values. A maximum level of drinking variable was created at each wave, with three levels: *no binge drinking*, *binge drinking* and *extreme binge drinking*. These variables and alcohol consequences variables were log transformed before imputation. Smoking, cannabis use, antisocial behaviour, mental health and summary measures of sexual risk-taking were imputed as binary variables at each wave. Age was imputed as a normal variable. After imputation, transformed variables were converted back to their original scale and all were categorised for analysis, with adaptive rounding used for binary measures<sup>2</sup>. Nine deceased participants were excluded from the imputed datasets. Frequencies and odds ratios were obtained by averaging results across the imputed datasets; inferences under multiple imputation were made using Rubin's rules<sup>1</sup>.

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