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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

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 ≥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.

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

Adolescent antisocial behaviour was assessed using 10 items from the Moffitt and Silva self-report early delinquency scale(16) that assessed property damage, interpersonal conflict and theft. Participants were asked if they had engaged in any of these behaviours *never, 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.

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

Adolescent mental health was assessed using the Clinical Interview Schedule (CIS-R)(17), which assesses depression and anxiety in non-clinical populations; a cut-off of >11 defined a mixed depression-anxiety state requiring clinical intervention . Mental health problems were summarised as having occurred: never, in one, or 2+ adolescent waves.

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

We calculated the prevalence at each wave and the number of waves of each type of binge drinking 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 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) (**see online appendix)**. All data analysis was undertaken using Stata 12(20).

Ethics

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

Role of the funding source

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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

need to understand why such high levels of alcohol use in adolescence continue into young adulthood.

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

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 assumes that data were missing at random, an assumption that is strengthened by the inclusion of auxiliary variables in the imputation model, but this assumption is unlikely to be true.

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. There is reasonable evidence for 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 use (as was the case here)(34, 35).

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. Notwithstanding these limitations, this study has provided unique prospective data on the persistence of a prevalent and hazardous drinking pattern into adulthood.

Conclusions

Alcohol is one of the biggest risk factors for disease burden among young people. Heavy consumption in young people is common and persistence into young adulthood is much more likely than not. The adoption of policies and interventions to reduce availability, 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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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

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)
ADOLESCENT PHASE (WAVES 2-6)									
Binge drinking by wave									
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)
Number of adolescent waves of any binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Binge drinking by wave									
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)
Number of adult waves of any binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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

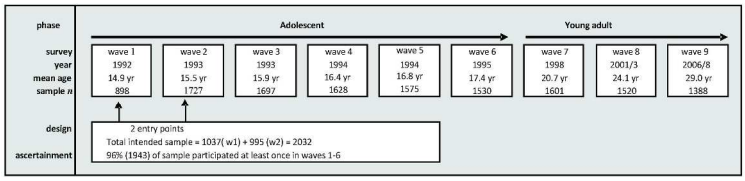
	Heavy binge drinking in the past week								
	Males (N=935)			Females (N=999)			Total (N=1934)		
	n	%	(95% CI)	n	%	(95% CI)	n	%	(95% CI)
ADOLESCENT PHASE (WAVES 2-6)									
Heavy binge drinking by wave									
Wave 2 (mean age 15.5 years)	44	4.8	(3.40 - 6.10)	32	3.2	(2.10 - 4.30)	77	4.0	(3.10 - 4.80)
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)
Number of adolescent waves of any heavy binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Heavy binge drinking by wave									
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)
Number of adult waves of any heavy binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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)
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)
Adolescent mental health problems								
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)
Adolescent consequences attributed to alcohol use								
Intense drinking[1]	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[2]	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[3]	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 [4]	1.75	(1.01 - 3.03)	1.51	(0.77 - 2.97)	2.09	(1.44 - 3.03)	1.64	(1.07 - 2.53)

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



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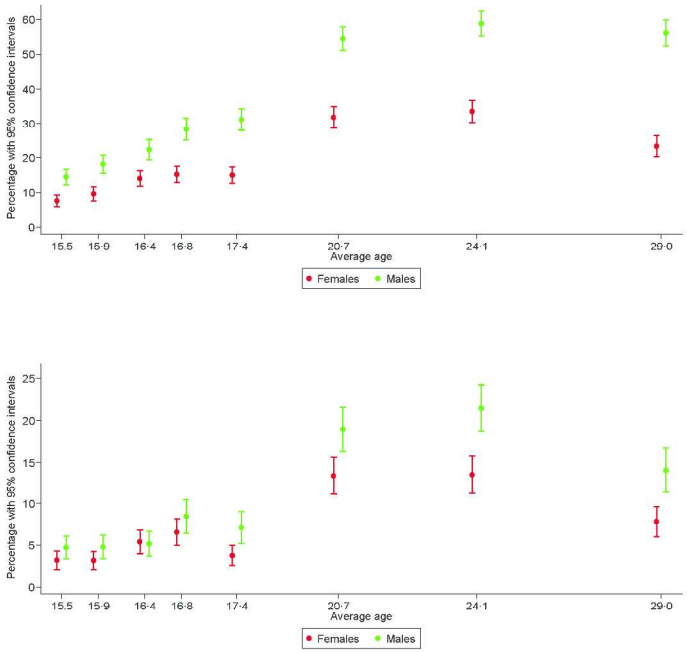

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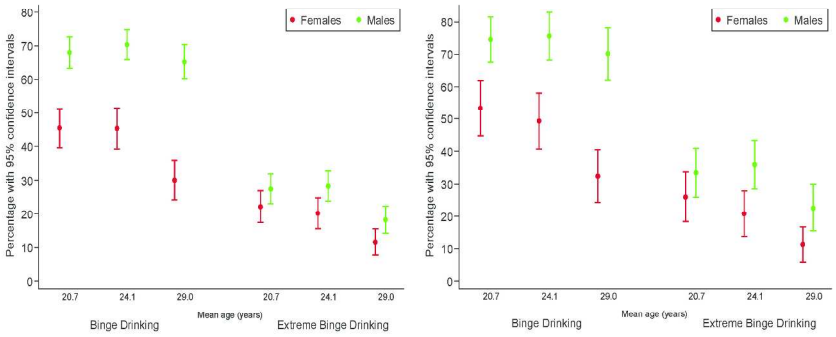

Note: Binge drinking defined as 5 or more drinks in one day in the past week. Heavy binge drinking defined as 11+ drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

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Online appendix: Approach to multiple imputation

Missing data were handled using multiple imputation[1]. 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[2]. 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[1].

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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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Conflict of interest: None.

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

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).

(1) '*Binge' drinking:* Defined (at each wave) as having drunk 5 or more 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 waves during the respective phase. For each phase, we identified the number of waves in which binge drinking occurred: none, one wave and 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 standard drinks for males and ≥11 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 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.

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

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, 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.

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 young adulthood wave. Those reporting sexual activity before 16 years were classified as *early onset sexually active*.

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.

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

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 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(26, 27) (**see online appendix)**. All data analysis was undertaken using Stata 12(28).

Ethics

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

Role of the funding source

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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

Table 2 reports associations between adolescent characteristics and binge and heavy binge drinking at any adult wave in adolescent-onset binge drinkers (n=821). At a univariate level, being male, and reporting adolescent antisocial behaviour 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. In multivariable analyses that included all covariates, the associations between adult bingeing and female gender were substantially unchanged (for young adult binge OR 0.23, 95%CI 0.13-0.40; for young adult heavy binge use OR 0.63, 95%CI 0.43-0.92). 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 (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

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

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 our findings on levels of binge drinking may underestimate total exposure to these levels of drinking overall and over time.

Third, all data were based on self-report. 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 use (as was the case here) (30, 31).

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

We have clearly identified that binge alcohol use is a common behaviour among adolescents, and that it is likely to persist into young adulthood. 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(32). Second, the longer-term health effects of persistent binge drinking during adulthood 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 that persisted into young adulthood. There is an urgent need to understand why such high levels of alcohol use in adolescence continue into young adulthood.

Social acceptability, ready availability and low cost of alcohol are likely to be important drivers of early initiation into binge drinking and continuing high levels of consumption. Both the taste (33) and packaging (34) of pre-mixed drinks are particularly attractive to young people; exposure to some forms of advertising is also associated with increased consumption (35), as are increased numbers of outlets selling alcohol (36-38), extended

opening hours(39, 40), and reduced alcohol taxes (39, 41) (though only applied similarly across products(42)). The *persistence* of binge drinking into young adulthood may also be related to a delay in 'maturing out' of drinking as a result of the postponement in recent cohorts of major social role transitions such as marriage and parenthood into later adulthood(43).

Conclusions

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

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)
ADOLESCENT PHASE (WAVES 2-6)									
Binge drinking by wave									
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)
Number of adolescent waves of any binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Binge drinking by wave									
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)
Number of adult waves of any binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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)
ADOLESCENT PHASE (WAVES 2-6)									
Heavy binge drinking by wave									
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)
Number of adolescent waves of any heavy binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Heavy binge drinking by wave									
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)
Number of adult waves of any heavy binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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)
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)
Adolescent mental health problems								
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)
Adolescent consequences attributed to alcohol use								
Intense drinking[1]	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[2]	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[3]	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 [4]	1.75	(1.01 - 3.03)	1.51	(0.77 - 2.97)	2.09	(1.44 - 3.03)	1.64	(1.07 - 2.53)

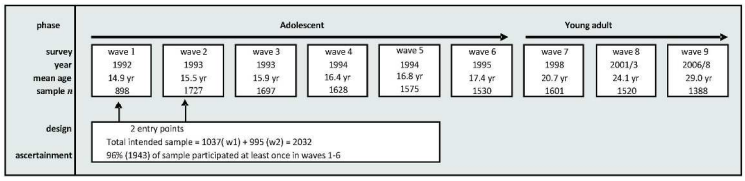
Note: 'Binge' drinking defined as 5 or more drinks in one day in the past week. 'Heavy binge' drinking defined as >11 drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

[1] Couldn't remember what said or did the night before as a result of alcohol use

[2] Lost friends, school trouble, argued with family as a result of alcohol use

[3] Injuries, accidents, violence attributed to their alcohol use

[4] Regretted having sex, or had sex without protection or contraceptives as a result of alcohol use



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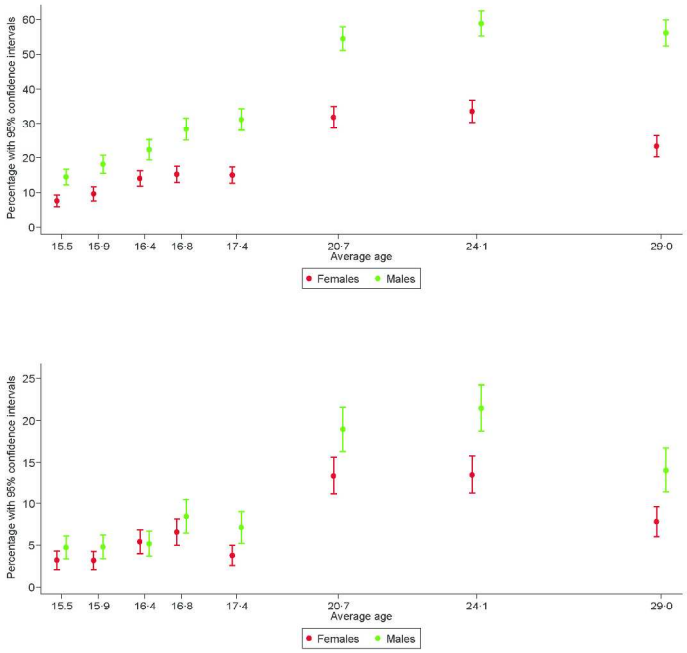

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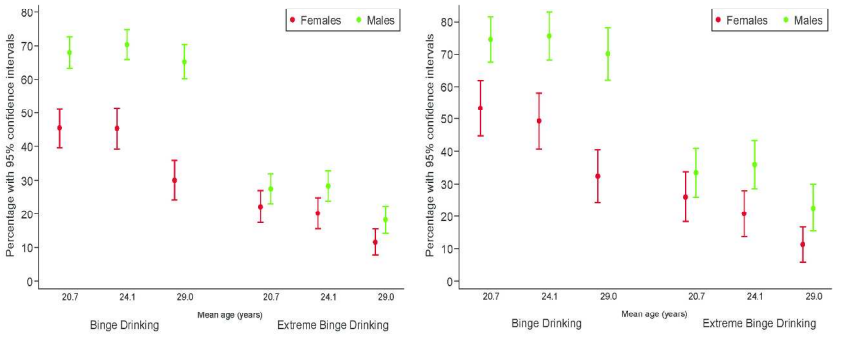

Note: Binge drinking defined as 5 or more drinks in one day in the past week. Heavy binge drinking defined as 11+ drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

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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: **This addressed in both title and abstract** (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found: **We have done so.**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported: **This is covered in the introduction**
Objectives	3	State specific objectives, including any prespecified hypotheses: **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.**
Methods		
Study design	4	Present key elements of study design early in the paper: **We have presented key design elements in the methods.**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection: **These are included in the text and in figure 1.**
Participants	6	(*a*) *Cohort study*?Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. **These are described in the methods section and in figure 1 including rates of attrition and reasons for attrition.** (*b*) *Cohort study*?For matched studies, give matching criteria and number of exposed and unexposed*Case-control study*?For matched studies, give matching criteria and the number of controls per case **Not applicable**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. **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).**
Data sources/ 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. **These are provided on page 5**
Bias	9	Describe any efforts to address potential sources of bias. **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:** ***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.** ***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 he potential for bias is small.**
Study size	10	Explain how the study size was arrived at. **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.**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why. **This explained in methods, results and in the tables.**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding. **Where relevant this is explained in the methods and results sections.** (*b*) Describe any methods used to examine subgroups and interactions. **We examined for first-order interactions where appropriate in the models.** (*c*) Explain how missing data were addressed. **This is described in the analysis sections and in the appendix.** (*d*) *Cohort study*?If applicable, explain how loss to follow-up was addressed. **This was described in analysis section.** (*e*) Describe any sensitivity analyses **We present available case analyses in the online appendix to allow the reader to examine the impact of multiple imputation.**
Results		
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: **This is shown in figure 1 and described in the results.**
		(*b*) Give reasons for non-participation at each stage. **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.**
		(*c*) Consider use of a flow diagram **See figure 1.**
Descriptive data	14*	(*a*)Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. **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*) Indicate number of participants with missing data for each variable of interest. **This study had very low levels of missing data for variables where the participant completed a wave.**
		(*c*) *Cohort study*? Summarise follow-up time (eg average and total amount). **See figure 1.**
Outcome data	15*	*Cohort study*? Report numbers of outcome events or summary measures over time. **See table 1. Summary measures and numbers are shown in the other tables.**
		Case-control study? Report numbers in each exposure category, or summary measures of exposure. **N/A**
		Cross sectional study? Report numbers of outcome events or summary measures **N/A**
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. **This is summarised in figure 1.**
		(*b*) Give reasons for non-participation at each stage. ***See above.***
		(*c*) Consider use of a flow diagram **See figure 1.**
Other analyses	17	Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses **N/A**
Discussion		
Key results	18	Summarise key results with reference to study objectives **This is undertaken on pages 9-11**
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 **See pages 13-14**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **We have done so.**
Generalisability	21	Discuss the generalisability (external validity) of the study results **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.**
Other information		
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 . **Given at the end of the discussion.**

Online appendix: Approach to multiple imputation

Missing data were handled using multiple imputation[1]. 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[2]. 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[1].

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)
ADOLESCENT PHASE (WAVES 2-6)												
Binge drinking by wave												
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)
YOUNG ADULT PHASE (WAVES 7-9)												
Binge drinking by wave												
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)
ADOLESCENT PHASE (WAVES 2-6)												
Binge drinking by wave												
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)
YOUNG ADULT PHASE (WAVES 7-9)												
Binge drinking by wave												
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.

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

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Running head: Adolescent binge drinking

Word count (text only): 3,240; Abstract 250

Conflict of interest: None.

Style Definition: Comment Text

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.

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.

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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~~(1)~~(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~~(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).~~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~~(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. ~~Stage~~At stage one, 45 schools were randomly chosen from a stratified frame of government, Catholic and independent private schools. ~~Stage~~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~~(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 ~~of~~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 ≥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.

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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.

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

Adolescent antisocial behaviour was assessed using 10 items from the Moffitt and Silva self-report early delinquency scale~~(16) that~~(24), which assessed property damage, interpersonal conflict and theft. Participants were asked if they had engaged in any of these behaviours *never, 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.

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

Adolescent mental health was assessed using the Clinical Interview Schedule (CIS-R)~~(17), which assesses depression and anxiety in non-clinical populations; a cut-off of >11 defined~~(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.

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

We calculated the prevalence of binge drinking at each wave and the number of waves ~~of~~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(~~20~~28).

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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.

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~~(12).~~ (20). Consistent with cross-sectional surveys in England~~(21)~~(29), 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~~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

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

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 our findings on levels of binge drinking may underestimate total exposure to these levels of drinking overall and over time.

Third, all data were based on self-report. 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 use (as was the case here) (30, 31).

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

We have clearly identified that binge alcohol use is a common behaviour among adolescents, and that it is likely to persist into young adulthood. 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:~~(32). Second, the longer-term health effects of persistent binge drinking during adulthood 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 that persisted into young adulthood. There is an urgent need to understand why such high levels of alcohol use in adolescence continue into young adulthood.

~~Social acceptability, ready availability and low cost of alcohol are likely important drivers of early initiation and continuing high levels of consumption. Both the taste(23) and packaging(24) of pre-mixed drinks are particularly attractive to young people; exposure to some forms of advertising is also associated with increased consumption(25), as are increased numbers of outlets selling alcohol~~Social acceptability, ready availability and low

cost of alcohol are likely to be important drivers of early initiation into binge drinking and continuing high levels of consumption. Both the taste (33) and packaging (34) of pre-mixed drinks are particularly attractive to young people; exposure to some forms of advertising is also associated with increased consumption (35), as are increased numbers of outlets selling alcohol ~~(26-28)~~(36-38)~~, extended opening hours(29, 30), and reduced alcohol taxes(29, 31) (though only applied similarly across products(32)). The *persistence* of binge drinking into young adulthood may also be related to a delay in 'maturing out' of drinking as a result of the postponement of major social role transitions such as marriage and parenthood into later adulthood~~, extended opening hours(39, 40), and reduced alcohol taxes (39, 41) (though only applied similarly across products(42)). The *persistence* of binge drinking into young adulthood may also be related to a delay in 'maturing out' of drinking as a result of the postponement in recent cohorts of major social role transitions such as marriage and parenthood into later adulthood~~(33)~~(43).

~~**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 assumes that data were missing at random, an assumption that is strengthened by the inclusion of auxiliary variables in the imputation model, but this assumption is unlikely to be true.~~

~~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.~~ ~~There is reasonable evidence for 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 use (as was the case here)(34, 35).~~

~~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. Notwithstanding these limitations, this study has provided unique prospective data on the persistence of a prevalent and hazardous drinking pattern into adulthood.~~

Conclusions

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

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)
ADOLESCENT PHASE (WAVES 2-6)									
Binge drinking by wave									
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)
Number of adolescent waves of any binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Binge drinking by wave									
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)
Number of adult waves of any binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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.

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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)
ADOLESCENT PHASE (WAVES 2-6)									
Heavy binge drinking by wave									
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)
Number of adolescent waves of any heavy binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Heavy binge drinking by wave									
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)
Number of adult waves of any heavy binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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~~"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)
Adolescent mental health problems								
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)
Adolescent consequences attributed to alcohol use								
Intense drinking[1]	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[2]	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[3]	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[4]	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.

[1] Couldn't remember what said or did the night before as a result of alcohol use

[2] Lost friends, school trouble, argued with family as a result of alcohol use

[3] Injuries, accidents, violence attributed to their alcohol use

[4] Regretted having sex, or had sex without protection or contraceptives as a result of alcohol use

27

Online appendix: Approach to multiple imputation

Missing data were handled using multiple imputation[1]. 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[2]. 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[1].

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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).

(1) *'Binge' drinking:* Defined (at each wave) as having drunk 5 or more 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 waves during the respective phase. For each phase, we identified the number of waves in which binge drinking occurred: none, one wave and 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 standard drinks for males and ≥11 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 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.

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

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, 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.

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 young adulthood wave. Those reporting sexual activity before 16 years were classified as *early onset sexually active*.

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.

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

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

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(26, 27) (**see online appendix)**. All data analysis was undertaken using Stata 12(28).

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.

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

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

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

Table 2 about here

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

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

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 our findings on levels of binge drinking may underestimate total exposure to these levels of drinking overall and over time.

Third, all data were based on self-report. 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 use (as was the case here) (31, 32).

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

We have clearly identified that binge alcohol use is a common behaviour among adolescents, and that it is likely to persist into young adulthood. 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(33). Second, the longer-term health effects of persistent binge drinking during adulthood 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 that persisted into young adulthood. There is an urgent need to understand why such high levels of alcohol use in adolescence continue into young adulthood.

Social acceptability, ready availability and low cost of alcohol are likely to be important drivers of early initiation into binge drinking and continuing high levels of consumption. Both the taste (34) and packaging (35) of pre-mixed drinks are particularly attractive to

young people; exposure to some forms of advertising is also associated with increased consumption (36), as are increased numbers of outlets selling alcohol (37-39), extended opening hours(40, 41), and reduced alcohol taxes (40, 42) (though only applied similarly across products(43)). The *persistence* of binge drinking into young adulthood may also be related to a delay in 'maturing out' of drinking as a result of the postponement in recent cohorts of major social role transitions such as marriage and parenthood into later adulthood(44).

Conclusions

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

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

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)
ADOLESCENT PHASE (WAVES 2-6)									
Binge drinking by wave									
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)
Number of adolescent waves of any binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Binge drinking by wave									
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)
Number of adult waves of any binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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)
ADOLESCENT PHASE (WAVES 2-6)									
Heavy binge drinking by wave									
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)
Number of adolescent waves of any heavy binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Heavy binge drinking by wave									
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)
Number of adult waves of any heavy binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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)
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)
Adolescent mental health problems								
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)
Adolescent consequences attributed to alcohol use								
Intense drinking[1]	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[2]	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[3]	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 [4]	1.75	(1.01 - 3.03)	1.51	(0.77 - 2.97)	2.09	(1.44 - 3.03)	1.64	(1.07 - 2.53)

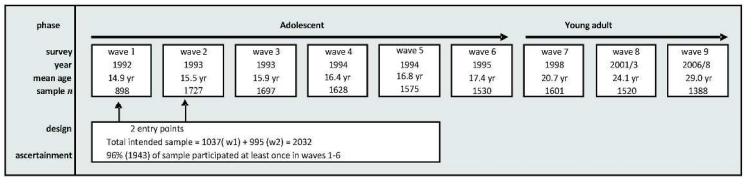
Note: 'Binge' drinking defined as 5 or more drinks in one day in the past week. 'Heavy binge' drinking defined as >11 drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

[1] Couldn't remember what said or did the night before as a result of alcohol use

[2] Lost friends, school trouble, argued with family as a result of alcohol use

[3] Injuries, accidents, violence attributed to their alcohol use

[4] Regretted having sex, or had sex without protection or contraceptives as a result of alcohol use



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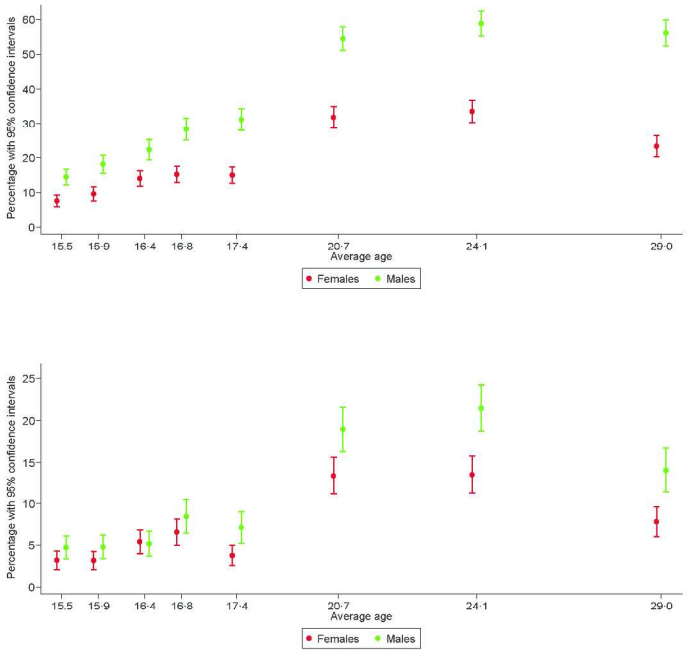

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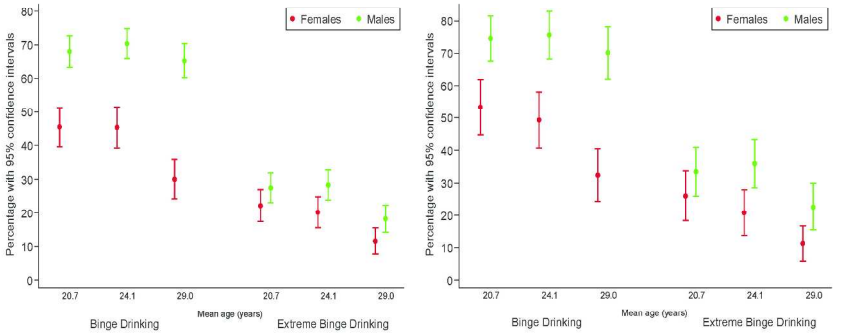

Note: Binge drinking defined as 5 or more drinks in one day in the past week. Heavy binge drinking defined as 11+ drinks in one day in the past week for females, >20 for males. Note that 21-22 years = wave 7; 24-25 years = wave 8; 28-29 years = wave 9.

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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: **This addressed in both title and abstract** (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found: **We have done so.**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported: **This is covered in the introduction**
Objectives	3	State specific objectives, including any prespecified hypotheses: **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.**
Methods		
Study design	4	Present key elements of study design early in the paper: **We have presented key design elements in the methods.**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection: **These are included in the text and in figure 1.**
Participants	6	(*a*) *Cohort study*?Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. **These are described in the methods section and in figure 1 including rates of attrition and reasons for attrition.** (*b*) *Cohort study*?For matched studies, give matching criteria and number of exposed and unexposed*Case-control study*?For matched studies, give matching criteria and the number of controls per case **Not applicable**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. **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).**
Data sources/ 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. **These are provided on page 5**
Bias	9	Describe any efforts to address potential sources of bias. **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:** ***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.** ***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 he potential for bias is small.**
Study size	10	Explain how the study size was arrived at. **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.**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why. **This explained in methods, results and in the tables.**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding. **Where relevant this is explained in the methods and results sections.** (*b*) Describe any methods used to examine subgroups and interactions. **We examined for first-order interactions where appropriate in the models.** (*c*) Explain how missing data were addressed. **This is described in the analysis sections and in the appendix.** (*d*) *Cohort study*?If applicable, explain how loss to follow-up was addressed. **This was described in analysis section.** (*e*) Describe any sensitivity analyses **We present available case analyses in the online appendix to allow the reader to examine the impact of multiple imputation.**
Results		
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: **This is shown in figure 1 and described in the results.**
		(*b*) Give reasons for non-participation at each stage. **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.**
		(*c*) Consider use of a flow diagram **See figure 1.**
Descriptive data	14*	(*a*)Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. **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*) Indicate number of participants with missing data for each variable of interest. **This study had very low levels of missing data for variables where the participant completed a wave.**
		(*c*) *Cohort study*? Summarise follow-up time (eg average and total amount). **See figure 1.**
Outcome data	15*	*Cohort study*? Report numbers of outcome events or summary measures over time. **See table 1. Summary measures and numbers are shown in the other tables.**
		Case-control study? Report numbers in each exposure category, or summary measures of exposure. **N/A**
		Cross sectional study? Report numbers of outcome events or summary measures **N/A**
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. **This is summarised in figure 1.**
		(*b*) Give reasons for non-participation at each stage. ***See above.***
		(*c*) Consider use of a flow diagram **See figure 1.**
Other analyses	17	Report other analyses done?eg analyses of subgroups and interactions, and sensitivity analyses **N/A**
Discussion		
Key results	18	Summarise key results with reference to study objectives **This is undertaken on pages 9-11**
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 **See pages 13-14**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **We have done so.**
Generalisability	21	Discuss the generalisability (external validity) of the study results **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.**
Other information		
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 . **Given at the end of the discussion.**

Online appendix: Approach to multiple imputation

Missing data were handled using multiple imputation[1]. 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[2]. 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[1].

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)
ADOLESCENT PHASE (WAVES 2-6)												
Binge drinking by wave												
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)
YOUNG ADULT PHASE (WAVES 7-9)												
Binge drinking by wave												
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)
ADOLESCENT PHASE (WAVES 2-6)												
Binge drinking by wave												
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)
YOUNG ADULT PHASE (WAVES 7-9)												
Binge drinking by wave												
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.

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

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Running head: Adolescent binge drinking

Word count (text only): 3,240; Abstract 250

Conflict of interest: None.

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;

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

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).

(1) '*Binge' drinking:* Defined (at each wave) as having drunk 5 or more 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 waves during the respective phase. For each phase, we identified the number of waves in which binge drinking occurred: none, one wave and 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 standard drinks for males and ≥11 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 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.

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

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, 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.

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 young adulthood wave. Those reporting sexual activity before 16 years were classified as *early onset sexually active*.

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.

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

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 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(26, 27) (**see online appendix)**. All data analysis was undertaken using Stata 12(28).

Ethics

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

Role of the funding source

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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

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

Table 2 reports associations between adolescent characteristics and binge and heavy binge drinking at any adult wave in adolescent-onset binge drinkers (n=821). At a univariate level, being male, and reporting adolescent antisocial behaviour 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. In multivariable analyses that included all covariates, the associations between adult bingeing and female gender were substantially unchanged (for young adult binge OR 0.23, 95%CI 0.13-0.40; for young adult heavy binge use OR 0.63, 95%CI 0.43-0.92). Associations with behavioural characteristics were substantially attenuated when adjusted for sex and other characteristics, with the strongest independent effect being an increased the odds of young adult binge drinking~~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 (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

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

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 our findings on levels of binge drinking may underestimate total exposure to these levels of drinking overall and over time.

Third, all data were based on self-report. 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 use (as was the case here) (31, 32).

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

We have clearly identified that binge alcohol use is a common behaviour among adolescents, and that it is likely to persist into young adulthood. 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(33). Second, the longer-term health effects of persistent binge drinking during adulthood 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 that persisted into young adulthood. There is an urgent need to understand why such high levels of alcohol use in adolescence continue into young adulthood.

Social acceptability, ready availability and low cost of alcohol are likely to be important drivers of early initiation into binge drinking and continuing high levels of consumption. Both the taste (34) and packaging (35) of pre-mixed drinks are particularly attractive to young people; exposure to some forms of advertising is also associated with increased consumption (36), as are increased numbers of outlets selling alcohol (37-39), extended opening hours(40, 41), and reduced alcohol taxes (40, 42) (though only applied similarly across products(43)). The *persistence* of binge drinking into young adulthood may also be related to a delay in 'maturing out' of drinking as a result of the postponement in recent cohorts of major social role transitions such as marriage and parenthood into later adulthood(44).

Conclusions

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

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)
ADOLESCENT PHASE (WAVES 2-6)									
Binge drinking by wave									
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)
Number of adolescent waves of any binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Binge drinking by wave									
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)
Number of adult waves of any binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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)
ADOLESCENT PHASE (WAVES 2-6)									
Heavy binge drinking by wave									
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)
Number of adolescent waves of any heavy binge drinking									
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)
YOUNG ADULT PHASE (WAVES 7-9)									
Heavy binge drinking by wave									
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)
Number of adult waves of any heavy binge drinking									
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)
CONTINUITY AND DISCONTINUITY FROM ADOLESCENCE (WAVES 2-6) TO YOUNG ADULTHOOD (WAVES 7-9)									
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)
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)
Adolescent mental health problems								
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)
Adolescent consequences attributed to alcohol use								
Intense drinking[1]	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[2]	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[3]	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[4]	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.

[1] Couldn't remember what said or did the night before as a result of alcohol use

[2] Lost friends, school trouble, argued with family as a result of alcohol use

[3] Injuries, accidents, violence attributed to their alcohol use

[4] 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[1]. 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[2]. 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[1].

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.