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RESEARCH REPORT

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Alcohol consumption trajectories over the Australian life course

Geoffrey Leggat[1] | Michael Livingston[1,2,3] | Sandra Kuntsche[1] | Sarah Callinan[1]

[1]Centre for Alcohol Policy Research (CAPR), La Trobe University, Melbourne, Victoria, Australia

[2]National Drug Research Institute, Curtin University, Perth, Western Australia, Australia

[3]Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Södermanland and Uppland, Sweden

Correspondence
Geoffrey Leggat, Centre for Alcohol Policy Research (CAPR), La Trobe University, Plenty Rd and Kingsbury Dr., Melbourne, VIC 3086, Australia.
Email: g.leggat@latrobe.edu.au.

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Abstract

Background and Aims: Alcohol consumption changes markedly over the life course, with important implications for health and social development. Assessment of these patterns often relies on cross-sectional data, which cannot fully capture how individuals' drinking changes as they age. This study used data from 18 waves of a general population panel survey to measure drinking trajectories over the life course in Australia.

Design and Setting: Longitudinal survey data from the Household, Income and Labour Dynamics in Australia (HILDA) survey between 2001 and 2018.

Participants: A total of 20 593 individuals ages 15 or above in two samples assessing quantity-frequency (n = 20 569, 52.0% female) and risky single occasion drinking (RSOD), respectively, (n = 17 340, 52.5% female), interviewed as part of HILDA.

Measurements: Usual quantity of alcohol consumed per drinking occasion; frequency of drinking occasions per week; average daily consumption, calculated by combining reported usual quantity and frequency; and average reported frequency of RSOD per week.

Findings: Multilevel, mixed effects models run with fractional polynomial terms found similar male and female alcohol consumption trajectories for quantity-frequency and RSOD measures. Usual quantity of alcohol consumed per drinking occasion (5.4 drinks for men, 3.8 for women) and RSOD frequency (0.56 occasions/week for men, 0.38 for women) peaked in young adulthood, whereas frequency of drinking occasions (2.5 occasions/week for men, 1.7 for women) peaked in middle age. Middle-age drinkers had the highest average daily consumption of alcohol (1.4 drinks/day for 54-year-old men, 0.6 drinks for 57-year-old women) and engaged in RSOD slightly less than young adults.

Conclusions: Alcohol consumption in Australia appears to vary substantially over the life course, with usual quantity per drinking occasion and frequency of risky single occasion drinking peaking during early adulthood and average daily consumption and frequency of consumption peaking in middle age.

KEYWORDS
Alcohol consumption, Australia, drinking trajectories, life course, longitudinal, risky single occasion drinking

INTRODUCTION

Millions of deaths are attributable to alcohol globally each year [1], with 4186 in Australia alone in 2017 [2]. Alcohol consumption contributes to a range of health impacts, including injuries, accidents and longer-term alcohol-related diseases [3]. In 2015, alcohol was a top 10 leading risk factor for burden of disease across the Australian population [4]. For young people, ages 15–24, alcohol was the leading risk factor for burden of disease for men and the second leading risk factor for women [4]. Young adult drinkers (18–24), are generally most likely to exceed single-occasion drinking guidelines and put themselves at risk of intoxication or short-term, alcohol-related harms [5]. In contrast, the tendency of older drinkers to drink more frequently [6] may put them at greater risk of long-term alcohol-related, non-communicable diseases such as cancer or heart or liver disease [2, 7]. This considerable burden of disease attributable to alcohol across the population makes alcohol a key public health concern in Australia and internationally [4].

Drinking is a dynamic behaviour that varies over the life course. Cross-sectional, Australian analyses have shown alcohol consumption is greatest in early adulthood, following quick increases in adolescence [5, 8]. Consumption then declines with age [8, 9], particularly risky single occasion drinking (RSOD). However, frequency of drinking appears to increase with age, with many older Australians drinking daily [5]. These findings are broadly consistent with work in other countries, such as the United States and United Kingdom (UK) [6, 10–13]. These age specific patterns are not fixed, however, with recent studies highlighting significant shifts in drinking trends internationally [14–17]. In particular, younger drinkers are consuming significantly less and abstaining more over the last decade [14–17], whereas middle-age drinkers have maintained, or in some cases increased, their consumption [14].

As a result, where research may have identified rising consumption during adolescence, peaking in emerging adulthood [6, 10, 18], middle-age drinkers may now be the peak consumers of alcohol [14] and most likely to exceed lifetime risk guidelines [5]. These shifts raise concerns regarding how trajectories of drinking may have shifted from previously identified patterns. Possibly indicating that current health promotion efforts to reduce risk of alcohol-related harms, often focused on youth drinking, could be better targeted. Work reassessing the prevalence of alcohol consumption and related behaviours across the life stages may help to identify trends in drinking and provide insight into potential stages of life of concern for use for policy or intervention implementation.

The substantial amount of data required to evaluate drinking behaviour over a lifetime has meant previous studies have often focussed on specific life stages [10, 19, 20] or relied on repeated cross-sectional snapshots [12, 14, 21]. Because cross-sectional methods cannot assess developments within individuals over time, longitudinal data are key for effectively assessing behavioural development. However, few appropriate longitudinal datasets have a period of follow-up long enough to provide meaningful assessments of change within individuals. Other studies have used multiple different data sources to synthesise trajectories of drinking over longer periods [6]. For example, Britton *et al*. [6], harmonised data from nine UK cohort studies to produce a key picture of alcohol consumption across the life course, finding mean alcohol consumption peaked in early adulthood, declined through adulthood, with a plateau in middle age, before declining into old age. This approach helps overcome difficulties in gaining the required data and allows for the inclusion of participants from multiple birth cohorts and age groups. However, a single longitudinal dataset may provide a more consistent examination of drinking patterns over time.

The present study uses data from a single, representative, longitudinal household survey to provide an overview of alcohol consumption across the life course in Australia. The use of a single dataset provides several benefits, including consistency of measures across the different waves. The survey's representativeness ensures that findings are reflective of the broader Australian population. In addition, the long running time of the survey ensures there are a suitable number of repeated measurements to observe development within participants, while also assessing these developments among similarly age individuals across multiple cohorts. In this study, we will assess multiple alcohol consumption measures over the life course: frequency of consumption, usual quantity per drinking occasion and RSOD.

METHODS

Study sample

Data were obtained from the Household, Income and Labour Dynamics in Australia survey (HILDA). HILDA is a representative, longitudinal, Australian household population survey that has been collecting data annually since 2001. Detailed sampling and survey methodology are available elsewhere [22, 23]. HILDA's response and retention rates, (that have remained above 87% from 2002 to 2018 [waves 2–18]) [23]), as well as its recruitment methods and representativeness, compare favourably to other similar household surveys [24]. Participants must be at least 15 years of age to take part. If a participant moves households, the new household members are added to the survey. To ensure the survey remained representative of the Australian population an additional top-up sample was included from 2011 (wave 11) [23], although ongoing consideration is also given to ensure new immigrants are sufficiently represented [22].

Within HILDA, usual quantity per drinking occasion and frequency of alcohol consumption are collected annually. In addition, a gendered RSOD measure (5+ standard drinks for women and 7+ for men) is assessed every 2 years. Therefore, we used two samples to assess these measures. The primary sample includes annual quantity and frequency responses from between 2001 and 2018 (18 waves), whereas the second, the RSOD sample, includes the RSOD frequency measure featured in every second wave of HILDA since 2007 (2007–2017 [6 waves]).

To suitably balance available data and model fit, and ensure that individual development would be considered within each model, a range of models with differing minimum years of survey participation requirements were compared. Wave participation was defined by completion of an interview, (i.e. an individual who completes an interview, but does not respond to any alcohol measures is considered as participating in that wave). Individuals who did not participate in the minimum number of surveys, (because of attrition or being unavailable for enough interviews for example) were excluded. In addition, individuals who participated in enough surveys, but did not respond to any alcohol consumption questions throughout were also excluded.

Covariates

Participant age (in years), gender and household income are reported each wave. Household income was used to adjust for different alcohol consumption outcomes related to differing socioeconomic status [25, 26]. To account for the different economic resources available to individuals in different households, equivalised household income was calculated by totalling household income and dividing by an equivalence factor determined by household composition [27]. For example, a single person household with an income of $100 000 has a higher equivalised income than a 2 adult-3 child household with an identical $100 000 income.

Gender is included because men historically consume more and experience a greater level of harm from alcohol than women [28]. In addition, men's alcohol consumption often differs from women's at specific stages of life [6, 12, 29], and in response to life events (e.g. pregnancy, childbirth) [30, 31].

Outcomes

Alcohol consumption was assessed using quantity-frequency measures. Frequency of alcohol consumption is based on participant responses to the question 'Do you drink alcohol?' Responses were coded based on the average occasions per week that alcohol is consumed and ranged from 0 (for those who responded 'I have never drunk alcohol' or 'I no longer drink'), to 7 (for 'Yes, I drink alcohol everyday').

Usual quantity of alcohol consumption per drinking occasion was assessed by the question 'On a day that you have an alcoholic drink, how many standard drinks do you usually have?' Participant responses were coded onto a scale from 1.5 ('1 to 2 standard drinks') through to 13.5 ('13 or more standard drinks'). Those who indicated they did not or no longer drank alcohol were coded as 0.

A measure of average daily alcohol consumption was derived by multiplying usual quantity and frequency values. These totals were then divided by 365 to obtain average daily alcohol consumption, in standard drinks. An Australian standard drink is equivalent to 10 g of alcohol.

RSOD was assessed by participants reporting the frequency they exceed sex-based thresholds (5 standard drinks for women and 7 for men) in response to the question 'How often do you have 5/7 or more standard drinks on one occasion?' Participants were coded from 0 (for those who abstained or did not exceed the threshold in the past year), to 5 (for those exceeding the threshold 5 or more times per week).

Full response categories for each outcome measure are provided in the Supporting information.

Statistical analysis

In Stata 15 [32], multilevel mixed effects models with three levels and fractional polynomial terms were run to account for the longitudinal, household-based structure of the data. Each observation (or person-year, that is each year each individual responded to the survey) (level 1) was nested within each individual (level 2), to account for the longitudinal nature of the included waves of participant responses, whereas each individual was additionally nested within a household (level 3), representing the sampling cluster. Separate models examining average daily consumption, usual quantity, frequency and RSOD were run, individually for men and women, to assess how alcohol consumption varied over time and as a function of age. Each model adjusted for equivalised household income, as a representation of socioeconomic status.

Fractional polynomials are often used in regression models to fit non-linear functions [33, 34] and involve fitting variables within a model with a range of fractional polynomial terms to identify the best fitting model. The goal of fractional polynomial models is to provide flexible models that are as simple and quick to run as possible [33]. Model selection was carried out using the 'fp_select' postestimation tool, which implements the function selection criteria described by Royston [34]. Specifically, 'fp_select' tests the fit of each fractional polynomial model against similar models with an increasing number of fractional polynomial terms or dimensions, to a maximum of 5 in this case. Increasing the number of dimensions increases the complexity and widens the range of possible shapes a solution may take. Details of the implemented tests are provided elsewhere [34], but briefly, a model with a single fractional polynomial is first tested against a model with two terms. A non-significant test indicates the less complex model is preferable, otherwise the cycle continues with more complex models up to maximum of 5 in this case [34].

The analysis plan and methods in the present study have not been pre-registered and as such, the results should be considered exploratory.

RESULTS

Comparisons of different minimum years of participation found broadly similar outcomes. Ultimately, a minimum of 5 waves was identified as providing the best balance of sample size, model fit and

consideration of individual development for the primary sample and a minimum of 3 years for the RSOD sample.

For the primary sample, 14 358 (of 34 927) individuals did not participate in sufficient waves and were excluded before analysis. This included 2463 (17.1%) respondents who dropped out, 7148 (49.8%) that were not eligible to participate in HILDA for long enough, 4127 (28.7%) that missed too many waves and 620 (4.3%) that did not provide any alcohol consumption data throughout. This left a total of 20 569 (52.0% female) participants and 255 182 respondent-years of data. Of this, 34 095 (13.4%) person-years were missing because of respondents not completing the alcohol questions in individual waves.

For the RSOD sample, 9303 individuals were considered ineligible (2336 [27.8%] dropped out, 1586 [18.9%] were not eligible for HILDA for enough waves, 4485 [53.3%] because of wave non-participation) and 896 (4.9%) did not respond to any alcohol questions. This left a total of 17 340 (52.5% female) participants and 86 714 person-years. A total of 10 955 (12.6%) of these person-years were missing in this sample.

Sample demographics for the primary sample and the RSOD sample are provided in Tables 1 and 2, respectively. Quantitative model results are provided in the Supporting information.

Among the primary sample, men were slightly younger (35 vs 36 years), drank more per occasion, (3.50 vs 1.50 drinks) and more often than women (1.50 vs 0.58 occasions per week). There were few individuals abstaining across the entire survey (6.2% of men, 9.5% of women), however, there was a comparatively large number of individual person-years in which participants abstained (12.1% male person-years, 18.6% female person-years).

In the RSOD sample, men were slightly younger (39 vs 40 years) and engaged in RSOD more often than women (0.11 vs 0 median risky occasions per week). Compared to the primary sample, a much greater proportion of participants abstained partially and throughout the entire study period (15.4% of men, 34.4% of male person-years, 23.6% of women, 49.2% of female person-years).

Primary sample models

Average daily alcohol consumption

The fitted model results for the number of standard drinks consumed per day for men and women are presented in Fig. 1. For both men and women, five-dimensional models provided the best fit.

Both trajectories have similar patterns of consumption across the life course. Average daily consumption initially peaks during young adulthood (18–24), with declines through adulthood (25–44), and a further sustained peak throughout middle age (45–64) for both men and women before declines in old age (65+). Men consumed more than women at all ages, peaking at 1.4 standard drinks per day in middle age, compared to 0.6 drinks at a similar age for women.

Usual quantity per drinking occasion

For both men and women, the most suitable model was the five-dimensional model. Again, trajectories were similar for men and

TABLE 1 Sample demographics by gender for the primary sample, used for the average volume, quantity, and frequency models

	Men	*Women*	*Tests of significance*
Total participants	9878 (48.0%)	10 691 (52.0%)	
Total person-years	121 280 (47.5%)	133 902 (52.5%)	
Indigenous background[a]	228 (2.3%)	296 (2.8%)	Z = −4.28, *P* < 0.001
Median age at first wave (IQR)[a]	35.0 (29.0)	36.0 (29.0)	Z = −2.93, *P* = 0.003
Age groups (years) (%)			
15–24	3100 (31.4%)	3217 (30.1%)	
25–34	1757 (17.8%)	1926 (18.0%)	
35–44	1748 (17.7%)	1875 (17.5%)	
45–54	1391 (14.1%)	1474 (13.8%)	
55–64	967 (9.8%)	1039 (9.7%)	
65+	915 (9.3%)	1160 (10.8%)	
Median daily alcohol consumption (standard drinks/day) (IQR)[a]	0.75 (1.70)	0.12 (0.70)	Z = 114.88, *P* < 0.001
Median usual quantity per drinking occasion (IQR)[a]	3.50 (2.00)	1.50 (2.00)	Z = 105.35, *P* < 0.001
Median frequency of drinking occasions (per week) (IQR)[a]	1.50 (3.27)	0.58 (1.27)	Z = 93.63, *P* < 0.001
Abstainers (%) /person-years with 0 consumption[a]	617 (6.2%) /14720 (12.1%)	1021 (9.5%) /24925 (18.6%)	Z = −6.79, *P* < 0.001/Z = −42.50, *P* < 0.001

IQR, interquartile range.
[a]Significant difference at 0.05 level.

TABLE 2 Sample demographics by gender for the RSOD sample

	Men	*Women*	*Tests of significance*
Total participants	8229 (47.5%)	9111 (52.5%)	
Total person-years	40 904 (47.2%)	45 810 (52.8%)	
Indigenous background[a]	196 (2.4%)	250 (2.7%)	Z = −2.46, *P* = 0.014
Median age (IQR)[a]	39.0 (30.0)	40.0 (30.0)	Z = −2.66, *P* = 0.008
Age groups (years) (%)			
15–24	21 247 (25.8%)	2252 (24.7%)	
25–34	1377 (16.7%)	1484 (16.3%)	
35–44	1412 (17.2%)	1618 (17.8%)	
45–54	1362 (16.5%)	1462 (16.0%)	
55–64	990 (12.0%)	1132 (12.4%)	
65+	964 (11.7%)	1163 (12.8%)	
Median frequency of RSOD (per week) (IQR)[a]	0.11 (0.23)	0 (0.11)	Z = 20.83, *P* < 0.001
Abstainers from RSOD (%)/person-years with 0 RSOD events[a]	1267 (15.4%) /14053 (34.4%)	2155 (23.6%) /22557 (49.2%)	Z = −13.22, *P* < 0.001/Z = −44.02, *P* < 0.001

IQR, interquartile range; RSOD, risky single occasion drinking.
[a]Significant difference at 0.05 level.

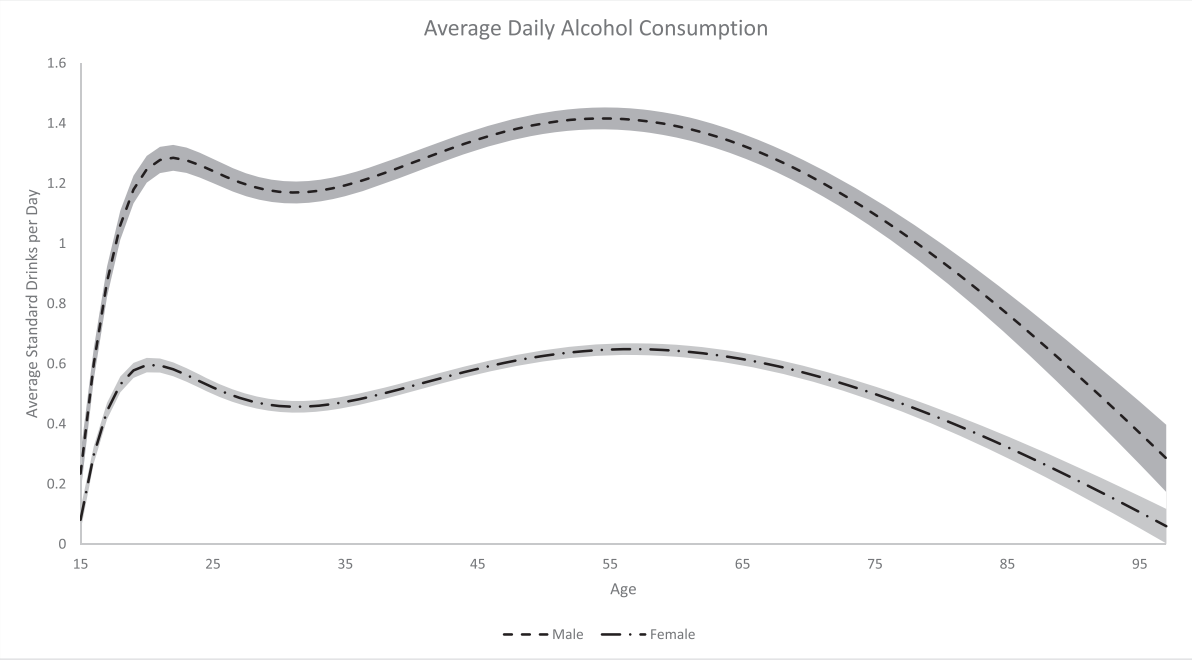

FIGURE 1 Average daily alcohol consumption across the life course for men and women. Shaded areas represent 95% confidence intervals

women, with men exhibiting greater per-occasion consumption across the life course.

Usual quantity per occasion peaked at ~5.5 standard drinks per occasion for men and just under 4 for women (Fig. 2) in young adulthood (18–24). These peaks were followed by slight declines and a levelling out in middle age (45–64) at around 3 standard drinks for men and 2 for women, before further declines for both genders into old age (65+).

Frequency of drinking occasions

The model selection procedure indicated a five-dimensional model was preferable for women and a four-dimensional model preferable for men. Despite this difference, trajectories of drinking frequency were broadly similar for men and women.

Frequency of drinking rose sharply for adolescents (Fig. 3). For women there was a plateau during young adulthood (18–24) at 1.1

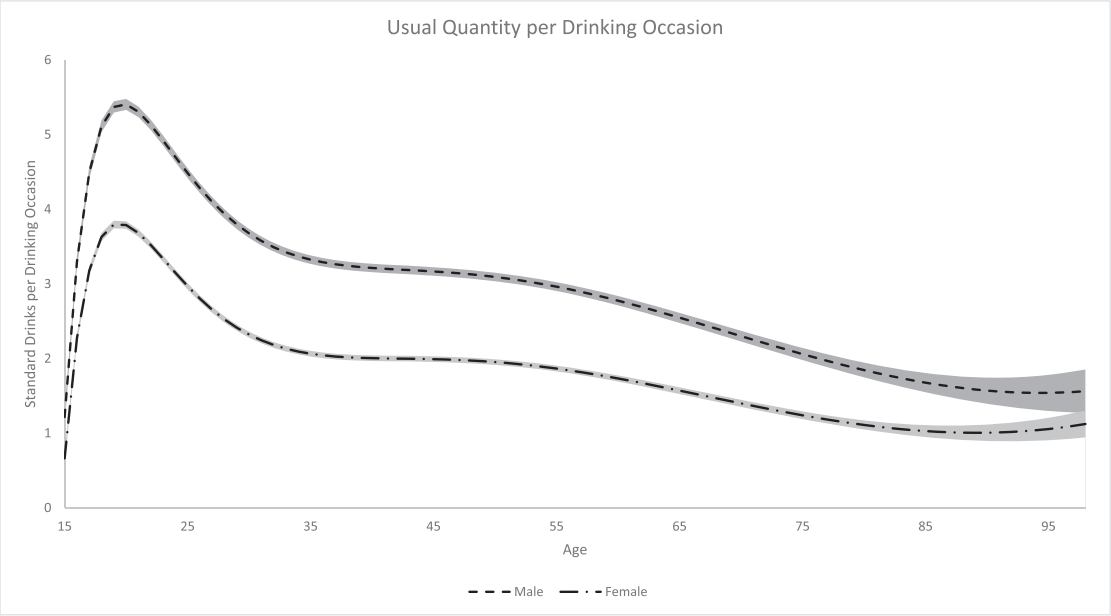

FIGURE 2 Male and female usual quantity of alcohol consumed at each drinking occasion across the life course. Shaded areas represent 95% confidence intervals

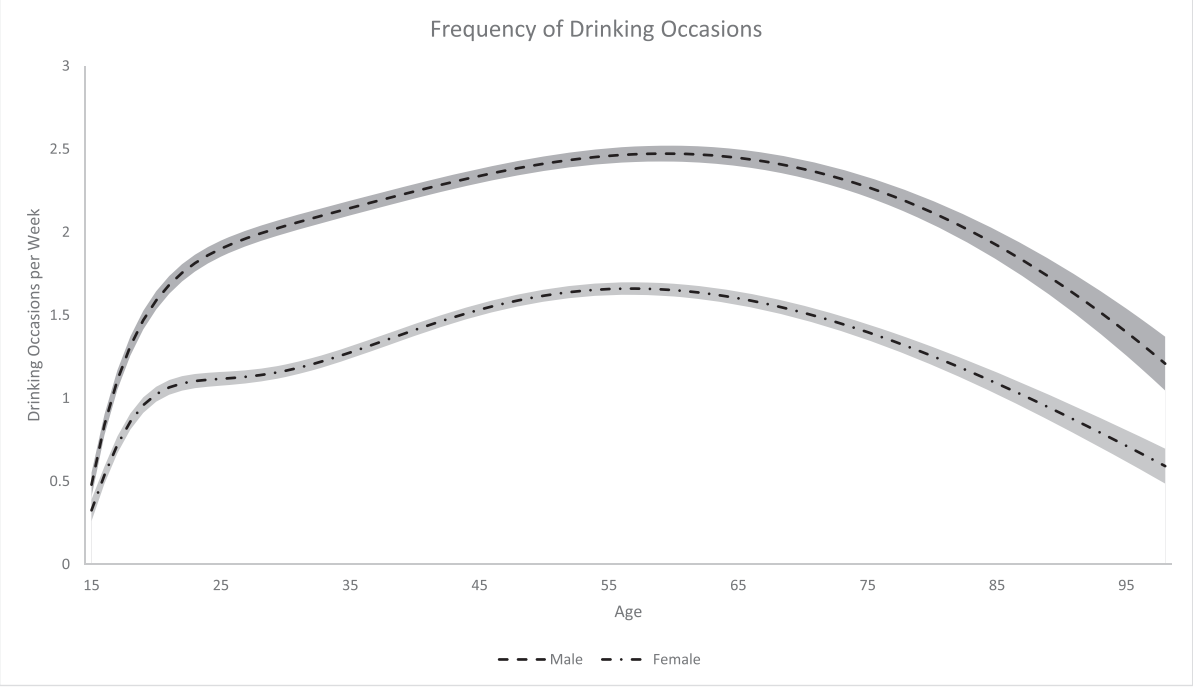

FIGURE 3 Male and female frequency of drinking occasions across the life course. Shaded areas represent 95% confidence intervals

drinking occasions per week. For men, frequency continued rising throughout adulthood, if more slowly than during adolescence. Frequency continued to rise throughout adulthood (25–44), peaking in middle age (45–64) for men and women. Middle-age men engaged in approximately one extra drinking occasion per week than women at the peak (2.5 vs 1.7 occasions, respectively). Following middle age frequency declined for both men and women, with men exhibiting a steeper decline into old age (65+).

Risky single occasion drinking models

Risky single occasion drinking

Five-dimensional models were again the best fit for men and women according to our model selection procedure (Fig. 4).

There was a broad similarity in the development of RSOD among men and women, although male RSOD remained more frequent than

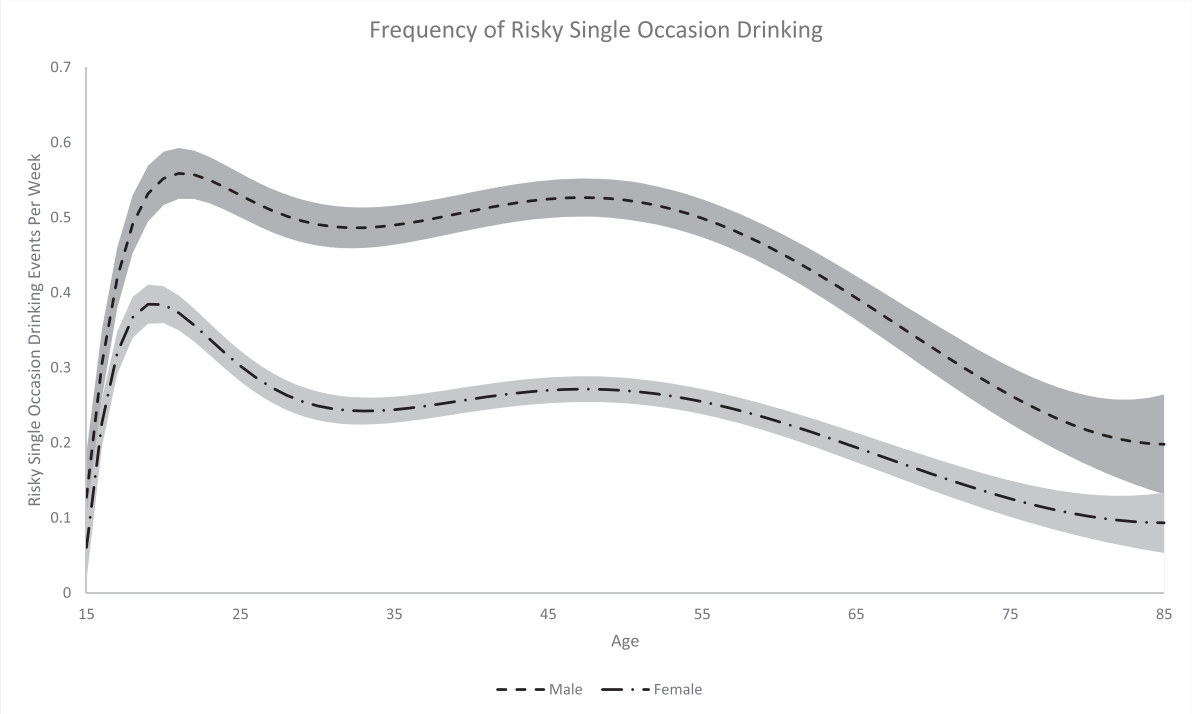

FIGURE 4 Frequency of risky single occasion drinking across the life course. Shaded areas represent 95% confidence intervals

women. RSOD frequency peaked in young adulthood (18–24) for men (0.6 RSOD per week) and women (0.4). Similar to usual quantity, both men and women experienced declines in RSOD during adulthood (25–44), followed by slight increases as they approached middle age (45–64). Declines were again evident following middle age, with men displaying a sharper decrease compared to women into old age (65+).

DISCUSSION

To our knowledge, this is the first single sample longitudinal study to develop a model of multiple drinking measures across the life course. We found men and women shared similar trajectories across all alcohol consumption measures assessed, with men peaking at and maintaining a higher level than women for each measure.

Our results show that RSOD and usual quantity per drinking occasion peak in young adulthood, whereas frequency of drinking occasions peaks in middle age. Consequently, total consumption peaks in middle age rather than adulthood, despite reductions in the amount consumed per drinking occasion. These findings broadly reflect existing literature surrounding trends in drinking, including Australian drinkers [6, 14, 29].

In particular, past international studies have identified peaks in usual quantity in young adulthood [10,29] and plateaus and slight increases relative to mid-adulthood in middle age [35]. The plots of age effects on alcohol volume observed by Kerr *et al.* [12] were broadly similar to our curves of usual quantity per drinking occasion for men and women. Studies have also found frequency of drinking occasions to peak among middle-age and older drinkers, following rapid increases during adolescence and young adulthood, [6, 29]. Casswell *et al.* [10] identified similar trends in frequency of drinking occasions among adolescents and young adults in their sample, which contained drinkers from a birth cohort older predating young adults in our own sample. Highlighting the consistency with which younger drinkers have engaged in drinking over past decades.

Our findings concur with those that find a peak in RSOD in young adulthood [12, 36, 37]; however, the increasing frequency of RSOD we observed among middle-age men and women differed from previous studies [36, 37]. Kerr *et al.* [12] identified a trajectory for RSOD frequency similar to our own among men, but not for women. Despite evidence of reductions in frequency of RSOD [15], young adults continue to engage in RSOD with a frequency unmatched by other age groups. However, the frequency that middle-age drinkers engage in RSOD is still of concern, with middle-age men reporting drinking seven or more drinks in a single occasion on average once a fortnight.

Overall, younger drinkers drank the greatest usual quantity per drinking occasion on average, while also engaging in RSOD with the greatest frequency. Comparatively, middle-age drinkers drank with the greatest frequency and had the greatest average daily alcohol consumption, while also engaging in frequent RSOD. The scale that young adults and middle-age drinkers consume alcohol and engage in RSOD indicates these age groups to be key points of the life course in which further consideration or implementation of targeted interventions may help reduce the risk of harms from alcohol.

The inclusion and synthesis of multiple birth cohorts from a single longitudinal survey within the present study is a key strength. Cross-sectional studies generally only observe behaviours in a population at a fixed point in time, whereas longitudinal studies based on a single

birth cohort may only observe changes that reflect the behaviours of that cohort carrying specific consumption habits throughout the study period. Comparatively, the use of multiple cohorts herein allows us to discern the general effect of age on the development of drinking behaviours more thoroughly.

Limitations

The HILDA survey uses an annual follow-up, requiring participants to recall their average consumption behaviour over an entire year. As a result, participants may unintentionally respond to these questions inaccurately. Evidence also suggests the use of quantity-frequency measures, such as those in HILDA, may underestimate alcohol consumed [38], particularly compared to per-capita consumption data or against specialised alcohol surveys [39]. It should also be noted that our usual quantity per drinking occasion measure did not incorporate responses given for RSOD drinking measures. Although individuals may have accounted for RSOD when responding, it is likely that further accounting for or including RSOD drinking may have altered our results, particularly for younger and middle-age drinkers who engaged in RSOD most frequently. Therefore, the results presented here likely underestimate true levels of consumption across the life course. However, the overall trends in alcohol consumption observed in HILDA are broadly reflective of per-capita population-level consumption in Australia [39], suggesting the patterns observed here are likely representative.

Our sample included limited numbers of older drinkers (307 (1.5%) and 347 (2.0%) individuals age 80+ at first response in our primary and RSOD samples, respectively). This may limit our ability to identify trajectories of drinking among older drinkers that are more representative of multiple birth cohorts. However, the declines in consumption following middle age observed in our models reflect similar behaviours as in other studies of alcohol consumption among older drinkers [20, 40]. Comparatively, recent sharp declines in youth drinking will only be partially captured in this sample, because it combines data for specific ages across the entire study period (2001–2019).

These findings represent average population trajectories. These trajectories smooth out the effects of socio-demographic factors (e.g. region, income) and specific life events (e.g. marriage), which have been shown to influence drinking behaviour [30, 41].

CONCLUSION

This study provides the first comprehensive, longitudinal assessment of life-course patterns of alcohol consumption in Australia. Our findings indicate there are substantial changes in alcohol consumption habits as individuals age. Usual quantity per drinking occasion and frequency of risky single occasion drinking peaked during early adulthood, whereas contrary to traditional focuses on harms for younger drinkers, average daily consumption and frequency of consumption was greatest for middle-age drinkers. Aside from providing an updated picture of drinking trajectories across the life course, these findings also highlight young adulthood and middle age as key points of the life course where future research, education and policy or interventions to reduce harms from drinking could be targeted.

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DECLARATION OF INTERESTS

None.

AUTHOR CONTRIBUTIONS

Geoffrey Leggat: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; validation; visualization. **Michael Livingston:** Conceptualization; formal analysis; funding acquisition; investigation; methodology; project administration; resources; supervision; validation; visualization. **Sandra Kuntsche:** Conceptualization; formal analysis; funding acquisition; investigation; methodology; project administration; resources; supervision; validation; visualization. **Sarah Callinan:** Conceptualization; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; supervision; validation; visualization.

ORCID

Geoffrey Leggat https://orcid.org/0000-0003-2298-3952
Michael Livingston https://orcid.org/0000-0002-8995-9386
Sarah Callinan https://orcid.org/0000-0003-4146-1244

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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