The natural history of risky drinking and associated harms from adolescence to young adulthood: findings from the Australian Temperament Project

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Background. We aimed to describe the natural history of heavy episodic drinking (HED) and associated harms from adolescence to young adulthood in a large Australian population cohort study.

Method. The Australian Temperament Project consists of mothers and babies (4–8 months) recruited from Infant Welfare Centres and followed every 2 to 4 years until age 28 years. Analyses were based on data from 1156 young people (497 male; 659 female) surveyed repeatedly at ages 16, 18, 20, 24 and 28 years. We used dual processes latent class growth analysis to estimate trajectories of HED and associated harms, employing a piecewise approach to model the hypothesized rise and subsequent fall across adolescence and the late twenties, respectively.

Results. We identified four sex-specific trajectories and observed little evidence of maturing-out across the twenties. In males, a normative pattern of increasing HED across the twenties with little related harm was observed (40% of the male sample). Early and late starter groups that peaked in harms at age 20 years with only minor attenuation in binging thereafter were also observed (6.1% and 35%, respectively). In females, a normative pattern of increasing, but moderate, HED with little related harm was observed (44% of the female sample). Early and late starter groups were also identified (18% and 17%, respectively); however, unlike males, the female late starter group showed a pattern of increasing HED and related harms.

Conclusions. Continued patterns of risky alcohol use and related harms are apparent for both males and females across the twenties.

Introduction

'Maturing out' of risky alcohol use, most simply understood as a decline in the prevalence of risky alcohol use during the twenties, has been broadly accepted by many in the alcohol research field (Zucker, 1986; Vergés *et al.* 2012; Powers *et al.* 2015). Two theories have come to articulate the 'maturing-out' phenomenon. Role incompatibility proposes that, as individuals age, their roles change to reflect the current stage of development, reducing their involvement in previous roles now in conflict with the newly gained responsibilities of adulthood (Yamaguchi & Kandel, 1985). Social control theory proposes two mechanisms by which stable relationships promote health behaviours. As an individual adopts behaviours of responsibility towards a spouse or offspring they may internalize these norms thereby controlling their own health behaviours, while explicit sanctions for deviations from these norms add a second incentive to adopt conventional behaviours (Umberson, 1987). In Australia, alcohol-related road accidents, acute hospitalizations, injury from violence and unwanted sexual activity disproportionately affect young people (Midford *et al.* 2014). This has led not only to a concentration of prevention strategies which target young drinkers, but has also seen prevention programmes aimed at future drinkers embedded in high school curriculums (Howard *et al.* 2014).

Although such efforts are essential, the notion of a 'developmentally limited' period of risky alcohol use,

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beginning during adolescence and ending in the late twenties, is in need of further clarification. A smaller body of research suggests maturing out is relevant only to a severe subgroup (Lee *et al.* 2013) and may not be due to the maturational processes of adulthood (Vergés *et al.* 2012, 2013). Such inconsistencies may be an artefact of statistical or methodological limitations. Studies supporting a maturing-out process have commonly employed methodologies incapable of identifying potentially important subgroups (Zucker, 1986; Patrick & Schulenberg, 2011; Meier *et al.* 2013; Powers *et al.* 2015).

Few studies have followed participants until the mid-twenties, utilized multiple indices of alcohol use (Thompson *et al.* 2014) or extracted multiple trajectories of alcohol use via latent variable approaches (Maggs & Schulenberg, 2004; Jackson *et al.* 2005). Of these studies, Thompson *et al.* (2014) found that all indicators of alcohol involvement (i.e. frequency, quantity, volume and episode) increased until 21 years before declining thereafter, while Jackson *et al.* (2005) identified large heterogeneity in alcohol and tobacco use despite an overall decline after the transition to adulthood. Furthermore, studies have often employed definitions of alcohol use which emphasize associated harms rather than actual consumption. High levels of alcohol consumption are important regardless of perceived concurrent harms, given that long-term risky drinking is associated with a range of negative health outcomes (Rehm *et al.* 2009).

The purpose of this study was to investigate trajectories of heavy episodic drinking (HED) and associated harms (i.e. trouble at school/work, regretted sexual activities, subject to injury or violence) in a cohort of young people from age 16 to 28 years who were participants in the Australian Temperament Project (ATP), a large community-based study of psychosocial development. Building on previous research on alcohol use and related harms in this cohort (Little *et al.* 2012, 2013), we use latent class growth analysis to examine potential trajectories of risky alcohol use that do not fit the maturing-out profile. Identification of such trajectories may suggest the need to rethink prevention strategies with a new aim of preventing escalation through young adulthood.

Method

Sample

Participants were from the ATP, a large multi-wave longitudinal study following the psychosocial development of young people from infancy to adulthood (Prior *et al.* 2000). The baseline sample consisted of 2443 infants aged between 4 and 8 months and their mothers recruited from infant welfare centres across the state of Victoria, Australia in 1983. Centres were selected to reflect the urban/rural population balance, and provided a sample representative of the Victorian general population (Prior *et al.* 2000). A total of 15 assessments across the subsequent 27-year period ascertained a range of factors including psychological and behavioural problems, substance use as well as familial, social and environmental indicators. Further information regarding the sample characteristics and procedures of the ATP are available elsewhere (Sanson *et al.* 1985). In this study we used self-reported measures of alcohol use and alcohol-related harms from five successive waves of follow-up when participants were aged 16, 18, 20, 24 and 28 years old. To be included in the study participants needed to have survey responses relating to alcohol use and harms from at least three of the five measurement occasions resulting in a sample size of 1156 (497 male; 659 female) (number of responders per follow-up: $n = 1288$ age 16 years; $n = 1254$ age 18 years; $n = 1138$ age 20 years; $n = 995$ age 24 years; $n = 1012$ age 28 years).

Measures of HED and alcohol-related harms

At each adolescent and young adult follow-up, HED was measured as the number of times in the past month a participant had consumed five or more 'drinks' of alcohol in quick succession on a single occasion, with responses recoded as a four-level ordinal variable (1 = never; 2 = monthly; 3 = < weekly; 4 = weekly or more). At each follow-up participants were also asked whether their alcohol use had resulted in the occurrence of one or more of five alcohol-related harms over the past year using items adapted from the Victorian Adolescent Health Survey (Hibbert *et al.* 1996; Little *et al.* 2013). Items were coded yes/no and combined into a four-level ordinal variable (1 = none of these events; 2 = one of these events; 3 = two of these events; 4 = three or more of these events). The five events included: (i) had trouble at school or work the following day; (ii) got injured or had an accident; (iii) became violent or got into a fight; (iv) had sex with someone and later regretted; and (v) got into trouble with the police. Some minor age-appropriate adjustments were made: (i) at age 15 years the question about trouble at school did not include work, and trouble with police was instead trouble with your family; and (ii) from age 19 years school was replaced with university/TAFE (technical and further education).

Latent class growth analysis (LCGA)

We used dual processes LCGA to derive correlated trajectories of alcohol use and alcohol-related harms (i.e. modelled as separate processes but allowing processes

to be correlated) using the robust maximum likelihood estimator (MLR) available in Mplus version 6 (Muthén, 1998–2010), and using full information maximum likelihood (FIML) to account for missing data (Muthén, 1998–2010; Byrne, 2012). We explored the suitability of quadratic and piecewise linear LCGA to account for non-linear trends. Piecewise linear LCGA refers to the addition of an extra slope without an additional intercept, and is an alternative approach to introducing a quadratic term. This model essentially consists of two straight lines meeting at a change-point at age 20 years (the midpoint of our study period), with one capturing the change from age 16 to 20 years, and another capturing the change from age 20 to 28 years.

Next we assessed a number of different models separately by sex, including linear, quadratic and piecewise linear, LCGA over two to six classes (i.e. trajectories). To assess which model best summarized the data, we used a combination of the Bayesian information criterion (BIC), the sample size-adjusted BIC, in addition to using the bootstrap likelihood ratio test (BLRT) to evaluate fit between nested models (Nylund *et al.* 2007). Lastly, to better understand which specific harms were driving the trajectories, we undertook a descriptive analysis comparing the proportions of specific harms across time for both male and female trajectories.

Missing data

We explored how loss to follow-up may have biased our results using two methods. First we reran the structural equation modelling using the default Mplus FIML setting, by which a participant is included in the analyses so long as they have a measure at any single time point, resulting in a sample size of 1603 (799 males; 804 female). In addition, we conducted a logistic regression analysis in which the probability of not being included in the final analysis was calculated depending on a number of baseline variables as one way to assess whether or not attrition may have biased our findings.

Ethics

Research ethics approval for data collection within the ATP is currently approved and held by the Ethics in Human Research Committee, The Royal Children's Hospital Melbourne, Australia.

Results

At baseline (age 16 years) 81.3% of the sample came from households in which parents were married and living together, while the majority of those in a single parent household resided with the biological mother

(10.3%). Almost half of the fathers (48.7%) were employed in professional or managerial positions while the number for mothers was 36.6%, and only 13.3% of the participants had a parent who had experienced unemployment in the last 12 months. Lastly, 23.9% and 19.8% of fathers and mothers had completed post-secondary education, respectively.

Results from the LCGA suggested that in both the male and female samples, models incorporating piecewise trajectories provided a superior fit to the data when compared with either linear or quadratic trajectories (Table 1). The optimal number of classes (i.e. trajectories), according to the BIC, adjusted BIC and the BLRT, was determined to be four in both samples. The five-class solution presented as a suitable choice in the female sample; however, as the BIC did not make meaningful improvements after the four-class solution we chose the more parsimonious representation of the data.

Figs 1 and 2 show the trajectories of HED and associated harms in males and females, respectively, which are interpreted as the estimated proportions of participants within each trajectory at each time point who had binged more than monthly and experienced two or more associated harms (trajectories showing the higher threshold of binging at least weekly and experiencing three or more associated harms are shown in the online Supplementary Figs S1 and S2). Importantly, the alcohol consumption and harms variables were modelled in their ordinal forms, but to aid interpretation we present the probabilities of exceeding certain levels separately.

In males, we observed two trajectories consistent with the idea of 'maturing out' of alcohol-related harms but not HED. These were characterized by rising alcohol-related harms during adolescence which later fell during early adulthood and were labelled 'early starters' and 'late starters' (prevalence = 6.1% and 35%, respectively). In addition to an earlier onset, early starters exhibited the greatest levels of related harms, while late starters had the highest level of binging by age 20 years. Importantly, with regards to binging, despite minor attenuation from the peak exhibited at age 20 years, neither group saw an attenuation in binging that could be interpreted as having matured out, with relatively high levels of binging sustained throughout the study period.

In females, we observed a single trajectory consistent with the 'maturing-out' profile with regard to harms only, labelled the 'early starters' trajectory (18.7%). Like the male trajectories, the female trajectory was associated with the greatest level of associated harms which had decreased by age 28 years. However, despite more clearly exhibiting a decreasing trend in binging by age 28 years compared with their male

Table 1. *Fit indices of latent class growth analysis separately in males (n = 497) and females (n = 659)*

	BIC	BIC-SSA	Entropy[a]	BLRT[b]
Male sample				
Linear model				
Two-class	8238	8197	0.75	–
Three-class	8132	8075	0.73	–
Four-class	8042	7969	0.73	–
Five-class	8030	7941	0.76	–
Six-class	8032	7927	0.69	–
Quadratic model				
Two-class	7971	7917	0.78	–
Three-class	7885	7808	0.77	–
Four-class	7839	7741	0.75	–
Five-class	7851	7731	0.72	–
Six-class	7863	7720	0.74	–
Piecewise model				
Two-class	7946	7893	0.77	–
Three-class	7854	7778	0.73	<0.001
Four-class[c]	7809	7711	0.76	<0.001
Five-class	7826	7705	0.76	<0.001
Six-class	7843	7701	0.73	–
Female sample				
Linear model				
Two-class	11 606	11 565	0.75	–
Three-class	11 503	11 446	0.71	–
Four-class	11 471	11 398	0.70	–
Five-class	11 457	11 368	0.71	–
Six-class	11 452	11 347	0.72	
Quadratic model				
Two-class	11 539	11 485	0.76	–
Three-class	11 429	11 353	0.70	–
Four-class	11 401	11 303	0.70	–
Five-class	11 397	11 277	0.70	–
Six-class	11 397	11 254	0.72	–
Piecewise model				
Two-class	11 494	11 440	0.76	–
Three-class	11 375	11 299	0.72	<0.001
Four-class[c]	11 346	11 248	0.70	<0.001
Five-class	11 341	11 221	0.71	<0.001
Six-class	11 347	11 204	0.69	–

BIC, Bayesian information criterion; BIC-SSA, Bayesian information criterion – sample size adjusted; BLRT, bootstrap likelihood ratio test.

[a] Entropy is a measure of how well individuals have been assigned to their respective classes.

[b] The BLRT was calculated to compare between the models for which the difference in BIC was not large.

[c] Optimal number of classes.

counterparts, binging also remained prevalent among this group throughout the study period.

In addition, we identified a number of different trajectories suggestive of a more heterogeneous natural history than commonly considered in the current literature. Specifically, in males, we identified a very common trajectory (capturing 40% of male participants) that initially exhibited a less severe binging profile but which increased rapidly during adolescence and more steadily in early adulthood, and had a relatively low probability of associated harms, which we labelled the 'normative' trajectory. We also identified a male trajectory that consisted of participants (17.9%) who had a 5% or lower probability of binging more than monthly before age 24 years, with a minor increase thereafter, and who experienced virtually no related harms over the study period. This was labelled the 'infrequent HED' trajectory.

In females we identified a trajectory that demonstrably contradicted the maturing-out profile, representing a pattern of both binging and associated harms that increased across the study period. This trajectory, labelled 'late starters' (17.1%), exhibited the highest level of binging and associated harms by age 23 years. Lastly, 'normative' (43.9%) and 'infrequent HED' (20.2%) trajectories were also identified among females, which largely conformed to the trajectories of their male counterparts.

The descriptive analyses showing the probabilities of experiencing the specific alcohol-related harms are shown in Figs 3 and 4 for males and females, respectively (including in each case only the two trajectories exhibiting substantial amounts of harms). For males, Fig. 3 shows that when comparing the early and late starters, most types of harms had converged by age 28 years except for problems at school/work and violence, which therefore probably account for the increased probability of experiencing harms in the former group at age 28 years. In females, Fig. 4 shows that when comparing the early and late starters, problems at school/work among the latter group at age 28 years surpassed the level exhibited by the former group at age 16 years.

When we reran the LCGA including all participants with at least one observation on any alcohol indicator (n = 1603), the resulting four-class solution was practically identical to the main findings in both the shape and prevalence of the trajectories among the male and female samples (online Supplementary Figs S3 and S4). Lastly, the logistic regression attrition analysis (online Supplementary Table S1) showed that those lost to follow-up were twice as likely to be male and more likely to come from a low-socio-economic (SES) background, but maternal age did not predict attrition.

Discussion

The results of this study suggest that although alcohol-related harms moderated across the twenties, alcohol consumption did not, with high levels of binging
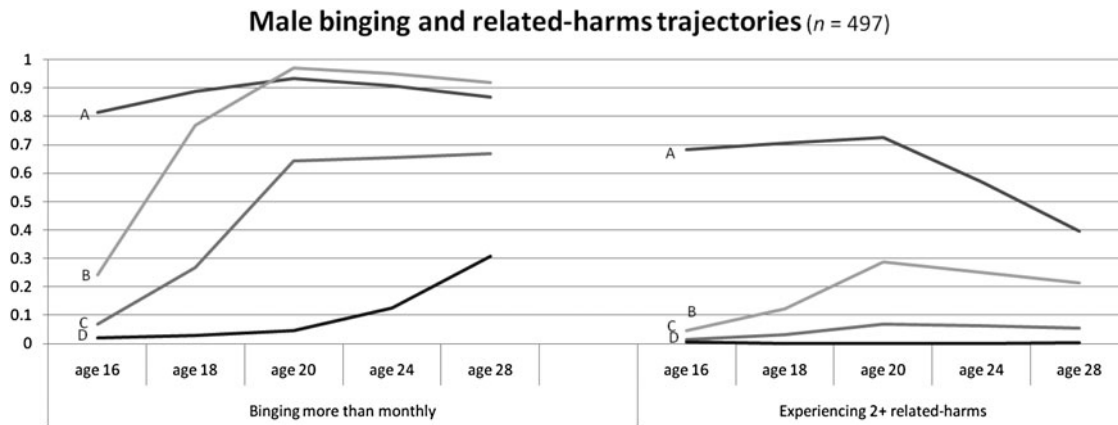
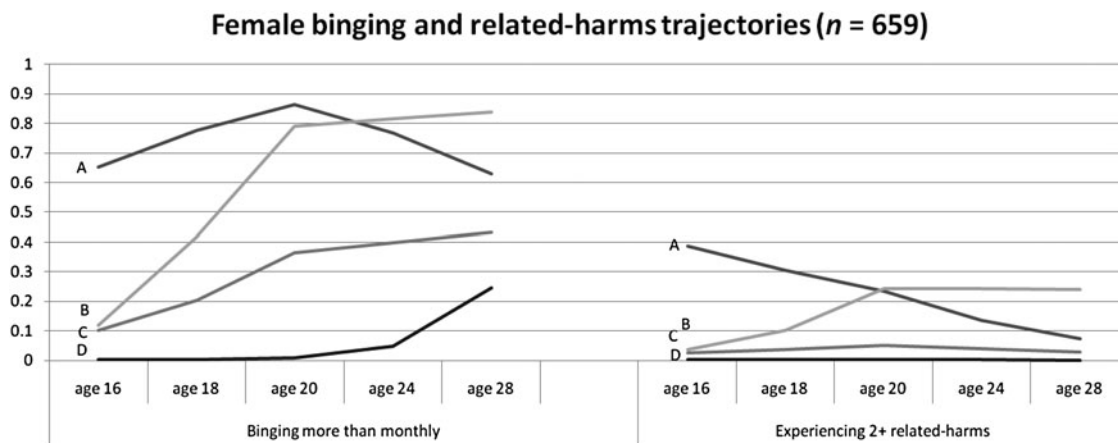## Male binging and related-harms trajectories (*n* = 497)

Fig. 1. Trajectories A to D of male binging (left-hand side) and alcohol-related harms (right-hand side), showing the estimated proportions of participants drinking five or more drinks in a single occasion at a frequency of more than monthly and the number of different types of alcohol-related harms experienced at a frequency of two or more out of five, for four classes. A, Early starters (class prevalence 6.1%); B, late starters (class prevalence 35.0%); C, normative (class prevalence 41.0%); D, infrequent heavy episodic drinking (class prevalence 17.9%).

Female binging and related-harms trajectories (*n* = 659)

Fig. 2. Trajectories A to D of female binging (left-hand side) and alcohol-related harms (right-hand side), showing the estimated proportions of participants drinking five or more drinks in a single occasion at a frequency of more than monthly and the number of different types of alcohol-related harms experienced at a frequency of two or more out of five, for four classes. A, Early starters (class prevalence 18.7%); B, late starters (class prevalence 17.1%); C, normative (class prevalence 43.9%); D, infrequent heavy episodic drinking (class prevalence 20.2%).

persisting across the twenties (increasing in the case of females). A sizeable 41% of the male sample showed a pattern of a steady increase in binging, and 17% of the female sample showed a sharp increase in both binging and associated harms across the twenties. Further research in cohorts with carefully specified definitions of alcohol use which combine consumption and harms is needed to inform more refined approaches to preventing alcohol-related harms at their time of peak prevalence in young adulthood.

Overall, our findings support the studies of Vergés *et al.* (2012, 2013) and Lee *et al.* (2013), and add to these by demonstrating that the maturing-out hypothesis has relevance only to a minority of drinkers and

primarily with regard to alcohol-related harms. Substantial amounts of HED persist even as these harms decline. For other groups, HED emerges later in early adulthood and is accompanied by only a very low probability of associated harms. In addition, it is important to note that since the first discussions of a 'developmentally limited alcoholism' appeared in the literature (Zucker, 1986), the maturation processes of early adulthood (i.e. child rearing, full-time employment, serious relationship) have shifted and now occur later on average. Thus, the maturing-out process may have likewise shifted to a new peak closer to age 30 years, for which further investigation is necessary. A recent study examining men's and
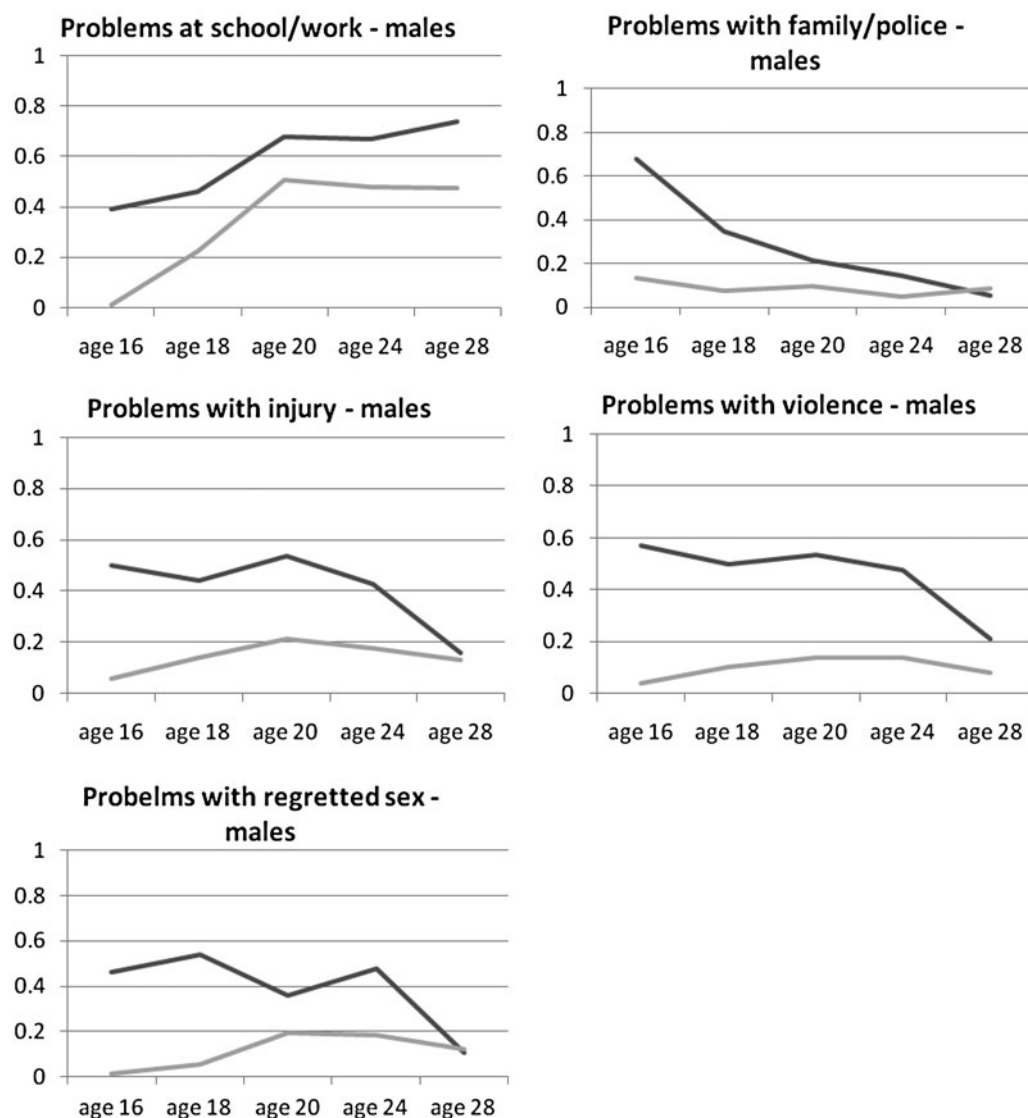
Problems at school/work - males

Problems with family/police - males

Problems with injury - males

Problems with violence - males

Probelms with regretted sex - males

Fig. 3. Probability of specific alcohol-related harms between two groups of males: (1) the early starters (—) and (2) the late starters (—). Proportions were estimated according to each individual's most likely class membership (*n* = 30 and *n* = 172, respectively). The other two groups of males were not included due to having a low probability of any harms.

women's drinking from adolescence to middle age suggested that these patterns are likely to have changed in more recently born cohorts due to shifting norms regarding family role responsibilities and attitude towards alcohol use, particularly among women (Staff *et al.* 2014).

Regardless of the applicability of maturing out, the risk of allowing alcohol-related harms to dominate our understanding of alcohol use trends among young people obscures the ongoing and, for some, increasing trend towards binging. Excessive alcohol use in the absence of perceived harms may have adverse short- and long-term consequences for individuals and place high costs on medical and mental health services. Our data may suggest that among

young people increasing age is associated with an increased ability to utilize harm-reduction strategies which mitigate the potential harms of alcohol use despite ongoing high levels of use. However, it is possible that some individuals reporting low or decreasing levels of alcohol-related harms in the presence of higher levels of drinking have become accustomed to and/or are experiencing denial regarding harmful consequences. The inclusion of multiple informants and objective assessments of health, legal and social consequences of alcohol use could help to address this concern in future studies.

In addition to the main findings, we noted a previously unidentified pattern of considerable public health concern in females, in which binging continued
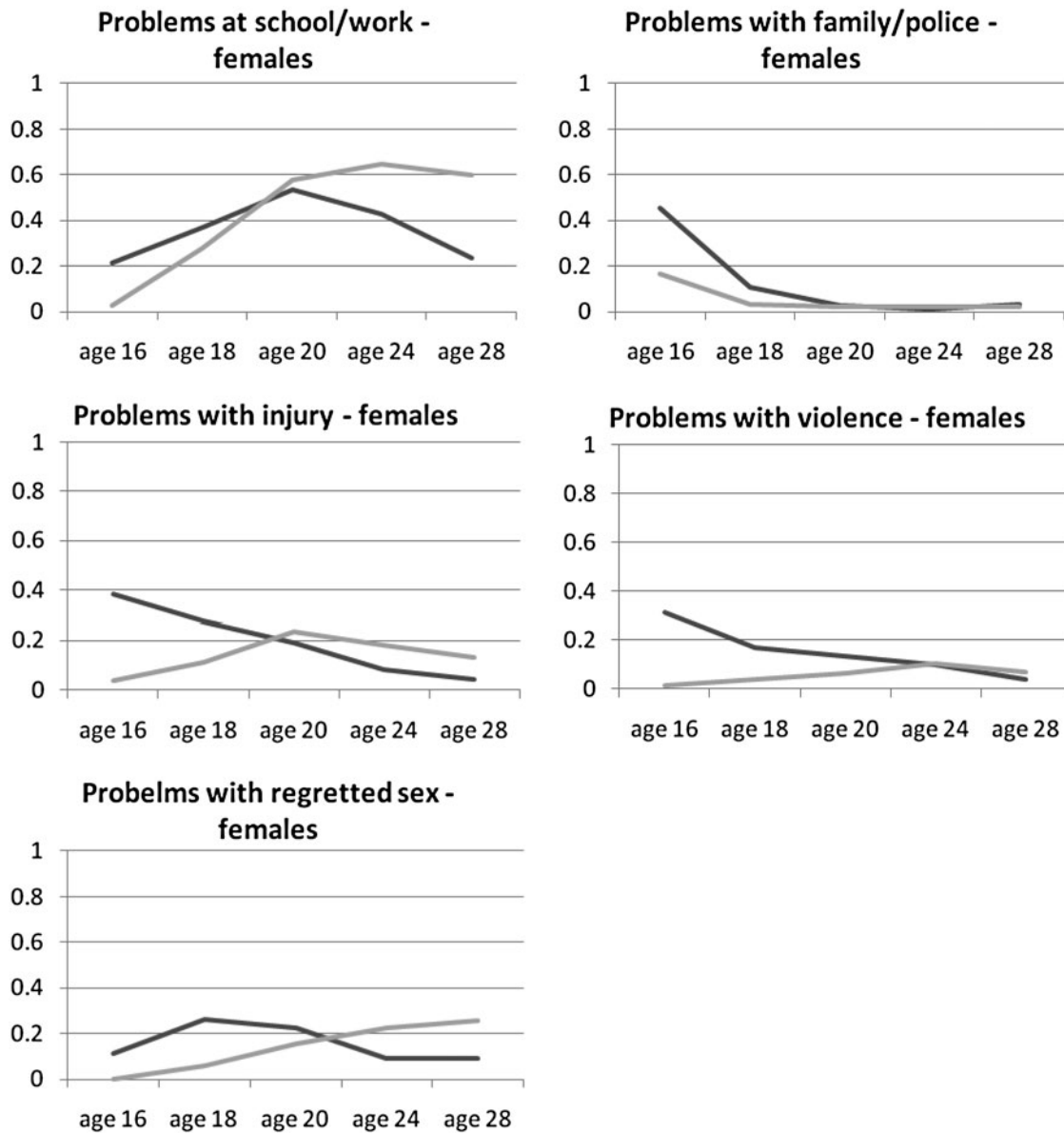
Fig. 4. Probability of specific alcohol-related harms between two groups of females: (1) The early starters (─) and (2) the late starters (─). Proportions were estimated according to each individual's most likely class membership (*n* = 127 and *n* = 98, respectively). The other two groups of females were not included due to having a low probability of any harms.

to increase rapidly from adolescence to adulthood and was accompanied by increasing levels of alcohol-related harms. Although the proportion of males found to exhibit a similar HED profile was far greater than that found among females (40% – normative males *v.* 17% – late starter females), this group of males also exhibited a very slow increase which did not appear to be nearing the peak levels observed in males with a maturing-out profile, in addition to being associated with a very low level of alcohol-related harms. Conversely in females, by age 28 years this group had practically matched the peak levels of binging exhibited by the early starters at age

20 years, and were likewise approaching the peak levels of related harms exhibited by the early starters group at age 20 years.

Increasing rates of alcohol use in females during adolescence and the early twenties have been previously demonstrated (Roche & Deehan, 2002; Chikritzhs *et al.* 2003; Goddard, 2008; Keyes *et al.* 2011; Geels *et al.* 2012; Keyes & Miech, 2013). This phenomenon is thought to result from a growing equality in gender roles wherein alcohol use is no longer regarded as a largely masculine pastime (Holmila & Raitasalo, 2005). Findings from our team using prospective intergenerational cohort data (the Mater University Study of

Pregnancy) similarly found that young Australian women were more than five times as likely to drink at the highest recorded level of alcohol use compared with their mothers at a similar age when measured 20 years earlier (Alati *et al.* 2014). Lastly, in the present study we used the same definition of HED in males and females (5+ drinks), rather than the sex-specific definitions (5+ for males; 4+ for females) defined by the National Institutes of Health (2016). Thus it is important to consider that by using a 'relatively higher' cut-off in women we have probably identified more severe non-normative groups among females than males. Importantly, however, this would not account for the increasing trend of binging found in one group of females and in fact serves to increase the importance of identifying strategies capable of reducing this drinking profile.

The present study's strengths include the availability of prospective data spanning 12 years through adolescence to adulthood from a large-scale longitudinal community study of Australian youth. The growth-mixture modelling approach allowed us to explore the notion of maturing out by identifying subgroups of individuals in the community with different profiles of alcohol use and alcohol-related harms. It is, however, important to consider our findings within the permissive youth drinking context of Australia (legal age limit of 18 years and a cultural acceptability to drink), which may mean that we observed relatively elevated level of drinking by international standards. Replication in other datasets collected in different countries characterized by less permissive drinking cultures is thus important to ascertain the generalizability of the findings.

Our study also had a number of important limitations. First, our indices of alcohol frequency/quantity and associated harms were not drawn from a diagnostic interview, meaning the clinical utility of the thresholds presented in our study are somewhat uncertain. However, previous research has established that the five-drink threshold for HED is meaningful (Wechsler & Austin, 1998) and shows moderate agreement with alternative measures of alcohol including alcohol use disorders (Jackson *et al.* 2005). Second, our survey question did not define the term 'drink', leaving the precise quantity of five drinks open to respondents' subjective interpretation and we encourage further studies with objective definitions of 'drink' to replicate our findings. Third, our interest in broad-ranging alcohol harms led to the use of a harms variable including a number of heterogeneous events; however, we did separate out these events into separate trajectories in supplementary analyses. Finally, as with all prospective research, biased attrition presents a concern for the generalizability of results. Importantly, the attrition

analyses showed that we disproportionately lost participants who were male and from a lower-SES background, suggesting the more problematic trajectories in the male sample may have had a higher prevalence had we been able to retain the entire sample. However, when we reran the analyses including participants with at least a single measure the results did not vary substantively.

In conclusion, our findings suggest that the concept of maturing out of alcohol use across early adulthood is largely a misnomer. While increasing age in early adulthood appears to have a positive impact on alcohol-related harms, substantial amounts of HED persist and emerge separately in early adulthood. Notably, among one group of females (17% of the sample) these patterns of HED are also accompanied by related harms, particularly in the school/work domain. Considering the long-term health consequences of persistent intoxication, the present findings suggest that intervention needs to shift in emphasis from preventing alcohol-related harms in adolescence and early adulthood, to include a focus on building strategies to decrease the high levels of alcohol consumption which continue after the mid-twenties.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S0033291717000654

Acknowledgements

K.S.B. has been designated principal author and was responsible for the bulk of the literature review, drafting, statistical analysis and discussion. C.A.O. provided significant guidance in the study conception and design, in addition to drafting and writing. P.B. provided expert statistical and analytical advice, and helped draft the Method section. D.H. and G.Y. provided expert psychological opinion, and were key to interpreting the results from a clinical viewpoint. R.A. provided expertise in lifecourse and longitudinal epidemiology and helped with redrafting. P.L. oversaw data collection over multiple waves and provided expert knowledge in the ATP study and assistance with redrafting.

K.S.B. had access to the complete dataset used in the study and takes responsibility for the integrity of the data and accuracy of the data analyses.

Declaration of Interest

None.

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