Drug and Alcohol REVIEW

APSAD

Drug and Alcohol Review (May 2016), 35, 307–316
DOI: 10.1111/dar.12350

Trajectories of alcohol use and association with symptoms of depression from early to late adolescence: The Norwegian Longitudinal Health Behaviour Study

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Abstract

Introduction and Aims. *Adolescence is a period in which many have an onset of alcohol use, but there is much heterogeneity in the individual development of alcohol use. Further, there is a general increase in depressive symptoms from early to late adolescence, but less is known about how different alcohol habit trajectories are associated with symptoms of depression. The aims of the present study were: to identify trajectories of alcohol consumption and drinking to intoxication during adolescence (age 13–18 years); and examine to what extent the different trajectories of alcohol use were associated with symptoms of depression over the same age span, from early to late adolescence.* ***Methods.*** *Data from the Norwegian Longitudinal Health Behaviour Study were employed. Latent class growth analyses were employed to identify different trajectories of both alcohol consumption and drinking to intoxication. The resulting trajectories for each participant were used to estimate the gender-adjusted association between different development of alcohol use and symptoms of depression.* ***Results.*** *Four trajectories of both alcohol consumption and drinking to intoxication were identified. The trajectories with an early onset of alcohol consumption or drinking to intoxication were associated with higher levels of depressive symptoms compared with late onset or stable low use trajectories.* ***Conclusions.*** *The findings from the present study suggest that early onset developmental trajectories of alcohol use are associated with depression. Therefore, broad assessment and interventions targeting both alcohol and depression may be indicated among early onset alcohol users, especially if they report increasing levels of consumption.* [Skogen JC, Knudsen AK, Hysing M, Wold B, Sivertsen B. Trajectories of alcohol use and association with symptoms of depression from early to late adolescence: The Norwegian Longitudinal Health Behaviour Study. *Drug Alcohol Rev* 2016;35:307–316]

Key words: alcohol use, intoxication, adolescence, depression, development.

Introduction

Alcohol problems and mental health problems frequently co-occur in adolescents [1]. A recent cross-sectional study concluded that a range of alcohol and drug use indicators were consistently associated with more mental health problems among 16- to 19-year-olds [2].

Adolescence is a developmental period in which many start to drink alcohol. There is, however, much heterogeneity in the individual developmental trajectory of alcohol use [3–7]. At least three trajectories have been identified among adolescents: a low or non-using trajectory, a persistently high-using trajectory, and a trajectory of initial low and then increasing levels of use, with the latter group usually being the largest [8].

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Received 21 May 2015; accepted for publication 5 September 2015.

Increasers can be subcategorised into early versus late peakers [6]. A potential limitation of previous research investigating developmental heterogeneity is that most studies have focused on only one aspect of alcohol use, such as binge drinking, alcohol consumption or alcohol problems. While these aspects overlap, they have been shown to be differentially associated with various outcomes, including mental health problems. Frequency of binge drinking seems, for example, to be more consistently associated with mental health problems than mere alcohol consumption [9–12].

From early to late adolescence there is also a general increase in depressive symptoms, and depression is among the most prevalent mental health problems in this age group [1,13]. While some longitudinal studies have linked early depressive symptoms to later alcohol use [14], other studies have not found this association [15,16]. In terms of alcohol problems, evidence suggests that these are generally preceded by depressive symptoms [17–21].

Our understanding of the complexity of the association between alcohol use and depression remains limited [17,21,22], but there is reason to believe that early onset of alcohol use, and high levels of alcohol use is associated with later poor mental health, as well as functional, economic and social problems [23–31]. However, variability in alcohol use trajectories may be differentially associated with symptoms of depression. A deeper understanding of how specific alcohol use trajectories are linked to depressive symptoms during adolescence may help to identify vulnerable groups, and target interventions appropriately.

Based on these considerations, we aimed to identify trajectories of alcohol consumption and drinking to intoxication from age 13–18 years, and examine to what extent the different trajectories of alcohol use were associated with symptoms of depression over the same age span, from early to late adolescence.

Methods

Study population

The present study employs data from the Norwegian Longitudinal Health Behaviour Study (NLHB). NLHB is a nine-wave, cluster-sample research study which followed a cohort of adolescents from 13 (1990) to 30 years (2007) with a total sample of $n = 1242$. Overall, the study sample is considered representative of the birth-cohort attending ordinary school with regard to gender and residence distribution [32]. Regarding attrition, a previous study did not find any differences between responders and non-responders across waves for symptoms of depression, smoking, alcohol use, body mass index or parental socioeconomic status [33]. More girls did, however, complete all waves compared with boys. A more detailed description of the sampling procedures and data collection methods used in NLHB can be found elsewhere [34,35].

The questionnaires were distributed to the participants by their respective schools in the first waves (ages 13–15). For the later waves, questionnaires were mailed to the participants' home addresses. This paper employs data for the years 1990–1995 (ages 13–16, and 18 years), effectively ranging from early adolescence to the legal drinking age in Norway [36]. As the number of valid responses differed between the two measures of alcohol use, the total number of participants available for our analyses was 1102 for measures of alcohol consumption and 1095 for drinking to intoxication.

NLHB was approved by the Norwegian Data Inspectorate and the Regional Committee for Medical Research Ethics in Western Norway.

Instruments

Gender. Gender was reported in the first data collection wave, and reiterated at the time of each follow-up in order to assess gender distribution for each wave.

Alcohol variables. Alcohol consumption measures were available at ages 13–16 and 18 years. At each wave, four questions assessed the frequency of alcohol consumption, asking the respondents 'How often do you drink X?', where X denoted winecooler, beer, wine or liquor. The response categories for each question was 'Never', 'Less than once a month', 'Every month' and 'Every week'. For the purpose of the present study, a single four-level variable, ranging from never to every week for each wave was constructed, based on the highest reported frequency of consumption irrespective of the four types of beverage.

Drinking to intoxication was measured by a single question 'How often have you been drunk the last 6 months?' At each wave, the first three response categories were identical ('No time', '1 time' and '2–4 times'), but the number of categories differed between some of the waves, and the highest possible frequency category changed from '≥11' to '≥25' times between waves. For the latent class growth analyses (LCGA), drinking to intoxication was recoded to a binary variable indicating 'No time' versus '≥1 times' to ensure comparable measures between waves.

Symptoms of depression. Symptoms of depression were assessed using a 7-item depression inventory [37], which includes questions regarding feelings of hopelessness and feelings of sadness without any obvious

Table 1. *List of questions included in the 7-item depression inventory*

Item #	Question
1	'I often feel depressed without knowing why'
2	'Sometimes I think everything is so hopeless that I don't feel like doing anything'
3	'I don't think I have anything to look forward to'
4	'Sometimes I am just so depressed that I feel like staying in bed for the whole day'
5	'I am often sad without seeing any reason for it'
6	'I think my life is mostly miserable'
7	'Sometimes I think my life is not worth living'

All responses were rated on a 6-point scale. Response options: 'Does not apply at all', 'Does not apply well', 'Applies somewhat', 'Applies fairly well', 'Applies well' and 'Applies exactly'.

reason (Table 1). Cronbach's α ranged 0.81–0.90 across all waves, which indicate a high internal consistency [38].

Statistical procedure

LCGAs. LCGA was employed to identify different trajectories of both frequency of alcohol consumption, and of drinking to intoxication from ages 13–18 years [39]. LCGA is a person-centred approach that in a probabilistically manner assigns individuals to latent classes based on similar patterns of observed longitudinal data [40]. Using LCGA, repeated measurements of observed variables are used as indicators of individual's change, most commonly represented by two latent variables; intercept and slope [40]. The purpose of the LCGA in the present study was to identify the optimal number of trajectories for the indicators 'alcohol consumption' and 'drinking to intoxication' from age 13–18 years. The LCGA models were specified with factor loadings corresponding to distance in time from wave 1 (1990; specified as '0') to wave 5 (1995; specified as '5') for the intercept and slope. The '0' for the slope growth factor at wave 1 defines the intercept growth factor as an initial status factor [39]. Six models were estimated for both indicators separately, ranging from a 1-class to a 6-class model. Final models were conditioned on gender [3]. The models identified were similar when including information regarding living situation and parental occupational status in the LCGA (data not shown). For each of the six classes, model fit was evaluated using the Akaike and Bayesian Information Criterion (AIC; BIC), Vuon–Lo–Mendell–Rubin likelihood ratio test (VLM-LRT), bootstrap likelihood ratio test and entropy values. Iterative comparisons of AIC- and BIC-values between the different models were performed, starting with the 1-class model, where lower values indicated a better fit between the proposed model and the actual data. When the iterative comparisons yielded a non-significant VLM-LRT statistic, this indicated that one less class was preferable. In order to assess the robustness of the VLM-LRT statistic, at least six models were computed for both indicators ('alcohol consumption' and 'drinking to intoxication'). The entropy values were compared, with values closer to 1.0 reflecting a higher classification accuracy [41]. Conversely, an entropy value closer to zero is a cause for concern as it implies that posterior probabilities does not separate well between trajectories [41]. After iterative comparisons, the estimated models were visually inspected, and the retained models were chosen based on the model fit in concert with coherence, interpretability and parsimony. All LCGAs were computed using Mplus 7.1 [42] and the full information maximum likelihood estimator for handling of missing information [42].

Association between trajectories and symptoms of depression. The estimated class membership for each participant of the retained models for 'alcohol consumption' and 'drinking to intoxication' were saved and migrated to Stata version 13.1 [43]. In Stata, the information about assigned class membership was merged with the remainder of the dataset, and the gender-adjusted association between different trajectories and symptoms of depression were computed for ages 13–18 years. In order to ease comparison, the mean depression score was standardised [mean: 0, standard deviation (SD): 1] at each wave, and the class membership variables were employed as categorical indicators in multiple linear regression analyses.

Results

Among the total number of participants 45.6% were female, with a comparable gender distribution across waves (Table S1). The unstandardised mean scores of depression were relatively stable across waves, while alcohol consumption and drinking to intoxication increased steeply during the age span (Table S1).

Trajectories of alcohol consumption and drinking to intoxication

For both alcohol consumption and drinking to intoxication, the successive comparisons suggested that four-class models should be retained (Table 2). For both measures, we returned to a four-class model since the fit of the five-class model was not significantly better according to the VLMR-LRT-test (both $P > 0.05$). This choice was further supported as the additional classes

Table 2. *Latent class growth modelling fit indices for the latent class growth analysis of alcohol consumption and drinking to intoxication*[a]

Number of classes	AIC	BIC	BLRT	Entropy	VLMR-LRT	VLMR Adjusted-LRT	Lowest estimated probability of class membership	Highest estimated probability of class membership
Alcohol consumption (n = 1 102)								
1	10 098.355	1 0128.385	N/A	N/A	N/A	N/A	N/A	N/A
2	9 197.356	9 247.405	$P < 0.001$	0.709	$P < 0.0001$	$P < 0.0001$	0.894	0.931
3	9 085.366	9 155.434	$P < 0.001$	0.611	$P = 0.0015$	$P = 0.0018$	0.793	0.839
4	**9 023.069**	**9 113.157**	**$P < 0.001$**	**0.637**	**$P = 0.0060$**	**$P = 0.0070$**	**0.712**	**0.837**
5	8 997.827	9 107.934	$P < 0.001$	0.667	$P = 0.2244$	$P = 0.2367$	0.694	0.814
6	8 973.397	9 103.524	$P < 0.001$	0.635	$P = 0.2462$	$P = 0.2531$	0.668	0.796
Drinking to intoxication (n = 1 095)								
1	4 537.841	4 557.835	$P < 0.001$	N/A	N/A	N/A	N/A	N/A
2	3 873.535	3 913.523	$P < 0.001$	0.655	$P < 0.0001$	$P < 0.0001$	0.869	0.914
3	3 783.636	3 843.619	$P < 0.001$	0.597	$P = 0.0008$	$P = 0.0010$	0.741	0.875
4	**3 749.539**	**3 829.515**	**$P < 0.001$**	**0.703**	**$P = 0.0003$**	**$P = 0.0003$**	**0.778**	**0.850**
5	3 748.820	3 848.790	$P = 0.051$	0.627	$P = 0.2497$	$P = 0.2603$	0.722	0.905
6	3 748.783	3 868.747	$P = 0.500$	0.618	$P = 0.1618$	$P = 0.1698$	0.638	0.805

[a]Handling of missing data estimated using the full information maximum likelihood-approach (FIML), which assume that probability of the missing data on a certain variable Y relies on other variables on the values of Y itself. No baseline differences on the variables of alcohol use and depression were noted for those who completed all waves and those who dropped out over time during the data collection in our study. AIC, Akaike information criteria; BIC, Bayesian information criteria; BLRT, Bootstrapped likelihood test; N/A, not applicable; VLMR-LRT, Vuon-Lo-Mendell-Rubin likelihood ratio test; VLMR Adjusted-LRT, Vuon–Lo–Mendell–Rubin adjusted likelihood ratio test. Bold indicates the retained models.

only differed with regard to level of alcohol use, and not with regard to the shape of the curves. Although the AIC- and BIC-values continued to decrease, the bootstrap likelihood ratio test–statistic was significant with the addition of classes for alcohol consumption, and the AIC-value continued to decrease for drinking to intoxication, the changes were small, and a simultaneous decrease in entropy and/or non-significant VLMR-LRT-tests were observed. In addition, the four-class model was theoretically more meaningful than the five- and six-class model, as the additional trajectories only differed quantitatively from the trajectories in the four-model solutions.

The trajectories of alcohol consumption were labelled as follows: 'stable low' (12.3%), 'late onset' (15.0%), 'early onset high' (31.7%), and 'early onset low' (41.0%; Figure 1). There were more male participants in the categories 'stable low', 'late onset' and 'early onset high' (P values 0.003–0.037), while there was no difference in the gender distribution for 'early onset low' ($P = 0.582$; Table 3). For drinking to intoxication (Figure 2), the following labels were assigned: 'late onset' (34.4%), 'intermediate onset' (43.2%), 'early onset' (18.2%) and 'early onset and stable' (4.2%; Table 3). In the category 'late onset', there were more male participants ($P < 0.001$) while the remaining categories had a more even gender distribution (P values 0.136–1.000).

At the legal age of 18 years, 25.5% of all participants reported weekly alcohol consumption (the highest frequency that could be reported). This was not reported by anyone in the 'stable low' trajectory, while 13.5% in the 'late onset', 18.6% in the 'early onset low' and 53.7% in the 'early onset high' trajectory reported weekly consumption at age 18.

Further, a total of 31.8% of the participants reported being intoxicated ≥11 times in the last 6 months at age 18. This type of alcohol use also differed between trajectories, and was reported by 10.5% in the 'early onset and stable' trajectory, 11.3% in the 'late onset' trajectory, 40.9% in the 'intermediate onset' trajectory and 57.4% in the 'early onset' trajectory.

Trajectories of alcohol use and symptoms of depression

Symptoms of depression differed between trajectories both for alcohol consumption and for drinking to intoxication. For the alcohol consumption measure, increased symptom levels of depression was reported at all time-points in the 'early onset high' trajectory compared with the 'stable low' (0.33–0.46 SD), while the 'early onset low' trajectory reported increased levels of depression at age 18 years (0.24 SD; Table 4). For the drinking to intoxication measure, the 'early onset' trajectory reported increased symptom levels of

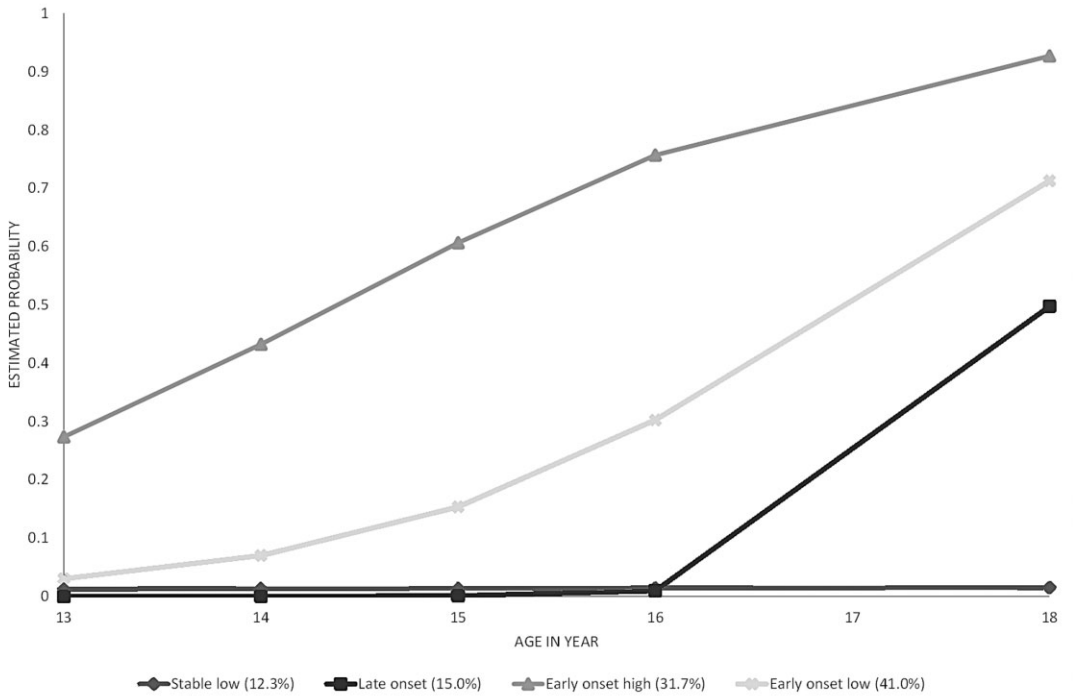

Figure 1. *Developmental trajectories of alcohol consumption (≥monthly) from ages 13–18 years.*

Table 3. *Gender distribution of trajectories of alcohol consumption and drinking to intoxication*

Alcohol consumption, class number				
	1—Stable low (CI 95%)	2—Late onset (CI 95%)	3—Early onset high (CI 95%)	4—Early onset low (CI 95%)
Female (%)	**35.3% (26.6–45.1)**	**39.7% (32.7–47.0)**	**44.4% (39.2–49.7)**	51.3% (46.8–55.8)
Drinking to intoxication, class number				
	1—Late onset (CI 95%)	2—Intermediate onset (CI 95%)	3—Early onset (CI 95%)	4—Early onset and stable (CI 95%)
Female (%)	**37.6% (33.0–42.5)**	52.0% (47.5–56.5)	50.0% (42.9–57.1)	35.7% (20.2–55.0)

One-sample binomial tests were employed to test the observed distribution of male and female participants in each class compared with a hypothesised 50:50 distribution. Bold indicates significant difference from the hypothesised distribution ($P < 0.05$). CI, confidence interval.

depression at ages 13–15 and 18 years compared with the 'late onset' trajectory (0.26–0.34 SD), while the 'early onset and stable' trajectory reported increased levels of depression at ages 13, 14 and 16 years (0.56–0.60 SD; Table 5).

Discussion

This study investigated the heterogeneity in the developmental trajectories of alcohol consumption and drinking to intoxication, and the trajectories' association with depression from early adolescence to the legal drinking age in Norway. Four trajectories of alcohol consumption and drinking to intoxication were identified, where only the 'early onset high' trajectory of alcohol consumption was consistently associated with higher levels of depressive symptoms across all waves, from early to late adolescence. All of the trajectories with an early onset of alcohol consumption or drinking to intoxication were, however, associated with higher

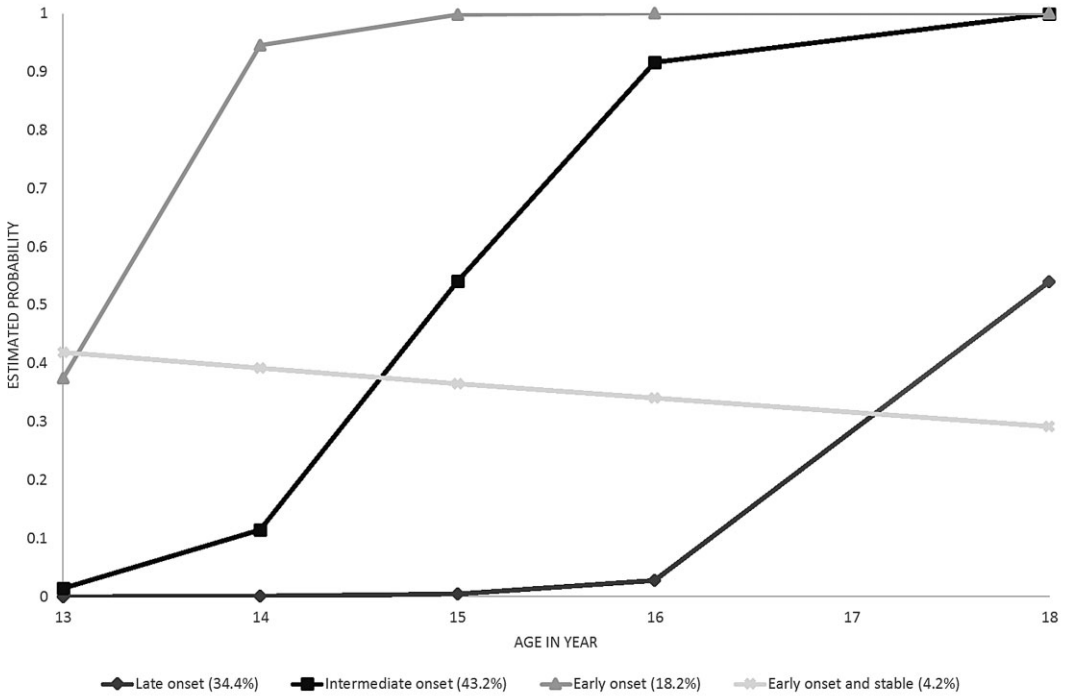

Figure 2. *Developmental trajectories of drinking to intoxication from ages 13–18 years.*

Table 4. *Gender-adjusted association between different alcohol consumption trajectories and symptoms of depression at ages 13, 14, 15, 16 and 18 years*

Class number	Age 13 ($n = 663$)	Age 14 ($n = 926$)	Age 15 ($n = 859$)	Age 16 ($n = 687$)	Age 18 ($n = 770$)
1—Stable low	Reference	Reference	Reference	Reference	Reference
2—Late onset	0.12 (–0.19, 0.42)	0.20 (–0.06, 0.46)	0.14 (–0.12, 0.41)	0.16 (–0.12, 0.44)	0.11 (–0.16, 0.38)
3—Early onset high	**0.33 (0.05, 0.61)**	**0.46 (0.22, 0.70)**	**0.40 (0.16–0.65)**	**0.35 (0.10, 0.61)**	**0.37 (0.13, 0.61)**
4—Early onset low	0.10 (–0.17, 0.37)	0.16 (–0.07, 0.39)	0.15 (–0.09, 0.39)	0.09 (–0.16, 0.33)	**0.24 (0.02, 0.47)**

Regression coefficients are estimated as difference in standard deviations from reference group. Patterns of significance were identical for the crude regression models. Bold indicates significant associations ($P < 0.05$).

Table 5. *Gender-adjusted association between different drinking to intoxication trajectories and symptoms of depression at ages 13, 14, 15, 16 and 18 years*

Class #	Age 13 ($n = 663$)	Age 14 ($n = 925$)	Age 15 ($n = 858$)	Age 16 ($n = 687$)	Age 18 ($n = 768$)
1—Late onset	Reference	Reference	Reference	Reference	Reference
2—Intermediate onset	0.03 (–0.14, 0.20)	0.03 (–0.12, 0.17)	0.04 (–0.11, 0.19)	0.10 (–0.07, 0.26)	0.08 (–0.08, 0.24)
3—Early onset	**0.26 (0.05, 0.47)**	**0.34 (0.17, 0.52)**	**0.30 (0.11, 0.49)**	0.16 (–0.06, 0.37)	**0.27 (0.06, 0.48)**
4—Early onset and stable	**0.56 (0.11, 1.01)**	**0.60 (0.21, 0.99)**	0.29 (–0.12, 0.69)	**0.56 (0.11, 1.01)**	0.23 (–0.22, 0.68)

Regression coefficients are estimated as difference in standard deviations from reference group. Patterns of significance were identical for the crude regression models. Bold indicates significant associations ($P < 0.05$).

levels of depressive symptoms compared with stable low or late onset trajectories at least at some waves.

Alcohol trajectories

For both alcohol consumption and drinking to intoxication, trajectories with early onset and late onset were identified, a finding largely in line with previous studies of adolescent drinking trajectories [5]. The 'early onset low' trajectory was the largest for alcohol consumption (41.0%) followed by 'early onset high' (31.7%), while the largest trajectories for drinking to intoxication was 'intermediate onset' (43.2%) and 'late onset' (34.4%). For both alcohol measures, the smallest group was the stable group. This is in accordance with the existing literature documenting that adolescence is the predominant period of initiation and escalation of alcohol use [3,44]. Furthermore, the identification of dominating trajectories characterised by increasing alcohol use is also supported by previous findings in Norwegian samples [2,9], as well as the finding that a high proportion of adolescents are drinking to intoxication.

Looking at the gender distribution in the different trajectories, there is an indication that somewhat more male participants compared with female participants consume alcohol frequently from early adolescence, which is in line with previous reports [45]. Earlier onset of drinking to intoxication was more evenly distributed among male and female participants, similar to previously reported results [45]. Furthermore, male participants were somewhat overrepresented in the 'late onset' trajectory with regard to drinking to intoxication. Overall, gender differences were evident, but not consistently so, which is in line with previous research stemming from Norwegian samples [2,9] and an LCGA of a German sample [6].

Previous research has consistently shown that alcohol use in the late adolescence and early adulthood is characterised by heavy episodic drinking in Northern Europe [45,46], and early onset of drinking to intoxication is often followed by a steep increase in frequency of this behaviour during adolescence [30,31]. This tendency was supported in our sample, where more than half of the 'early onset' intoxication-trajectory reported being intoxicated ≥11 times the last 6 months at age 18. Further, the 'early onset high' alcohol consumption-trajectory was also associated with an escalation culminating into at least weekly alcohol consumption at age 18. This is of concern, as it is likely that many of these will engage in weekly heavy drinking [30,31]. This pattern of alcohol use co-occurs with a time when the adolescents move away from parental supervision and restrictions, and when their freedom is increased. Considering the potential negative consequences, including functional, economic and psychosocial problems and the immediate high risk of accidents and violence of such high frequency of alcohol consumption and/or drinking to intoxication early in adult life [47], it seems evident that early onset and escalation of alcohol use is a considerable public health concern [30,31].

Trajectories: associations with symptoms of depression

The current study indicates a consistent association between alcohol consumption and depressive symptoms, which is in line with a recent cross-sectional study that demonstrated a strong association between depression and alcohol consumption [2]. The usefulness of early onset in itself as an indicator in alcohol research has been questioned [12]. However, the trajectories of early onset of alcohol consumption, and of drinking to intoxication were characterised by increase in these behaviours across waves in our study, and these trajectories were associated with higher levels of depressive symptoms compared with stable low or late onset trajectories. Thus a trajectory characterised by early onset followed by increased levels of consumption or intoxication may be useful indicators of other adverse conditions, such as depression, in these individuals, although the direction of the association is unknown. It is little doubt that depression is associated with alcohol-related problems, both in the short- and long-term [48], and a number of potential explanations for this have been posited, including a tendency to use alcohol as a coping strategy and using alcohol in an effort to dampen negative affectivity among depressed individuals [49,50]. Also, both symptoms of depression and problems related to alcohol use may have a common pathway through genetic and/or environmental influences [51–55]. Although our data are not suited to shed any light on the direction of causality, they may increase our knowledge about the complexity of the alcohol use–depression association.

Implications for public health initiatives

The evidence for heterogeneity in alcohol trajectories among Norwegian adolescents suggests that different preventive measures should be considered for the different subgroups. For instance, those with an early onset of drinking to intoxication are likely to escalate this behaviour rather rapidly, and are more likely to report depressive symptoms. Furthermore, as the increase seemed to occur in the first few intervening years between 13 and 18 years of age, the optimal window for intervention is 13 years or earlier [6]. Likewise, the individuals in the 'early onset high' trajectory of alcohol consumption consistently reported more symptoms of depression at all waves in this study. It is likely that for this group, both interventions aimed at

preventing or delaying alcohol onset in combination with harm-reduction and reduction of depressive symptoms are particularly important (e.g. [12,56]). Early prevention and treatment of depression may have the added effect of preventing the development of problematic alcohol use among adolescents, as indicated in a randomised controlled trial showing a secondary benefit of depression treatment on subsequent alcohol use disorders [57].

Other trajectories, such as those with a late onset may require little or no tailored intervention beyond the existing universal intervention strategies. Furthermore, the study indicates that having an earlier onset of alcohol consumption is not necessarily associated with depressive symptoms at the time of alcohol onset, as evidenced by the 'early onset low' trajectory. However, it should be noted that also this group reported increased levels of depression at age 18 compared with those with a late onset of alcohol consumption. In sum, the findings in this study suggest that preventive strategies which are able to both focus on delaying the onset of alcohol use and harm-reduction, while also targeting those with an early onset of drinking to intoxication should be considered a primary public health task in relation to adolescent health [12,56].

Strengths and limitations

The employment of a longitudinal study design to identify trajectories of alcohol use from early adolescence to the legal drinking age, and the possibility to compare different trajectories' association with symptoms of depression are primary strengths of the present study. Also, the inclusion of a measure of frequency of alcohol use and drinking to intoxication allowed for the identification of developmental trajectories related to different dimensions of alcohol use. Conversely, the present study has several limitations. Firstly, the measurements of alcohol consumption were based on fixed categories related to frequency of alcohol consumption, which negated any direct conversion to the actual alcohol consumption in standard units, and may have induced underreporting due to lack of specificity. Arguably, it would have been preferable to be able to also calculate the consumption of alcohol in standard units, as it has been done in previous research in this area [6]. Secondly, while the questions of drinking to intoxication were phrased identically at all waves, they had differences in the fixed response categories. Due to this, it was deemed necessary to use this variable as a binary variable in the LCGA, only discriminating between those responding 'no' versus 'yes'. Thirdly, the inventory used for measuring symptoms of depression is not a well-validated questionnaire, which may limit generalisability. The content of the questionnaire, does however hold face-value, and includes major symptoms of depression such as feelings of hopelessness and feelings of sadness without any obvious reason. Furthermore, it has been successfully employed in previous studies [32,33,58,59] and psychometric assessment of the inventory have approximated other, more well-known depression scales [60]. Also, the questionnaire have a high internal consistency as well as an acceptable temporal stability between total scores [33]. Fourthly, the final models for alcohol consumption and drinking to intoxication had entropy values that were rather low indicating that the discrimination between the different classes was not optimal. Inspection of the estimated probability of class membership, however, indicated that the discrimination of the classes were sufficient to allow for meaningful interpretation. Fifthly, although the age range of 13–18 years covers an important period, based on the present findings it seems evident that it would have been preferable to have information about the variables of interest preceding this age range in order to assess initial onset of alcohol consumption for all participants [30,31].

Conclusions

Using data from a longitudinal study with five waves from ages 13–18, we identified four different prototypic trajectories of frequency of alcohol consumption and drinking to intoxication. The identified trajectories indicated that an early onset with later increase of both alcohol consumption and drinking to intoxication is associated with a higher risk of symptoms of depression. The findings from the present study and from previous research suggest that different developmental trajectories of alcohol use imply different and sometimes targeted intervention strategies.

Acknowledgements

The Norwegian Longitudinal Health Behaviour Study was started up and administered by the Research Centre of Health Promotion, Faculty of Psychology at the University of Bergen. We would like to acknowledge the initiatives of Professor Knut-Inge Klepp, who was the founder of the study and Professor Bente Wold who is currently the coordinator.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Table S1. Gender distribution, mean depression score and proportion of monthly alcohol consumption and drinking to intoxication across ages 13–18.

Supplemental table 1: Gender distribution, mean depression score and proportion of monthly alcohol consumption and drinking to intoxication across ages 13 to 18.

Age (year)	Gender (% female)	Mean depression score, range 1-6 (SD)	Weekly alcohol consumption (%)	Drinking to intoxication ≥11 times last 6 months (%)
13 years (1990)	44.8%	2.3 (0.9)	1.1%	0.4%
14 years (1991)	44.6%	2.2 (1.0)	5.1%	3.0%
15 years (1992)	44.6%	2.4 (1.1)	9.1%	7.9%
16 years (1993)	48.0%	2.1 (1.0)	10.8%	13.2%
18 years (1995)	50.6%	2.4 (1.1)	25.5%	31.8%