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# Alcohol and drug use among adolescents - and the co-occurrence of mental health problems. Ung@hordaland, a population-based study.

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## ABSTRACT

**Objectives:** The use of alcohol and drugs is prevalent among adolescents, but little is known about the association between debut of alcohol and drug use and concurrent mental health. The aim of the study was to investigate the cross-sectional association between debut of any alcohol or drug use and alcohol- and drug-related problems, and mental health. We also wanted to examine potential interactions between gender and age, and alcohol- and drug-related exposures.

**Design:** Cross-sectional study.

**Setting:** Population-based sample of Norwegian adolescents.

**Participants:** Data stem from the large population-based ung@hordaland study (N=9,203), where all adolescents aged 16-18 years living in Hordaland county (Norway) were invited to participate. The main exposures were debut of alcohol and drug use, alcohol consumption, and presence of alcohol and drug problems as measured by CRAFFT.

**Outcomes:** The outcomes were self-reported symptoms of anxiety, depression, inattention and hyperactivity.

**Results:** Both debut of alcohol and drug use were associated with symptoms of depression, inattention and hyperactivity (crude ORs 1.69-2.38, Ps<0.001), while only debut of drug use was associated with increased symptoms of anxiety (OR=1.33, CI95%1.05-1.68, P=0.017). Alcohol- and drug-related problems as measured by CRAFFT were associated with all mental health problems (crude ORs 1.68-3.24, Ps<0.001). There was little evidence of any substantial age- or gender confounding on the estimated associations between alcohol- and drug-related measures and the mental health outcomes.

**Conclusion:** Early debut of alcohol and drug use and drug problems are consistently associated with more symptoms of mental health problems, indicating that these factors are an important general indicator of mental health in adolescence.


## STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study employed a large well-defined population-based sample of adolescents.
- The data employed in this study is from a recent data collection.
- This study included several different measures of alcohol- and drug use, as well as measures of both internalizing and externalizing problems.
- The cross-sectional design of this study precluded any causal inference.
- This study only had a limited age-range, a wider range would enable a more thorough investigation of age-related effects of alcohol and drug use.

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## BACKGROUND

The disease burden attributed to alcohol and illicit drug use is considerable worldwide.[1, 2] Alcohol and illicit drug use tend to begin and escalate during adolescence and early adulthood.[3, 4] Early life alcohol and drug patterns are predictive of later use and abuse,[5] and for alcohol it has been shown that a 10% time-delay in debut would lead to a 35% decrease in the subsequent expected alcohol consumption .[6]

Drug use and abuse have been related to a range of mental health problems, most consistently to externalizing problems such as those associated with conduct disorder (CD) and attention-deficit-hyperactivity disorder (ADHD), [7] while the increased risk for anxiety disorders are lower. Also of note, several previous studies in adult populations have found that there is a J- or U-shaped relationship between alcohol consumption and mental health outcomes,[8-12] where both abstainers and high-level alcohol consumers have increased risk for mental health problems. Several explanations of this curvilinear relationship have been suggested: moderate alcohol consumers may directly benefit from a protective effect on mental health from alcohol, or their drinking habits may be a mere reflection of their psychological wellbeing.[9] Also, in cultures where alcohol use is the norm, moderate consumers may be more well-adjusted than individuals at the extremes of the consumption spectrum.[13] To date, few studies have investigated the relationship between the full spectrum of alcohol consumption (from non-debut to high-level alcohol consumption) and symptoms of mental health problems in a population-based sample of adolescents

Boys have an earlier debut of both alcohol consumption and intoxication according to most studies,[3] while the gender-pattern for onset of drug use is more unclear.[14-19] The established gender differences with males using more alcohol and drugs seems, however, to be closing [20] with recent studies not finding a higher rate of drug use among males.[21] If the relation between alcohol and drug use and mental health is gender specific is less clear. A lack of gender difference has been documented in population-based studies where the use of alcohol and drugs is associated with worse mental health.[22-25] In contrast, some studies have reported a modifying effect of gender and age in relation to the association between alcohol use and mental health.[23, 26, 27] For instance, a recent study investigating the association between alcohol intoxications and mental health problems among 13-19-year-olds found that high level alcohol consumption was associated with conduct and attention problems for both genders, but only girls who reported frequent intoxications reported more symptoms



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of anxiety and depression.[23] On the other hand, Verdurmen and colleagues reported a modifying effect of age on the association between alcohol use and mental health, but found no evidence of any modifying effects of gender.[26] The association between alcohol use and mental health is, however, not quite consistent, as a Dutch study did not confirm the expected relation between binge drinking and mental health problems among 16-18-years-olds in a population based study.[28]

Less is known whether the associations between the drug use and mental health is gender-specific, but there are some indications that co-occurrence of other mental health problems are higher for girls than boys.[7] However, in a sample of late adolescent urban youth gender did not have a moderating effect on the relationship between substance abuse and mental health, and a Finnish study did not support a gender specific association between depression and substance use.[21] These studies are rather small, and the results may have been hampered by lack of statistical power. It is also uncertain if the co-occurrence is specifically related to alcohol or drug dependence or also evident for mere alcohol or drug use.[7] Overall, there is still a need for further investigation of the association between early alcohol and drug use and mental health in a general population of adolescents.[29]

To that end, the aim of the present study was to

i) Describe the debut of alcohol and drug use, alcohol use patterns and potential drug problems among Norwegian adolescents using data from a recent population-based study.

ii) To investigate the cross-sectional relationship between a) alcohol and illicit drug use and b) alcohol and drug problems and mental health among adolescents. We also investigated any interactions with age and gender on the associations of interest, as well as the association between the full spectrum of alcohol consumption and binge drinking frequency in relation to mental health.

## METHODS

### Study population

This study employed information from the ung@hordaland-survey ("youth@hordaland") of adolescents in the county of Hordaland in western Norway. All adolescent born 1993-1995 living in Hordaland were invited to participate. Ung@hordaland is a population-based study, and carried out in close collaboration with the county council administration. The majority of participants responded to the questionnaires during school hours. The general aim of the ung@hordaland-survey was to assess mental health, lifestyle, school performance and health-



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service use in adolescents, with a special emphasis on the prevalence of mental health problems. The data was collected during January-February 2012. Adolescents in upper secondary education received information per e-mail, and one school hour was allocated for them to complete the questionnaire at school. Those not in school received information by mail to their home addresses. The questionnaire was web-based and covered a broad range of mental health issues, daily life functioning, use of health and social services, demographic background variables, and a request for permission to obtain school data, and to link the information with national registries and parental questionnaires. Uni Health and Hordaland County Council are collaborating partners in conducting the study. The study was approved by The Regional Committee for Medical Research Ethics in Western Norway. After complete description of the study to the subjects, written informed consent was obtained.

The current study is based on the first version of data files released in May 2012, with a total of 10,220 participants. Based on list-wise deletion of those with missing information on both exposures and outcomes, n=1,017 were excluded, leaving 9,203 in the final study sample. Those with missing information on the exposures and the outcomes, were slightly younger than those with valid information on the included variables (mean difference 0.12 years, p<.001) and more likely to be males (61.6% versus 45.7% in the analysed sample, p<.001).

**Identification of alcohol problems and illicit drug use**

Self-reported debut, frequency and amount of alcohol consumption and illicit drug use were included as main exposure variables. We included a binary measure of alcohol debut "Have you ever tried alcohol?" (Yes/No), and illicit drug use debut: "Have you ever tried hash, marihuana or other narcotic substances?" (Yes/No). Out of the total study sample, n=11 individuals did not answer the question on illicit drug use, and they were recoded to the "No" category. Alcohol use was measured using the self-reported units of beer, cider, wine, spirits and illegally distilled spirits usually consumed during the last 14 days. Based on this information about consumption and alcohol debut, a summed variable including the following gender-specific distribution was constructed: "Never tried", "Non-consumption" (if reported consumption was "0"), "0.1-19.9$^{th}$", "20.0-39.9$^{th}$", "40.0-59.9$^{th}$", "60.0-79.9$^{th}$", "80.0-89.9$^{th}$", "90.0-100$^{th}$". Excessive alcohol consumption was defined as above the 90$^{th}$ percentile sum score.[11, 30] Frequent binge drinking was defined as drinking so much that one was clearly intoxicated more than 10 times, based on the question: "Have you ever consumed so much alcohol that you were clearly intoxicated (drunk)?", with five categories ranging from "No, never" to "Yes, more than 10 times". There were n=147 missing responses on the binge drinking item, leaving a sample of N=9,056 for this measure. In



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addition, potential alcohol and drug problems were identified employing the six-item inventory CRAFFT.[31] CRAFFT was specifically designed to identify alcohol and illicit drug problems among adolescents,[31] and have been shown to have acceptable sensitivity and specificity at a cut-off of >=2 in international studies.[32, 33] In relation to the ung@hordaland sample, a linear relationship between CRAFFT-score and excessive alcohol consumption, binge drinking and debut of illicit drug use has previously been reported.[33]

**Mental health problems**

Depression was assessed using the short version of the Mood and Feelings Questionnaire (SMFQ).[34] The SMFQ comprises 13 items assessing depressive symptoms rated on a 3-point scale. The wordings of the response categories in the Norwegian translation equal the original categories of "Not true", "Sometimes true" and "True". High internal consistency between the items and a strong unidimensionality have been shown in population-based studies,[35] and was recently confirmed in a study based on the sample included in the present study.[36] For the purposes of the current study, depression was defined as a score above the 90$^{th}$ percentile of the Total SMFQ-score. It should be noted that term depression as used in the current study does not imply existence of a clinical diagnosis, such as MDD. Also, being a relatively brief self-report questionnaire, the SFMQ does not differentiate between different types of depressive disorders/conditions. The Cronbach's alpha of the SMFQ in the ung@hordaland-sample was 0.91.

Symptoms of anxiety was identified using the five-item inventory SCARED, which is short-form of the 41-item version screening inventory for anxiety disorders.[37] The short-form of the SCARED has showed similar psychometric properties to the full version.

Symptoms of inattention and hyperactivity were measured using sub-scores from the official Norwegian translation of the Adult ADHD Self-report Scale (ASRS),[38] originally constructed for use in adults, but recently validated among adolescents.[39] ASRS is an 18-item self-report scale, comprising 9 items on a hyperactivity-impulsivity subscale and 9 items on an inattention-subscale. The responses are given on a 5-point scale (ranging from "Never" to "Very often").

**Statistical analysis**

Five different alcohol and drug-related binary variables were constructed as main exposures: Ever consumed alcohol (Yes/No), ever tried illicit drugs (Yes/No), those reporting 90$^{th}$ gender-specific percentile alcohol consumption (Yes/No), binge drinking >10 times (Yes/No) and CRAFFT-caseness according to the ≥2 cutoff



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(Yes/No). For outcome variables the mental health questionnaires were dichotomised at the 90th percentile, identifying those with high sum scores on the ASRS subscales of inattention and hyperactivity-impulsivity, the SMFQ scale of depression and the SCARED scale of anxiety.

First, the sample was described in relation to exposures stratified for age and gender. Second, odds ratios were computed using simple logistic regression models for the associations between exposures and outcomes, as well as logistic regression models adjusted for age and gender. In addition, we investigated the potential two-way interaction with age and gender for the alcohol- and drug-related exposures in relation to mental health problems. The presence of significant interactions was assessed using likelihood-ratio tests (Wald), and when significant interactions were identified the associations of interest were presented stratified for age or gender. In secondary analyses, we investigated the association between the spectrum of alcohol consumption ("Never tried alcohol", "Non-consumption", "0.1-19.9th", "20.0-39.9th", "40.0-59.9th", "60.0-79.9th", "80.0-89.9th", "90.0-100th") and binge drinking ("Never tried alcohol", "Never", "Once", "2-3 times", 4-10 times" and ">10 times") categories separately for all mental health variables, employing age- and gender-adjusted logistic regression models with "Never tried" as reference group. All analyses were performed using Stata 12.0.[40]

## RESULTS

The final sample consisted of N=9,203 participants, where 54.3% were female and the mean age was 17.9 (SD 0.8) years. Table 1 and Figure 1 show the use of alcohol and illicit drugs stratified by age and gender. A total of 20.7% of the girls and 27.1% of the boys had *not* tried alcohol, whereas 8.8% of the girls and 12.5% of the boys *had* tried any illicit drug. Also, ~22% percent of the sample was CRAFFT-cases, indicating some alcohol- or drug-related problem. There was a significant age-trend for all exposures for both genders, where increasing age was associated with increased proportion of participants having tried alcohol or illicit drugs, as well as reporting alcohol- and drug-related problems (p-values ranging from: 0.002 to <0.001).

Table 2 depicts the crude and age- and gender-adjusted associations between having tried alcohol, illicit drugs or reporting alcohol- and drug-related problems, in relation to mental health problems. Having ever consumed alcohol was associated with increased odds of all mental health problems in both crude and age- and gender-adjusted models, except for symptoms of anxiety (crude ORs ranging from 1.13 to 2.36). Having ever tried illicit drugs was associated with increased odds of all mental health problems in both crude and age- and gender-adjusted models (crude ORs ranging from 1.33 to 2.38). In relation to alcohol- and drug-related



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problems, CRAFFT-caseness was associated with increased odds of all mental health problems in both the crude and the age- and gender-adjusted model (crude ORs ranging from 1.68 to 3.24). Excessive alcohol consumption was associated with all mental health problems in both crude and age- and gender-adjusted models (crude ORs ranging from 1.61 to 2.70). Binge-drinking more than 10 times was associated with increased symptoms of depression, inattention and hyperactivity in both regression models, but not with symptoms of anxiety (ORs ranging from 0.95 to 2.08).

Table 3 shows the p-values of the two-way age- and gender-interactions across use of alcohol and illicit drugs and mental health problems. For the most part, no interactions were found; only seven out 40 (17.5%) investigated interactions were statistically significant. For age, significant interactions were found with having ever consumed alcohol and frequent binge drinking in relation to hyperactivity (p=0.002 and p=0.025, respectively). In the age-stratified analyses having ever tried alcohol was associated with increased levels of hyperactivity for 17-year-olds (OR=2.53, CI95% 1.88-3.43) and 18-year-olds (OR=2.34, CI95% 1.57-3.48), but not for 19-year-olds (OR=0.79, CI95% 0.47-1.34). Frequent binge drinking was associated with increased levels of hyperactivity for all age-groups, but more strongly among 17 (OR=2.56, CI95% 1.88-3.47) and 18-year-olds (OR=2.54, CI95% 1.93-3.34) than for 19-year-olds (OR=1.55, CI95% 1.16-2.08).

For gender, significant interactions were found with having ever tried illicit drugs and excessive alcohol consumption in relation to symptoms of anxiety (p=0.021 and p<0.001, respectively), excessive alcohol consumption and symptoms of hyperactivity (p=0.021), and with binge drinking and excessive consumption and symptoms of depression (p=0.027 and p=0.018, respectively). In the gender-stratified analyses, having ever tried illicit drugs and reporting excessive consumption were associated with increased symptoms of anxiety for boys (OR=2.44, [CI95% 1.57-3.78] and OR=4.36 [CI95% 2.52-7.57], respectively), but not for girls (OR=1.30 [CI95% 0.98-1.73] and OR=1.23 [CI95% 0.87-1.73], respectively). The same pattern was evident for depression, where frequent binge drinking was associated with increased symptoms in boys (OR=1.83, CI95%1.32-2.52) but not for girls (OR=1.19, CI95% 0.98-1.44). Excessive alcohol consumption was associated with increased symptoms of hyperactivity and depression, more strongly for boys (OR=3.78 [CI95% 2.65-5.40] and OR=3.57 [CI95% 2.32-5.51], respectively) than girls (OR=2.17 [CI95% 1.60-2.94] and OR=1.89 [CI95% 1.43-2.49], respectively).

Table 4 shows the associations between alcohol consumption and binge drinking categories with never having tried alcohol as reference. For symptoms of inattention, hyperactivity and depression there was a trend towards more symptoms of mental health problems with increasing levels of usual consumption and higher



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frequency for binge drinking (all p<0.001). This trend was not found for symptoms of anxiety where there were no associations with binge drinking categories (p-value for trend: 0.679) and alcohol consumption categories (p-value for trend: 0.058). The only significant difference was found with excessive alcohol consumption (90$^{th}$ percentile) compared to never having tried alcohol (OR=1.60, CI95%1.15-2.23).

## DISCUSSION

### Main findings

In sum, most adolescents aged 17 to 19 had tried alcohol and one-fifth of the girls and one-fourth of the boys had tried some illicit drug. Also, twenty percent of the adolescents reported some alcohol- or drug-related problems, as indicated by 2 or more points on the CRAFFT-questionnaire. There was a clear positive age-trend for having tried both alcohol and illicit drugs for both boys and girls, and debut of alcohol and illicit drug use was associated with mental health problems for both genders. Having tried illicit drugs, excessive alcohol consumption and CRAFFT-caseness were associated with all mental health problems. No J- or U-shaped association was found for alcohol consumption or binge drinking in relation to any of the mental health problems included in this study. There was weak evidence of any substantial age- or gender-confounding or interaction on the estimated association between alcohol- and drug-related measures and mental health problem. Moreover, a closing gender gap on alcohol and drug use was supported.

### Strengths and limitations

The current study holds several strengths. Firstly, it is a large well-defined population-based sample of adolescents. The sample size enabled the investigation of both main effects and potential interaction effects of age and gender. Secondly, the data collection is recent which allows for an updated and contemporary insight into the current status of alcohol- and drug use, presence of potential alcohol- and drug use problems, and associations with mental health problems. Thirdly, the study included different measures of alcohol- and drug use, as well as the validated CRAFFT-questionnaire for alcohol- or drug-related problems. Fourthly, we included measures of internalizing and externalizing mental health problems, using well-validated questionnaires measuring symptoms of depression and anxiety, as well as hyperactivity and inattention symptoms that are part of the ADHD-diagnosis.



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The current study has also some limitations. Firstly, the study is cross-sectional, and this precludes any causal inference of the estimated associations. Previous findings indicate that mental health problems can be a consequence of alcohol- and drug use, be a risk factor for alcohol- and drug use or that both are influenced by a common cause.[41-43] Secondly, the age-range included in the present study is limited, and a wider range would enable a more thorough investigation of age-related effects of alcohol and drug use, and probably also increase the chances of finding any moderating effects of age.[44] Thirdly, both data on exposures and outcomes were self-reported, which could lead to common methods bias and bias in reporting, especially underreporting for the exposures. Fourthly, due to missing information, almost ten percent of the total eligible study population was not included in our analyses. The attrition from the current study could affect generalizability, and result in adolescents attending school being overrepresented. Although no data on non-responders were available in the current wave of the Bergen Child Study, previous research from the former waves of the Bergen Child Study have shown that non-participants tend to have more psychological problems than participants.[45] This could suggest that the non-responders also have a higher alcohol and drug consumption, which could bias our sample further. This non-participation bias is, however, not likely to reduce the associations of interest substantially.[46] Finally, the assessment of illicit drug does not indicate type of drug tried and frequency, thus limiting conclusions drawn according to the relation between mental health and more specific drugs or consumption patterns.

**Interpretation**

The closing gender gap reported in previous studies, was partly confirmed by the present study.[20] Even though more girls in the younger age group had tried alcohol, boys showed a pattern of trying illegal drugs more often and there were more boys with problems related to alcohol and drug use, while there were no differences in patterns of problem drinking and binge drinking. The expected age pattern was confirmed with both more alcohol and drug use and binge drinking with increasing age. 18 years is the legal age when adolescents can buy alcohol in Norway, and thus an increase in alcohol use at this age is as expected. In the 19-years-olds more than a third reported binge drinking. Even though this is a lower rate than reported in a previous population-based Norwegian study ,[23] our findings suggest that this negative alcohol use pattern is highly frequent among Norwegian adolescents.

There was strong evidence for a co-occurrence of alcohol and drug problems and mental health problems among adolescents, consistent with findings in previous studies.[7, 25] While most studies have



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focused on drug abuse, we also found that even having tried alcohol or drugs in this age group are potential indicators of mental health problems for both genders. Due to the cross-sectional design of this study, we could not investigate direction of causality. But the relationship between alcohol and drug use and mental health problems in adolescence is probably complex and multidirectional.[24, 47] For instance, mental health problems like impulsivity and hyperactivity may possibly render an adolescent susceptible for using alcohol, but these problems may also be exacerbated by alcohol and drug use. There may also be common etiological factors that accounts for both an increased risk of mental health problems and alcohol consumption, such as parental alcohol use or social peer network. While both ADHD and depressive symptoms were consistently related to alcohol and drug use and abuse, the co-occurrence of these disorders may have impacted the association.

In general, we found little evidence of a substantial modifying effect of age or gender, which is contrary to some previous studies.[23, 26, 27] We did, however, find weak evidence for a modifying effect of age and gender for specific mental health domains: there was some evidence for an age-differential association between alcohol and drug exposures and symptoms of hyperactivity, where having tried alcohol or frequent binge drinking were more strongly associated with symptoms of hyperactivity for younger adolescents. This could be related to a lower level of cognitive and emotional control in early adolescence compared to at an older age,[44] increasing the susceptibility both to alcohol use, binge drinking and mental health problems.

We also found a gender-differential association between alcohol and drug exposures and symptoms of internalizing mental health problems, where boys showed more consistent association between exposures and symptoms of anxiety and depression than girls. Interestingly, we found that, among girls, excessive alcohol consumption was not associated with anxiety and frequent binge drinking was not associated with depression. This is contrary to results from a previous Finnish study which found stronger associations between heavy drinking and psychosocial dysfunction among girls than among boys.[27] One factor that may have impacted on this relation is the higher rate of depressive symptoms in girls,[36] and this may be understood in light of the "gender paradox" where the gender with the lowest prevalence rate will be more severely affected.[48] The interpretation of the findings concerning interactions should, however, be done with caution as the number of tested interactions (N=40) were high, and only 17.5% were significant. Future studies should therefore investigate the reported interactions in other study samples.

In the secondary analyses, we found no indication of any curvilinear relationship between alcohol consumption and frequency of binge drinking in relation to mental health problems. This is contrary to previous findings,[8-12] predominantly from adult populations, and may be an indication of a differential association



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between alcohol habits and mental health problems in adolescent versus in an adult population. Also, it may be an indication of cohort-effects, as there is a tendency for lower levels of alcohol consumption and more abstention among adolescents in recent years.[4, 49] Thus, as the abstention group grows, the group also includes more individuals who identify with being abstinent, who have a social network and actively chooses abstinence due to an increased focus on education, career or sports.[50]

**Clinical implications**

The high rate of alcohol and drug use in underage adolescents, 10 percent having tried illegal substances, as well as a pattern of negative alcohol and drug use characterised by binge drinking and large quantities of alcohol together represent a serious public health concern that emphasizes a need of preventive interventions. The strong co-occurrence of mental health and alcohol and drug related problems suggest that assessment of alcohol and drug use and abuse should become an integral part of mental health assessment and interventions, especially in adolescent with depression and ADHD.

In summary, it seems evident that both alcohol and drug debut, and the frequency and intensity of alcohol consumption are important and relevant indicators of mental health problems among adolescents. Investigation of the causal nature between alcohol and drug use, and mental health problems, as well as the access to health care and utilisation of health care among adolescents who use alcohol and drugs in hazardous ways should be addressed in future studies.

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## COMPETING INTERESTS

The authors declare that they have no competing interests.

## AUTHORS' CONTRIBUTIONS

JCS conceived the initial concept, and the initial analyses and literature search. JCS, BS, MH interpreted the initial analyses and wrote the first draft. AJL, KMS and RJ reviewed and revised the initial analyses and first draft, and suggested further analyses, as well as revisions of the first draft. The subsequent drafts were reviewed by all authors, and all authors read and approved the final manuscript.

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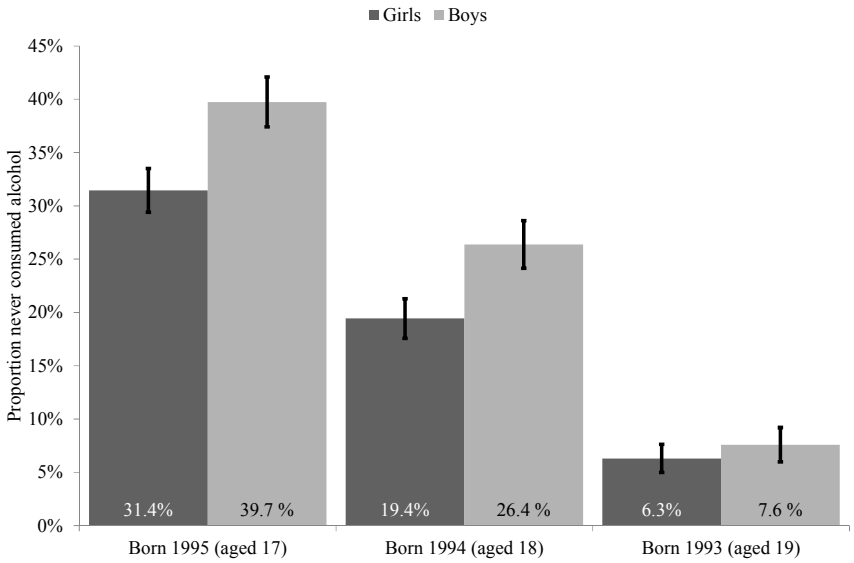
Figure 1: Proportion of participants having ever consumed alcohol and tried illicit drugs across gender-stratified age groups (N=9,203, girls n=4,995, boys n=4,208). Error bars represent 95% confidence intervals.



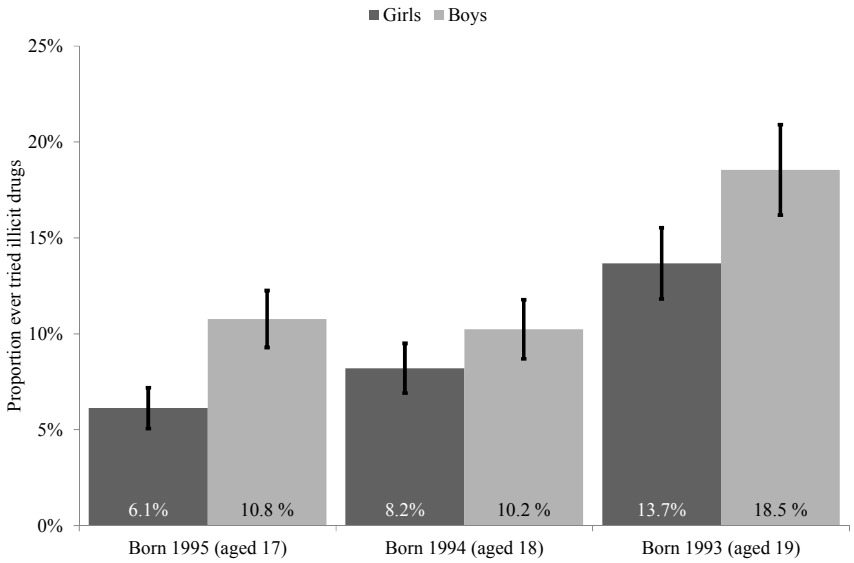




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Table 1: Description of abstention, drinking pattern, CRAFFT-caseness and drug use across age cohorts, stratified for gender. N=9,203 (girls n=4,995, boys n=4,208).

| | Total sample (95% CI) | Born 1995 (95% CI) | Born 1994 (95% CI) | Born 1993 (95% CI) | OR for age trend (95% CI) | p-value |
|---|---|---|---|---|---|---|
| **Never consumed alcohol (yes%)** | | | | | | |
| Girls | 20.7% (19.6-21.8) | 31.4% (29.4-33.5) | 19.4% (17.6-21.4) | 6.3% (5.1-7.7) | 0.42 (0.38-0.47) | <.001 |
| Boys | 27.1% (25.7-28.4) | 39.7% (37.4-42.1) | 26.4% (24.2-28.7) | 7.6% (6.1-9.4) | 0.41 (0.37-0.45) | <.001 |
| **Ever tried illicit drugs (yes%)** | | | | | | |
| Girls | 8.8% (8.1-9.6) | 6.1% (5.1-7.3) | 8.2% (7.0-9.6) | 13.7% (11.9-15.6) | 1.57 (1.39-1.77) | <.001 |
| Boys | 12.5% (11.5-13.5) | 10.8% (8.5-11.2) | 10.2% (8.8-11.9) | 18.5% (16.3-21.0) | 1.37 (1.22-1.54) | <.001 |
| **90$^{th}$ percentile alcohol consumption[a] (yes%)** | | | | | | |
| Girls | 7.7% (6.9-8.6) | 6.0% (4.8-7.4) | 7.7% (6.4-9.2) | 9.7% (8.2-11.5) | 1.30 (1.13-1.51) | <.001 |
| Boys | 7.4% (6.5-8.4) | 5.9% (4.6-7.6) | 5.9%(5.5-8.5) | 9.6% (7.9-11.6) | 1.31 (1.10-1.55) | =.002 |
| **Binge drinking (>10; yes%)[b]** | | | | | | |
| Girls | 20.5% (19.4-21.6) | 10.6% (9.3-12.0) | 19.7% (17.9-21.7) | 36.1% (33.6-38.8) | 2.20 (2.01-2.41) | <.001 |
| Boys | 21.3% (20.1-22.6) | 10.7% (9.3-12.3) | 21.9% (19.9-24.1) | 37.1% (34.2-40.1) | 2.21 (2.00-2.44) | <.001 |
| **CRAFFT positive (≥2; yes%)** | | | | | | |
| Girls | 23.3% (22.2-24.5) | 20.0% (18.3-21.8) | 22.4% (20.5-24.4) | 29.5% (27.1-32.1) | 1.29 (1.19-1.40) | <.001 |
| Boys | 20.3% (19.1-21.5) | 15.8% (14.1-17.6) | 19.3% (17.4-21.4) | 29.0% (26.3-31.8) | 1.47 (1.34-1.62) | <.001 |

95% confidence intervals in parentheses
[a]Only includes those who have tried alcohol (n=7,031).
[b]Only includes those with valid response on binge drinking (n=9,056).



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Table 2: Logistic regressions of use of alcohol and illicit drugs as risk factor for mental health problems. N=9,203 (girls n=4,995, boys n=4,208).

| | ASRS Inattention OR (95%CI) | ASRS Hyperactivity OR (95%CI) | SMFQ OR (95%CI) | SCARED OR (95%CI) |
|---|---|---|---|---|
| **Ever consumed alcohol** | | | | |
| Crude | 2.36 (1.90-2.93) | 2.08 (1.68-2.58) | 1.73 (1.43-2.09) | 1.13 (0.94-1.37) |
| Adjusted for age and gender | 2.21 (1.77-2.76) | 2.07 (1.66-2.58) | 1.64 (1.35-1.99) | 1.03 (0.84-1.25) |
| **Ever tried illicit drugs** | | | | |
| Crude | 2.38 (1.98-2.87) | 2.26 (1.86-2.74) | 1.69 (1.39-2.05) | 1.33 (1.05-1.68) |
| Adjusted for age and gender | 2.49 (2.06-3.02) | 2.36 (1.94-2.89) | 1.98 (1.62-2.42) | 1.55 (1.23-1.98) |
| **90$^{th}$ percentile alcohol consumption**[a] | | | | |
| Crude | 1.97 (1.55-2.51) | 2.70 (2.14-3.40) | 2.19 (1.74-2.75) | 1.61 (1.21-2.14) |
| Adjusted for age and gender | 1.96 (1.54-2.50) | 2.76 (2.19-3.48) | 2.27 (1.79-2.88) | 1.64 (1.22-2.19) |
| **Binge >10 times**[b] | | | | |
| Crude | 1.83 (1.56-2.15) | 2.08 (1.77-2.45) | 1.30 (1.10-1.52) | 0.95 (0.78-1.16) |
| Adjusted for age and gender | 1.80 (1.52-2.12) | 2.18 (1.84-2.59) | 1.36 (1.15-1.61) | 0.97 (0.79-1.20) |
| **CRAFFT-caseness (≥2)** | | | | |
| Crude | 3.15 (2.71-3.66) | 3.24 (2.78-3.78) | 2.84 (2.46-3.28) | 1.68 (1.42-1.99) |
| Adjusted for age and gender | 3.06 (2.63-3.56) | 3.22 (2.76-3.77) | 2.84 (2.45-3.29) | 1.62 (1.38-1.94) |

95% confidence intervals in parentheses

[a]Only includes those who have tried alcohol (n=7,031).

[b]Only includes those with valid response on binge drinking (n=9,056).



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Table 3: Summary of level of statistical significance for age- and gender-interactions across exposures and outcomes. N=9,203 (girls n=4,995, boys n=4,208).

| | ASRS inattention | | ASRS Hyperactivity | | SMFQ | | SCARED | |
|---|---|---|---|---|---|---|---|---|
| | Gender | Age | Gender | Age | Gender | Age | Gender | Age |
| Ever consumed alcohol | p=0.187 | p=0.595 | p=0.466 | **p=0.002** | p=0.257 | p=0.255 | p=0.052 | p=0.182 |
| Ever tried illicit drugs | p=0.666 | p=0.630 | p=0.542 | p=0.384 | p=0.054 | p=0.978 | **p=0.021** | p=0.425 |
| 90$^{th}$ percentile alcohol consumption | p=0.752 | p=0.359 | **p=0.021** | p=0.937 | **p=0.018** | p=0.639 | **p<0.001** | p=0.198 |
| Binge >10 | p=0.083 | p=0.427 | p=0.514 | **p=0.025** | **p=0.027** | p=0.889 | p=0.245 | p=0.452 |
| CRAFFT-caseness (≥2) | p=0.413 | p=0.263 | p=0.293 | p=0.190 | p=0.100 | p=0.840 | p=0.991 | p=0.464 |

*Significant interactions in bold. Interactions assessed using Wald likelihood-ratio tests.

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Table 4: Logistic regression models across alcohol consumption and binge drinking categories, "Never tried alcohol" as reference. Adjusted for age and gender (N=9,203 for alcohol consumption and N=9,056 for binge drinking).

| | ASRS Inattention OR (95%CI) | ASRS Hyperactivity OR (95%CI) | SMFQ OR (95%CI) | SCARED OR (95%CI) |
|---|---|---|---|---|
| **Categories** | Alcohol consumption categories as exposure | | | |
| Never consumed alcohol | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| Non-consumption | 1.90*** (1.45-2.48) | 1.46** (1.10-1.93) | 1.43** (1.12-1.82) | 1.01 (0.78-1.30) |
| 0.1-19.9th percentile | 1.61** (1.19-2.17) | 1.69** (1.25-2.27) | 1.44** (1.11-1.88) | 1.00 (0.75-1.32) |
| 20.0-39.9th percentile | 1.98*** (1.46-2.69) | 1.91*** (1.40-2.60) | 1.53** (1.16-2.03) | 0.90 (0.66-1.23) |
| 40.0-59.9th percentile | 1.92*** (1.42-2.59) | 1.55** (1.13-2.13) | 1.16 (0.87-1.56) | 0.97 (0.72-1.30) |
| 60.0-79.9th percentile | 2.56*** (1.92-3.40) | 2.55*** (1.92-3.40) | 1.85*** (1.42-2.41) | 0.84 (0.62-1.14) |
| 80.0-89.9th percentile | 3.77*** (2.75-5.17) | 3.56*** (2.59-4.91) | 2.21*** (1.62-3.02) | 1.39 (0.99-1.96) |
| 90.0-100th percentile | 4.16*** (3.05-5.68) | 5.28*** (3.91-7.12) | 3.47*** (2.60-4.62) | 1.60** (1.15-2.23) |
| p-value for trend | p<0.001 | p<0.001 | p<0.001 | p=0.058 |
| **Categories** | Binge drinking categories as exposure | | | |
| Never consumed alcohol | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| Never binge | 1.65*** (1.24-2.20) | 1.35* (1.00-1.81) | 1.30* (1.00-1.67) | 1.10 (0.85-1.43) |
| Once | 1.71** (1.23-2.38) | 2.06*** (1.50-2.82) | 1.55** (1.16-2.08) | 1.02 (0.74-1.39) |
| 2-3 times | 2.00*** (1.51-2.63) | 1.62** (1.21-2.15) | 1.61*** (1.26-2.07) | 0.88 (0.67-1.16) |
| 4-10 times | 2.49*** (1.90-3.26) | 2.05*** (1.55-2.72) | 1.85*** (1.44-2.36) | 1.05 (0.81-1.38) |
| >10 times | 3.14*** (2.43-4.05) | 3.36*** (2.61-4.33) | 1.95*** (1.54-2.47) | 0.98 (0.76-1.27) |
| p-value for trend | p<0.001 | p<0.001 | p<0.001 | p=0.679 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ in comparison to "Never tried alcohol"-category



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## Figure legends

Figure 1: Proportion of participants having ever consumed alcohol and tried illicit drugs across gender-stratified age groups (N=9,203, girls n=4,995, boys n=4,208). Error bars represent 95% confidence intervals.

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STROBE Statement—checklist of items that should be included in reports of observational studies
**"X" indicates checked**

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 X | (*a*) Indicate the study's design with a commonly used term in the title or the abstract |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found |
| **Introduction** | | |
| Background/rationale | 2 X | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 X | State specific objectives, including any prespecified hypotheses |
| **Methods** | | |
| Study design | 4 X | Present key elements of study design early in the paper |
| Setting | 5 X | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 X | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 X | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8* X | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group |
| Bias | 9 X | Describe any efforts to address potential sources of bias |
| Study size | 10 X | Explain how the study size was arrived at |
| Quantitative variables | 11 X | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods | 12 X | (*a*) Describe all statistical methods, including those used to control for confounding |
| | | (*b*) Describe any methods used to examine subgroups and interactions |
| | | (*c*) Explain how missing data were addressed |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses |

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| | | |
|---|---|---|
| **Results** | | |
| Participants | 13* X | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| | | (b) Give reasons for non-participation at each stage |
| | | (c) Consider use of a flow diagram |
| Descriptive data | 14* X | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| | | (b) Indicate number of participants with missing data for each variable of interest |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15 | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | X* | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures |
| Main results | 16 X | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included |
| | | (*b*) Report category boundaries when continuous variables were categorized |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 X | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| **Discussion** | | |
| Key results | 18 X | Summarise key results with reference to study objectives |
| Limitations | 19 X | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 X | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 X | Discuss the generalisability (external validity) of the study results |
| **Other information** | | |
| Funding | 22 X | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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# Alcohol and drug use among adolescents - and the co-occurrence of mental health problems. Ung@hordaland, a population-based study.

| | |
|---|---|
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# Alcohol and drug use among adolescents - and the co-occurrence of mental health problems. Ung@hordaland, a population-based study.

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## ABSTRACT

**Objectives:** The use of alcohol and drugs is prevalent among adolescents, but too little is known about the association between debut of alcohol and drug use, problematic use and concurrent mental health. The aim of the study was to investigate the cross-sectional association between debut of any alcohol or drug use and alcohol- and drug-related problems, and mental health. We also wanted to examine potential interactions between gender and age, and alcohol- and drug-related variables.

**Design:** Cross-sectional study.

**Setting:** Population-based sample of Norwegian adolescents.

**Participants:** Data stem from the large population-based ung@hordaland study (N=9,203), where all adolescents aged 16-18 years living in Hordaland county (Norway) were invited to participate. The main independent variables were debut of alcohol and drug use, alcohol consumption, and presence of alcohol and drug problems as measured by CRAFFT.

**Outcomes:** The dependent variables were self-reported symptoms of anxiety, depression, inattention and hyperactivity. Statistical analyses included logistic regression models.

**Results:** Both debut of alcohol and drug use were associated with symptoms of depression, inattention and hyperactivity (crude ORs 1.69-2.38, Ps<0.001), while only debut of drug use was associated with increased symptoms of anxiety (OR=1.33, CI95%1.05-1.68, P=0.017). Alcohol- and drug-related problems as measured by CRAFFT were associated with all mental health problems (crude ORs 1.68-3.24, Ps<0.001). There was little evidence of any substantial age- or gender confounding on the estimated associations between alcohol- and drug-related measures and the mental health problems.

**Conclusion:** Early debut of alcohol and drug use and drug problems are consistently associated with more symptoms of mental health problems, indicating that these factors are an important general indicator of mental health in adolescence.


## STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study employed a large well-defined population-based sample of adolescents.
- The data employed in this study is from a recent data collection.
- This study included several different measures of alcohol- and drug use, as well as measures of both internalizing and externalizing problems.
- The cross-sectional design of this study precluded any causal inference.
- This study only had a limited age-range; a wider range would enable a more thorough investigation of age-related effects of alcohol and drug use.

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## BACKGROUND

Previous studies of adolescents have found that a considerable proportion with one mental disorder also meets the criteria for at least one other mental disorder, including substance-use disorder.[1-3] Furthermore, drug use and abuse have been related to a range of mental health problems, most consistently to externalizing problems such as those associated with conduct disorder (CD) and attention-deficit-hyperactivity disorder (ADHD),[4] while the increased risk for anxiety disorders are lower. Also of note, several previous studies in adult populations have found that there is a J- or U-shaped relationship between alcohol consumption and mental health outcomes,[5-9] where both abstainers and high-level alcohol consumers have increased risk for mental health problems. Several explanations of this curvilinear relationship have been suggested: moderate alcohol consumers may directly benefit from a protective effect on mental health from alcohol, or their drinking habits may be a mere reflection of their psychological wellbeing.[6] Also, in cultures where alcohol use is the norm, moderate consumers may be more well-adjusted than individuals at the extremes of the consumption spectrum.[10] To date, few studies have investigated the relationship between the full spectrum of alcohol consumption (from non-debut to high-level alcohol consumption) and symptoms of mental health problems in a population-based sample of adolescents

Boys have an earlier debut of both alcohol consumption and intoxication according to most studies,[11] while the gender-pattern for onset of drug use is more unclear.[12-17] The established gender differences with males using more alcohol and drugs seems, however, to be closing [18] with recent studies not finding a higher rate of drug use among males.[19] Whether the relation between alcohol and drug use and mental health is gender specific is less clear. A lack of gender difference has been documented in population-based studies where the use of alcohol and drugs is associated with worse mental health.[20-23] In contrast, some studies have reported a modifying effect of gender and age in relation to the association between alcohol use and mental health.[21, 24, 25] For instance, a study investigating the association between alcohol intoxications and mental health problems among 13-19-year-olds found that high level alcohol consumption was associated with conduct and attention problems for both genders, but only the girls who reported frequent intoxication reported more symptoms of anxiety and depression.[21] On the other hand, Verdurmen and colleagues reported a modifying effect of age on the association between alcohol use and mental health, but found no evidence of any modifying effects of gender.[24] The association between alcohol use and mental health is, however, not quite consistent, as a Dutch study did not confirm the expected relation between binge drinking and mental health problems among



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16-18-years-olds in a population based study.[26]. Furthermore, most of the previous studies have focused on drug and alcohol use, whereas less is known about the relationship between mental health and debut in adolescence.

In general, the mental health problems show a consistent gender pattern in adolescence, with girls having a higher rate of depression and internalizing problems, and boys a higher rate of externalising disorders. [1] Less is known whether the associations between the drug use and mental health is gender-specific, but there are some indications that co-occurrence of other mental health problems are higher for girls than boys.[4] However, in a sample of late adolescent urban youth gender did not have a moderating effect on the relationship between substance abuse and mental health, and a Finnish study did not support a gender specific association between depression and substance use.[19, 27]

Also, it is uncertain if the co-occurrence is specifically related to alcohol or drug dependence or if it is also evident for mere alcohol or drug use.[4] Overall, there is still a need for further investigation of the association between early alcohol and drug use and mental health in a general population of adolescents.[28]

To that end, the aim of the present study was to

i) Describe the debut of alcohol and drug use, alcohol use patterns and potential drug problems among Norwegian adolescents using data from a recent population-based study.

ii) To investigate the cross-sectional relationship between a) alcohol and illicit drug use and b) alcohol and drug problems and mental health among adolescents. We also investigated any interactions with age and gender on the associations of interest, as well as the association between the full spectrum of alcohol consumption and frequency of drinking to intoxication in relation to mental health.

## METHODS

### Study population

This study employed information from the ung@hordaland-study of adolescents in the county of Hordaland in western Norway. All adolescents born 1993-1995 living in Hordaland were invited to participate (n=19,430), and 10,220 participated, yielding a participation rate of 53%. Ung@hordaland is a population-based study, carried out in close collaboration with the county council administration. The fourth wave of the longitudinal population-based study "Bergen Child Study" is also nested within ung@hordaland. The general aim of the ung@hordaland-survey was to assess mental health, lifestyle, school performance and health-service use in



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adolescents, with a special emphasis on the prevalence of mental health problems. The data was collected during January-February 2012. Adolescents in upper secondary education received information per e-mail, and one school hour was allocated for them to complete the questionnaire at school. Those not in school received information by mail to their home addresses. In addition, mental health facilities, juvenile detention centres and other institutions were contacted and the adolescents had the opportunity to participate. The questionnaire was web-based and covered a broad range of mental health issues, daily life functioning, use of health and social services, and demographic background variables. Upon participation electronic informed consent was obtained. The study was approved by The Regional Committee for Medical Research Ethics in Western Norway. Hordaland County is generally regarded representative of Norway as a whole, comprising both the second largest city of Norway (Bergen), as well as large rural areas. Official statistics of the general population (not just adolescents) show that Hordaland County does not deviate in any substantial degree from the national average on key parameters, including both socio-demographic indicators and several health indicators.

The current study is based on the first version of data files released in May 2012, with a total of 10,220 participants. Based on list-wise deletion of those with missing information on both independent and dependent variables, n=1,017 were excluded, leaving 9,203 in the final study sample. Those with missing information on the variables of interest were slightly younger than those with valid information on the included variables (mean difference 0.12 years, p<.001) and more likely to be males (61.6% versus 45.7% in the analysed sample, p<.001).

**Demographic information**

Information about age and gender was obtained on all participants. Furthermore, the participants indicated the perceived family socioeconomic status (SES) as i) "about the same as others" (67.9%), ii) "better than others" (25.1%) or iii) "worse than others" (7.1%), with n=172 missing responses recoded to "about the same as others".

**Identification of alcohol problems and illicit drug use**

Self-reported debut, frequency and amount of alcohol consumption and illicit drug use were included as main independent variables. We included a binary measure of alcohol debut "Have you ever tried alcohol?" (Yes/No), and illicit drug use debut: "Have you ever tried hash, marihuana or other narcotic substances?" (Yes/No). Out of the total study sample, n=11 individuals did not answer the question on illicit drug use, and they were recoded to the "No" category. Alcohol use was measured using the self-reported units of beer, cider, wine, spirits and



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illegally distilled spirits usually consumed during the last 14 days. Based on this information about consumption and alcohol debut, a summed variable on gender-specific distributions was constructed: "Never tried", "Non-consumption" (if reported consumption was "0"), "0.1-19.9$^{th}$", "20.0-79.9$^{th}$", "80.0-89.9$^{th}$", "90.0-100$^{th}$". Excessive alcohol consumption was defined as above the 90$^{th}$ percentile sum score.[8, 29] Frequent intoxication (binge drinking) was defined as drinking so much that one was clearly intoxicated more than 10 times, based on the question: "Have you ever consumed so much alcohol that you were clearly intoxicated (drunk)?", with five categories ranging from "No, never" to "Yes, more than 10 times". There were n=147 missing responses on the intoxication item, leaving a sample of N=9,056 for this measure. In addition, potential alcohol and drug problems were identified employing the six-item inventory CRAFFT.[30] CRAFFT was specifically designed to identify alcohol and illicit drug problems among adolescents,[30] and have been shown to have acceptable sensitivity and specificity at a cut-off of >=2 in international studies.[31, 32] In relation to the ung@hordaland sample, a linear relationship between CRAFFT-score and excessive alcohol consumption, frequency of intoxication and debut of illicit drug use has previously been reported.[32] In the current study, 28.4% of those having tried alcohol were CRAFFT-positive, while 61.1% of those having tried illicit drugs were CRAFFT-positive.

**Mental health problems**

Symptoms of depression, anxiety and ADHD were included as the main dependent variables. Depression was assessed using the short version of the Mood and Feelings Questionnaire (SMFQ).[33] The SMFQ comprises 13 items assessing depressive symptoms rated on a 3-point scale. The wordings of the response categories in the Norwegian translation equal the original categories of "Not true", "Sometimes true" and "True". High internal consistency between the items and a strong unidimensionality have been shown in population-based studies,[34] and was recently confirmed in a study based on the sample included in the present study.[35] For the purposes of the current study, depression was defined as a score above the 90$^{th}$ percentile of the Total SMFQ-score. It should be noted that term depression as used in the current study does not imply existence of a clinical diagnosis, such as MDD. Also, being a relatively brief self-report questionnaire, the SFMQ does not differentiate between different types of depressive disorders/conditions. The Cronbach's alpha of the SMFQ in the ung@hordaland-sample was 0.91.



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Symptoms of anxiety was identified using the five-item inventory SCARED, which is short-form of the 41-item version screening inventory for anxiety disorders.[36] The short-form of the SCARED has showed similar psychometric properties to the full version.

Symptoms of inattention and hyperactivity were measured using sub-scores from the official Norwegian translation of the Adult ADHD Self-report Scale (ASRS),[37] originally constructed for use in adults, but recently validated among adolescents.[38] ASRS is an 18-item self-report scale, comprising 9 items on a hyperactivity-impulsivity subscale and 9 items on an inattention-subscale. The responses are given on a 5-point scale (ranging from "Never" to "Very often").

**Statistical analysis**

Five different alcohol and drug-related binary variables were constructed as main independent variables: ever consumed alcohol (Yes/No), ever tried illicit drugs (Yes/No), those reporting ≥90$^{th}$ gender-specific percentile alcohol consumption (Yes/No), intoxication >10 times (Yes/No) and CRAFFT-positive according to the ≥2 cutoff (Yes/No). For dependent variables the mental health questionnaires were dichotomised at the 90$^{th}$ percentile, identifying those with high sum scores on the ASRS subscales of inattention (raw score range for cut-point 24-36, mean 27.2) and hyperactivity-impulsivity (raw score range for cut-point 20-36, mean 22.9), the SMFQ scale of depression (raw score range for cut-point 15-26, mean 19.3) and the SCARED scale of anxiety (raw score range for cut-point 5-10, mean 6.2).

First, the sample was described in relation to the independent variables, stratified for age and gender. Second, odds ratios were computed using crude logistic regression models for the associations of interest, as well as logistic regression models adjusted for age and gender, and then adjusted for age, gender and SES, with mental health variables both analysed separately, and collectively (i.e. entered into the same logistic regression model). In addition, as previous studies have shown differential age- and gender effects in the development of both mood disorder, anxiety disorder, behaviour disorder and substance use disorders among adolescents,[1] we investigated the potential two-way interaction with age and gender for the alcohol- and drug-related variables in relation to mental health problems. The presence of significant interactions was assessed using likelihood-ratio tests (Wald). When significant interactions were identified, the associations of interest were presented stratified for age or gender. In secondary analyses, we investigated the association between the spectrum of alcohol consumption ("Never tried alcohol", "Non-consumption", "0.1-19.9$^{th}$", "20.0-79.9$^{th}$", "80.0-89.9$^{th}$", "90.0-100$^{th}$") and frequency of intoxication ("Never tried alcohol", "Never intoxicated", "Once", "2-3 times", 4-10



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times" and ">10 times") categories separately for all mental health variables, employing age- and gender-adjusted logistic regression models with "Never tried" as reference group. All analyses were performed using Stata 12.0.[39] Due to missing information on the frequency of intoxication question, the analyses involving this variable only included n=9,056 participants. Frequency of intoxication was included as an independent variable in order to retain as much information as possible.

**RESULTS**

The final sample consisted of N=9,203 participants, where 54.3% were female and the mean age was 17.9 (SD 0.8) years. Table 1 and Figure 1 show the use of alcohol and illicit drugs stratified by age and gender. A total of 20.7% of the girls and 27.1% of the boys had *not* tried alcohol, whereas 8.8% of the girls and 12.5% of the boys *had* tried any illicit drug. Among the participants aged 17, 35.3% had *not* tried alcohol, compared to 16.0% aged 18 or more ($p<0.001$). Also, ~22% percent of the sample were CRAFFT-positive, indicating some alcohol- or drug-related problem. There was a significant age-trend for all independent variables for both genders, where increasing age was associated with increased proportion of participants having tried alcohol or illicit drugs, as well as reporting alcohol- and drug-related problems (p-values ranging from: 0.002 to <0.001).

Table 2 depicts the crude, age- and gender-adjusted, and age-, gender- and SES-adjusted associations between having tried alcohol, illicit drugs or reporting alcohol- and drug-related problems, in relation to mental health problems . Having ever consumed alcohol was associated with increased odds of all mental health problems in both crude and age- and gender-adjusted models, except for symptoms of anxiety (crude ORs ranging from 1.13 to 2.36). Having ever tried illicit drugs was associated with increased odds of all mental health problems in both crude and age- and gender-adjusted models (crude ORs ranging from 1.33 to 2.38). In relation to alcohol- and drug-related problems, being CRAFFT-positive was associated with increased odds of all mental health problems in both the crude and the age- and gender-adjusted model (crude ORs ranging from 1.68 to 3.24). Excessive alcohol consumption was associated with all mental health problems in both crude and age- and gender-adjusted models (crude ORs ranging from 1.61 to 2.70). Frequent intoxication was associated with increased symptoms of depression, inattention and hyperactivity in both regression models, but not with symptoms of anxiety (ORs ranging from 0.95 to 2.08). Further adjustment for self-reported perceived family SES only slightly altered the estimated associations.



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Table 3 shows the age- and gender-adjusted associations between having tried alcohol, illicit drugs or reporting alcohol- and drug-related problems, in relation to mental health problems analysed collectively. Entering all of the mental health variables into the same logistic regression model substantially attenuated the associations of interest, but the pattern of associations were similar to entering them separately.

For the most part, no two-way age- and gender-interactions across use of alcohol and illicit drugs and mental health problems were found; only seven out 40 (17.5%) investigated interactions were statistically significant (data not shown). For age, significant interactions were found with having ever consumed alcohol and frequent intoxication in relation to hyperactivity (p=0.002 and p=0.025, respectively). In the age-stratified analyses having ever tried alcohol was associated with increased levels of hyperactivity for 17-year-olds (OR=2.53, CI95% 1.88-3.43) and 18-year-olds (OR=2.34, CI95% 1.57-3.48), but not for 19-year-olds (OR=0.79, CI95% 0.47-1.34). Frequent intoxication was associated with increased levels of hyperactivity for all age-groups, more strongly among 17- (OR=2.56, CI95% 1.88-3.47) and 18-year-olds (OR=2.54, CI95% 1.93-3.34) than for 19-year-olds (OR=1.55, CI95% 1.16-2.08).

For gender, significant interactions were found with having ever tried illicit drugs and excessive alcohol consumption in relation to symptoms of anxiety (p=0.021 and p<0.001, respectively), excessive alcohol consumption and symptoms of hyperactivity (p=0.021), and with frequent intoxication and excessive consumption and symptoms of depression (p=0.027 and p=0.018, respectively). In the gender-stratified analyses, having ever tried illicit drugs and reporting excessive consumption were associated with increased symptoms of anxiety for boys (OR=2.44, [CI95% 1.57-3.78] and OR=4.36 [CI95% 2.52-7.57], respectively), but not for girls (OR=1.30 [CI95% 0.98-1.73] and OR=1.23 [CI95% 0.87-1.73], respectively). The same pattern was evident for depression, where frequent intoxication was associated with increased symptoms among boys (OR=1.83, CI95%1.32-2.52) but not for girls (OR=1.19, CI95% 0.98-1.44). Excessive alcohol consumption was associated with increased symptoms of hyperactivity and depression, more strongly for boys (OR=3.78 [CI95% 2.65-5.40] and OR=3.57 [CI95% 2.32-5.51], respectively) than girls (OR=2.17 [CI95% 1.60-2.94] and OR=1.89 [CI95% 1.43-2.49], respectively).

Table 4 shows the associations between alcohol consumption and frequency of intoxication categories with never having tried alcohol as reference. For symptoms of inattention, hyperactivity and depression there was a trend towards more symptoms of mental health problems with increasing levels of usual consumption and higher frequency of intoxication (all p<0.001). This trend was not found for symptoms of anxiety where there were no associations with intoxication categories (p-value for trend: 0.679) and alcohol consumption categories



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(p-value for trend: 0.061). The only significant difference was found with excessive alcohol consumption (90th percentile) compared to never having tried alcohol (OR=1.60, CI95%1.15-2.23).

## DISCUSSION

### Main findings

In sum, most adolescents aged 17 to 19 had tried alcohol and one-fifth of the girls and one-fourth of the boys had tried some illicit drug. Also, twenty percent of the adolescents reported some alcohol- or drug-related problems, as indicated by 2 or more points on the CRAFFT-questionnaire. There was a clear positive age-trend for having tried both alcohol and illicit drugs for both boys and girls, and debut of alcohol and illicit drug use was associated with mental health problems for both genders. Having tried illicit drugs, excessive alcohol consumption and being CRAFFT-positive were associated with all mental health problems. No J- or U-shaped association was found for alcohol consumption or frequency of intoxication in relation to any of the mental health problems included in this study. There was no clear evidence of any substantial age-, gender- or SES-confounding or modifying effect of age and gender on the estimated association between alcohol- and drug-related measures and mental health problem. Moreover, a closing gender gap on alcohol and drug use was supported.

### Strengths and limitations

The current study holds several strengths. Firstly, it is a large well-defined population-based sample of adolescents. The sample size enabled the investigation of both main effects and potential interaction effects of age and gender. Secondly, the data collection is recent and allows for an updated and contemporary insight into the current status of alcohol- and drug use, presence of potential alcohol- and drug use problems, and associations with mental health problems. Thirdly, the study included different measures of alcohol- and drug use, as well as the validated CRAFFT-questionnaire for alcohol- or drug-related problems. Fourthly, we included measures of internalizing and externalizing mental health problems, using well-validated questionnaires measuring symptoms of depression and anxiety, as well as hyperactivity and inattention symptoms that are part of the ADHD-diagnosis.

The current study has also some limitations. Firstly, the study is cross-sectional, and this precludes any causal inference of the estimated associations. Previous findings indicate that mental health problems can be a



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consequence of alcohol- and drug use, be a risk factor for alcohol- and drug use or that both are influenced by a common cause.[40-42] Secondly, the age-range included in the present study is limited, and a wider range would enable a more thorough investigation of age-related effects of alcohol and drug use, and probably also increase the chances of finding any moderating effects of age.[43] Thirdly, both data on the independent and dependent variables were self-reported, which could lead bias in reporting, especially underreporting for the independent variables. Fourthly, due to missing information, almost ten percent of the total eligible study population was not included in our analyses. The attrition from the current study could affect generalizability, and result in adolescents attending school being overrepresented. The problem with non-participation in survey research seems unfortunately to be on the rise.[44] Official data show that in 2012, 92% of all adolescents in Norway aged 16-18 attended high school,[45] compared to 98% in the current study. Based on previous research from the former waves of the Bergen Child Study (the nested within the current study), non-participants have also been shown to have more psychological problems than participants.[46] It is therefore likely that the prevalence of mental health problems is underestimated in the current study. This could suggest that the non-responders also have a higher alcohol and drug consumption, which could bias our sample further. This non-participation bias is, however, not likely to reduce the associations of interest substantially.[47] Finally, the assessment of illicit drug does not indicate type of drug tried and frequency, thus limiting conclusions drawn according to the relation between mental health and more specific drugs or consumption patterns. Lastly, the study is based on self-reported questionnaires assessing symptoms of both alcohol and drug problems and mental health problems, and multiple information would have been have been preferable to reduce informant bias and common method bias. Also, self-reported questionnaires do not provide information regarding the existence of a clinical diagnosis, and the lack of a clinical interview in confirming a formal diagnosis is a limitation of the present study.

**Interpretation**

The closing gender gap reported in previous studies was partly confirmed by the present study.[18] Even though more girls in the younger age group had tried alcohol, boys showed a pattern of trying illegal drugs more often and there were more boys with problems related to alcohol and drug use, while there were no differences in patterns of problem drinking and frequency of intoxication. The expected age pattern was confirmed with both more alcohol and drug use and frequent intoxication with increasing age. 18 years is the legal age when adolescents can buy alcohol in Norway, and thus an increase in alcohol use at this age is as expected. In the 19-years-olds more than a third reported drinking to intoxication. Even though this is a lower rate than reported in a



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previous population-based Norwegian study,[21] our findings suggest that this negative alcohol use pattern is frequent among Norwegian adolescents.

There was strong evidence for a co-occurrence of alcohol and drug problems and mental health problems among adolescents, consistent with findings in previous studies.[4, 23] While most studies have focused on drug abuse, we also found that even having tried alcohol or drugs in this age group are potential indicators of mental health problems for both genders. Due to the cross-sectional design of this study, we could not investigate direction of causality. But the relationship between alcohol and drug use and mental health problems in adolescence is probably complex and multidirectional.[22, 48] For instance, mental health problems like impulsivity and hyperactivity may possibly render an adolescent susceptible for using alcohol, but these problems may also be exacerbated by alcohol and drug use. There may also be common etiological factors that accounts for both an increased risk of mental health problems and alcohol consumption, such as parental alcohol use or social peer network. While both ADHD and depressive symptoms were consistently related to alcohol and drug use and abuse, the co-occurrence of these disorders may have impacted the association. In line with this the strength of the association was attenuated when including all of the mental health variables, while the pattern was similar and the associations were still significant. Thus, while co-occurrence of symptoms is frequent, both depressive and ADHD symptoms seems to have an independent contribution to the association between mental health and alcohol and drug use.

In general, we found little evidence of a substantial modifying effect of age or gender, which is contrary to some previous studies.[21, 24, 25] We did, however, find weak evidence for a modifying effect of age and gender for specific mental health domains: there was some evidence for an age-differential association between alcohol and drug variables and symptoms of hyperactivity, where having tried alcohol or frequent intoxication were more strongly associated with symptoms of hyperactivity for younger adolescents. This could be related to a lower level of cognitive and emotional control in early adolescence compared to at an older age,[43] increasing the susceptibility both to alcohol use, drinking to intoxication and mental health problems.

We also found a gender-differential association between alcohol and drug variables and symptoms of internalizing mental health problems, where boys showed more consistent association between alcohol and drug variables and symptoms of anxiety and depression than girls. Interestingly, we found that, among girls, excessive alcohol consumption was not associated with anxiety and frequent intoxication was not associated with depression. This is contrary to results from a previous Finnish study which found stronger associations between heavy drinking and psychosocial dysfunction among girls than among boys.[25] One factor that may have



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impacted on this relationship is the higher rate of depressive symptoms in girls,[35] and this may be understood in light of the "gender paradox" where the gender with the lowest prevalence rate will be more severely affected.[49] The interpretation of the findings concerning interactions should, however, be done with caution as the number of tested interactions (N=40) were high, and only 17.5% were significant. Future studies should therefore investigate the reported interactions in other study samples.

In the secondary analyses, we found no indication of any curvilinear relationship between alcohol consumption and frequency of intoxication in relation to mental health problems. This is contrary to previous findings,[5-9] predominantly from adult populations, and may be an indication of a differential association between alcohol habits and mental health problems in adolescents versus adults. Also, it may be an indication of cohort-effects, as there is a tendency for lower levels of alcohol consumption and more abstention among adolescents in recent years.[50, 51] Thus, as the abstention group grows, the group also includes more individuals who identify with being abstinent, who have a social network and actively chooses abstinence due to an increased focus on education, career or sports.[52]

Overall, there may be multiple reasons for discrepancies between our findings and previous studies. The recency of our data collection in comparison to a decade or so older comparison studies might have impacted the results, especially with regards to the pattern of drug and alcohol use. Also, the assessment of mental health differs across studies, with most other studies using brief general mental health measures.

**Clinical implications**

The high rate of alcohol and drug use in underaged adolescents, 10 percent having tried illegal substances, as well as a pattern of negative alcohol and drug use characterised by frequent intoxication and drinking large quantities of alcohol, together represent a serious public health concern that emphasizes a need of preventive interventions. The strong co-occurrence of mental health and alcohol and drug related problems suggests that assessment of alcohol and drug use and abuse should become an integral part of mental health assessment and interventions, especially in adolescents with depression and ADHD.

In summary, it seems evident that both alcohol and drug debut, and the frequency and intensity of alcohol consumption are important and relevant indicators of mental health problems among adolescents. Investigation of the causal nature between alcohol/drug abuse and mental health problems, as well as the access to health care and utilisation of health care among adolescents who use alcohol and drugs in hazardous ways should be addressed in future studies.



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**COMPETING INTERESTS**

The authors declare that they have no competing interests.

**AUTHORS' CONTRIBUTIONS**

JCS conceived the initial concept, and performed the initial analyses and literature search. JCS, BS, MH interpreted the initial analyses and wrote the first draft. AJL, KMS and RJ reviewed and revised the initial analyses and first draft, and suggested further analyses, as well as revisions of the first draft. The subsequent drafts were reviewed by all authors, and all authors read and approved the final manuscript. All authors contributed to the revision of the manuscript after peer-review.

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**DATA SHARING STATEMENT**

Data for research projects from the population-based ung@hordaland-study may be made available at request from Regional Centre for Child and Youth Mental Health and Child Welfare, Uni Health, Uni Research, Bergen, Norway.



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Table 1: Patterns of drinking and drug use, and problematic alcohol and drug use (CRAFFT positive) in adolescents born from 1993-1995, stratified for gender. N=9,203 (girls n=4,995, boys n=4,208).

| | Total sample % (95% CI) | Born 1995 % (95% CI) | Born 1994 % (95% CI) | Born 1993 % (95% CI) | Odds ratio for age trend (95% CI) | p-value |
|---|---|---|---|---|---|---|
| **Never consumed alcohol (% yes)** | | | | | | |
| Girls | 20.7 (19.6-21.8) | 31.4 (29.4-33.5) | 19.4 (17.6-21.4) | 6.3 (5.1-7.7) | 0.42 (0.38-0.47) | <.001 |
| Boys | 27.1 (25.7-28.4) | 39.7 (37.4-42.1) | 26.4 (24.2-28.7) | 7.6 (6.1-9.4) | 0.41 (0.37-0.45) | <.001 |
| **Ever tried illicit drugs (% yes)** | | | | | | |
| Girls | 8.8 (8.1-9.6) | 6.1 (5.1-7.3) | 8.2 (7.0-9.6) | 13.7 (11.9-15.6) | 1.57 (1.39-1.77) | <.001 |
| Boys | 12.5 (11.5-13.5) | 10.8 (8.5-11.2) | 10.2 (8.8-11.9) | 18.5 (16.3-21.0) | 1.37 (1.22-1.54) | <.001 |
| **90$^{th}$ percentile alcohol consumption[a] (% yes)** | | | | | | |
| Girls | 7.7 (6.9-8.6) | 6.0 (4.8-7.4) | 7.7 (6.4-9.2) | 9.7 (8.2-11.5) | 1.30 (1.13-1.51) | <.001 |
| Boys | 7.4 (6.5-8.4) | 5.9 (4.6-7.6) | 5.9(5.5-8.5) | 9.6 (7.9-11.6) | 1.31 (1.10-1.55) | =.002 |
| **Frequent intoxication (>10; % yes)[b]** | | | | | | |
| Girls | 20.5 (19.4-21.6) | 10.6 (9.3-12.0) | 19.7 (17.9-21.7) | 36.1 (33.6-38.8) | 2.20 (2.01-2.41) | <.001 |
| Boys | 21.3 (20.1-22.6) | 10.7 (9.3-12.3) | 21.9 (19.9-24.1) | 37.1 (34.2-40.1) | 2.21 (2.00-2.44) | <.001 |
| **CRAFFT positive (≥2; % yes)** | | | | | | |
| Girls | 23.3 (22.2-24.5) | 20.0 (18.3-21.8) | 22.4 (20.5-24.4) | 29.5 (27.1-32.1) | 1.29 (1.19-1.40) | <.001 |
| Boys | 20.3 (19.1-21.5) | 15.8 (14.1-17.6) | 19.3 (17.4-21.4) | 29.0 (26.3-31.8) | 1.47 (1.34-1.62) | <.001 |

95 confidence intervals in parentheses

[a]Only includes those who have tried alcohol (n=7,031).

[b]Only includes those with valid response on frequency of intoxication (n=9,056).

CRAFFT: Screening tool for identification of problematic alcohol and drug use among adolescents.



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Table 2: Logistic regression models of use of alcohol and illicit drugs as risk factor for mental health problems. Mental health variables analysed separately. N=9,203 (girls n=4,995, boys n=4,208).

| | ASRS Inattention Odds ratio (OR) (95CI) | ASRS Hyperactivity OR (95CI) | SMFQ OR (95CI) | SCARED OR (95CI) |
|---|---|---|---|---|
| **Ever consumed alcohol** | | | | |
| Crude | **2.36 (1.90-2.93)** | **2.08 (1.68-2.58)** | **1.73 (1.43-2.09)** | 1.13 (0.94-1.37) |
| Adjusted for age and gender | **2.21 (1.77-2.76)** | **2.07 (1.66-2.58)** | **1.64 (1.35-1.99)** | 1.03 (0.84-1.25) |
| Adjusted for age, gender and socioeconomic status (SES) | **2.15 (1.72-2.69)** | **2.03 (1.62-2.53)** | **1.59 (1.31-1.93)** | 0.99 (0.81-1.21) |
| **Ever tried illicit drugs** | | | | |
| Crude | **2.38 (1.98-2.87)** | **2.26 (1.86-2.74)** | **1.69 (1.39-2.05)** | **1.33 (1.05-1.68)** |
| Adjusted for age and gender | **2.49 (2.06-3.02)** | **2.36 (1.94-2.89)** | **1.98 (1.62-2.42)** | **1.55 (1.23-1.98)** |
| Adjusted for age, gender and SES | **2.42 (2.00-2.93)** | **2.31 (1.90-2.82)** | **1.91 (1.56-2.34)** | **1.50 (1.18-1.91)** |
| **90$^{th}$ percentile alcohol consumption**[a] | | | | |
| Crude | **1.97 (1.55-2.51)** | **2.70 (2.14-3.40)** | **2.19 (1.74-2.75)** | **1.61 (1.21-2.14)** |
| Adjusted for age and gender | **1.96 (1.54-2.50)** | **2.76 (2.19-3.48)** | **2.27 (1.79-2.88)** | **1.64 (1.22-2.19)** |
| Adjusted for age, gender and SES | **1.98 (1.55-2.53)** | **2.77 (2.19-3.49)** | **2.29 (1.80-2.90)** | **1.64 (1.22-2.20)** |
| **Intoxication >10 times**[b] | | | | |
| Crude | **1.83 (1.56-2.15)** | **2.08 (1.77-2.45)** | **1.30 (1.10-1.52)** | 0.95 (0.78-1.16) |
| Adjusted for age and gender | **1.80 (1.52-2.12)** | **2.18 (1.84-2.59)** | **1.36 (1.15-1.61)** | 0.97 (0.79-1.20) |
| Adjusted for age, gender and SES | **1.80 (1.52-2.13)** | **2.17 (1.83-2.58)** | **1.35 (1.14-1.61)** | 0.96 (0.78-1.18) |
| **CRAFFT-positive (≥2)** | | | | |



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| | | | | |
|---|---|---|---|---|
| Crude | **3.15 (2.71-3.66)** | **3.24 (2.78-3.78)** | **2.84 (2.46-3.28)** | **1.68 (1.42-1.99)** |
| Adjusted for age and gender | **3.06 (2.63-3.56)** | **3.22 (2.76-3.77)** | **2.84 (2.45-3.29)** | **1.62 (1.38-1.94)** |
| Adjusted for age, gender and SES | **3.01 (2.59-3.51)** | **3.18 (2.72-3.71)** | **2.80 (2.41-3.25)** | **1.59 (1.34-1.90)** |

Significant associations in bold.
95 confidence intervals in parentheses.
[a]Only includes those who have tried alcohol (n=7,031).
[b]Only includes those with valid response on frequency of intoxication (n=9,056).
CRAFFT: Screening tool for identification of problematic alcohol and drug use among adolescents.
ASRS: Adult ADHD Self-report Scale, screening inventory for attention-deficit-hyperactivity disorder. ASRS Inattention: the inattention sub-scale of the ASRS (9 items). ASRS Hyperactivity: the hyperactivity-impulsivity subscale of the ASRS (nine items).
SMFQ: The short version of the Mood and Feelings Questionnaire, screening inventory for symptoms of depression and depressive disorders.
SCARED: five-item screening inventory for symptoms of anxiety and anxiety disorders.

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Table 3: Table 2: Logistic regression models of use of alcohol and illicit drugs as risk factor for mental health problems, adjusted for age and gender. Mental health variables analysed collectively. N=9,203 (girls n=4,995, boys n=4,208).

| | ASRS inattention Odds ratio (OR) (95CI) | ASRS Hyperactivity Odds ratio (OR) (95CI) | SMFQ Odds ratio (OR) (95CI) | SCARED Odds ratio (OR) (95CI) |
|---|---|---|---|---|
| Ever consumed alcohol | **1.83 (1.44-2.32)** | **1.71 (1.35-2.16)** | **1.45 (1.17-1.78)** | **0.79 (0.64-0.98)** |
| Ever tried illicit drugs | **1.87 (1.50-2.32)** | **1.74 (1.40-2.17)** | **1.48 (1.18-1.86)** | 1.12 (0.86-1.46) |
| 90$^{th}$ percentile alcohol consumption[a] | 1.24 (0.94-1.63) | **2.30 (1.78-2.98)** | **1.88 (1.45-2.44)** | 1.18 (0.86-1.62) |
| Intoxication >10[b] | **1.45 (1.20-1.75)** | **1.95 (1.62-2.35)** | 1.18 (0.98-1.43) | **0.79 (0.63-0.99)** |
| CRAFFT-positive (≥2) | **1.97 (1.66-2.34)** | **2.27 (1.91-2.69)** | **2.17 (1.84-2.55)** | 0.99 (0.82-1.21) |

Significant associations in bold.
95 confidence intervals in parentheses.
[a]Only includes those who have tried alcohol (n=7,031).
[b]Only includes those with valid response on frequency of intoxication (n=9,056).
CRAFFT: Screening tool for identification of problematic alcohol and drug use among adolescents.
ASRS: Adult ADHD Self-report Scale, screening inventory for attention-deficit-hyperactivity disorder. ASRS Inattention: the inattention sub-scale of the ASRS (9 items). ASRS Hyperactivity: the hyperactivity-impulsivity subscale of the ASRS (nine items).
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Table 4: Logistic regression models across alcohol consumption and frequency of intoxication categories, "Never tried alcohol" as reference. Adjusted for age and gender (N=9,203 for alcohol consumption and N=9,056 for frequency of intoxication).

| | ASRS Inattention Odds ratio (OR) (95CI) | ASRS Hyperactivity OR (95CI) | SMFQ OR (95CI) | SCARED OR (95CI) |
|---|---|---|---|---|
| **Categories** | Alcohol consumption categories as independent variable | | | |
| Never consumed alcohol | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| Non-consumption | **1.90 (1.45-2.48)** | **1.46 (1.10-1.93)** | **1.43 (1.12-1.82)** | 1.01 (0.78-1.30) |
| 0.1-19.9$^{th}$ percentile | **1.61 (1.19-2.17)** | **1.69 (1.25-2.27)** | **1.44 (1.11-1.88)** | 1.00 (0.75-1.32) |
| 20.0-79.9$^{th}$ percentile | **2.15 (1.69-2.74)** | **1.99 (1.56-2.55)** | **1.51 (1.21-1.88)** | 0.90 (0.72-1.14) |
| 80.0-89.9$^{th}$ percentile | **3.77 (2.75-5.17)** | **3.56 (2.59-4.91)** | **2.21 (1.62-3.02)** | 1.39 (0.99-1.96) |
| 90.0-100$^{th}$ percentile | **4.16 (3.05-5.68)** | **5.28 (3.91-7.12)** | **3.47 (2.60-4.62)** | **1.60 (1.15-2.23)** |
| p-value for trend | p<0.001 | p<0.001 | p<0.001 | p=0.061 |
| **Categories** | Frequency of intoxication categories as independent variable | | | |
| Never consumed alcohol | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| Never intoxicated | **1.65 (1.24-2.20)** | **1.35 (1.00-1.81)** | **1.30 (1.00-1.67)** | 1.10 (0.85-1.43) |
| Once | **1.71 (1.23-2.38)** | **2.06 (1.50-2.82)** | **1.55 (1.16-2.08)** | 1.02 (0.74-1.39) |
| 2-3 times | **2.00 (1.51-2.63)** | **1.62 (1.21-2.15)** | **1.61 (1.26-2.07)** | 0.88 (0.67-1.16) |
| 4-10 times | **2.49 (1.90-3.26)** | **2.05 (1.55-2.72)** | **1.85 (1.44-2.36)** | 1.05 (0.81-1.38) |
| >10 times | **3.14 (2.43-4.05)** | **3.36 (2.61-4.33)** | **1.95 (1.54-2.47)** | 0.98 (0.76-1.27) |
| p-value for trend | p<0.001 | p<0.001 | p<0.001 | p=0.679 |

Significant associations in comparison to "Never tried alcohol"-category in bold.

ASRS: Adult ADHD Self-report Scale, screening inventory for attention-deficit-hyperactivity disorder. ASRS Inattention: the inattention sub-scale of the ASRS (9 items). ASRS Hyperactivity: the hyperactivity-impulsivity subscale of the ASRS (nine items).

SMFQ: The short version of the Mood and Feelings Questionnaire, screening inventory for symptoms of depression and depressive disorders.

SCARED: five-item screening inventory for symptoms of anxiety and anxiety disorders.



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## Figure legends

Figure 1: Proportion of participants having never consumed alcohol across gender-stratified age groups (N=9,203, girls n=4,995, boys n=4,208). Error bars represent 95% confidence intervals.

Figure 2: Proportion of participants having ever tried illicit drugs across gender-stratified age groups (N=9,203, girls n=4,995, boys n=4,208). Error bars represent 95% confidence intervals.

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**Alcohol and drug use among adolescents - and the co-occurrence of mental health problems. Ung@hordaland, a population-based study.**

Style Definition: Comment Text

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## ABSTRACT

**Objectives:** The use of alcohol and drugs is prevalent among adolescents, but too little is known about the association between debut of alcohol and drug use, problematic use and concurrent mental health. The aim of the study was to investigate the cross-sectional association between debut of any alcohol or drug use and alcohol- and drug-related problems, and mental health. We also wanted to examine potential interactions between gender and age, and alcohol- and drug-related ~~exposures~~variables.

**Design:** Cross-sectional study.

**Setting:** Population-based sample of Norwegian adolescents.

**Participants:** Data stem from the large population-based ung@hordaland study (N=9,203), where all adolescents aged 16-18 years living in Hordaland county (Norway) were invited to participate. The main ~~exposures~~independent variables were debut of alcohol and drug use, alcohol consumption, and presence of alcohol and drug problems as measured by CRAFFT.

**Outcomes:** The ~~outcomes~~dependent variables were self-reported symptoms of anxiety, depression, inattention and hyperactivity. Statistical analyses included logistic regression models.

**Results:** Both debut of alcohol and drug use were associated with symptoms of depression, inattention and hyperactivity (crude ORs 1.69-2.38, Ps<0.001), while only debut of drug use was associated with increased symptoms of anxiety (OR=1.33, CI95%1.05-1.68, P=0.017). Alcohol- and drug-related problems as measured by CRAFFT were associated with all mental health problems (crude ORs 1.68-3.24, Ps<0.001). There was little evidence of any substantial age- or gender confounding on the estimated associations between alcohol- and drug-related measures and the mental health ~~outcomes~~problems.

**Conclusion:** Early debut of alcohol and drug use and drug problems are consistently associated with more symptoms of mental health problems, indicating that these factors are an important general indicator of mental health in adolescence.


## STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study employed a large well-defined population-based sample of adolescents.
- The data employed in this study is from a recent data collection.
- This study included several different measures of alcohol- and drug use, as well as measures of both internalizing and externalizing problems.
- The cross-sectional design of this study precluded any causal inference.
- This study only had a limited age-range~~,~~; a wider range would enable a more thorough investigation of age-related effects of alcohol and drug use.



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**BACKGROUND**

~~The disease burden attributed to alcohol and illicit drug use is considerable worldwide.[1, 2] Alcohol and illicit drug use tend to begin and escalate during adolescence and early adulthood.[3, 4] Early life alcohol and drug patterns are predictive of later use and abuse,[5] and for alcohol it has been shown that a 10% time delay in debut would lead to a 35% decrease in the subsequent expected alcohol consumption .[6]~~

~~Drug~~Previous studies of adolescents have found that a considerable proportion with one mental disorder also meets the criteria for at least one other mental disorder, including substance-use disorder.[1-3] Furthermore, drug use and abuse have been related to a range of mental health problems, most consistently to externalizing problems such as those associated with conduct disorder (CD) and attention-deficit-hyperactivity disorder (ADHD~~), [7]),~~[4] while the increased risk for anxiety disorders are lower. Also of note, several previous studies in adult populations have found that there is a J- or U-shaped relationship between alcohol consumption and mental health outcomes,~~[8-12]~~[5-9] where both abstainers and high-level alcohol consumers have increased risk for mental health problems. Several explanations of this curvilinear relationship have been suggested: moderate alcohol consumers may directly benefit from a protective effect on mental health from alcohol, or their drinking habits may be a mere reflection of their psychological wellbeing.~~[9]~~[6] Also, in cultures where alcohol use is the norm, moderate consumers may be more well-adjusted than individuals at the extremes of the consumption spectrum.~~[13]~~[10] To date, few studies have investigated the relationship between the full spectrum of alcohol consumption (from non-debut to high-level alcohol consumption) and symptoms of mental health problems in a population-based sample of adolescents

~~Boys have an earlier debut of both alcohol consumption and intoxication according to most studies,[3] while the gender-pattern for onset of drug use is more unclear.~~Boys have an earlier debut of both alcohol consumption and intoxication according to most studies,[11] while the gender-pattern for onset of drug use is more unclear.[14-19][12-17] ~~The established gender differences with males using more alcohol and drugs seems, however, to be closing [20] with recent studies not finding a higher rate of drug use among males.[21] If the relation between alcohol and drug use and mental health is gender specific is less clear. A lack of gender difference has been documented in population based studies where the use of alcohol and drugs is associated with worse mental health.~~ The established gender differences with males using more alcohol and drugs seems,

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however, to be closing [18] with recent studies not finding a higher rate of drug use among males.[19] Whether the relation between alcohol and drug use and mental health is gender specific is less clear. A lack of gender difference has been documented in population-based studies where the use of alcohol and drugs is associated with worse mental health.~~[22-25]~~[20-23] In contrast, some studies have reported a modifying effect of gender and age in relation to the association between alcohol use and mental health.~~[23, 26, 27]~~[21, 24, 25] For instance, a ~~recent~~ study investigating the association between alcohol intoxications and mental health problems among 13-19-year-olds found that high level alcohol consumption was associated with conduct and attention problems for both genders, but only the girls who reported frequent ~~intoxications~~intoxication reported more symptoms of anxiety and depression.~~[23]~~[21] On the other hand, Verdurmen and colleagues reported a modifying effect of age on the association between alcohol use and mental health, but found no evidence of any modifying effects of gender.~~[26]~~[24] The association between alcohol use and mental health is, however, not quite consistent, as a Dutch study did not confirm the expected relation between binge drinking and mental health problems among 16-18-years-olds in a population based study.~~[28]~~[26]. Furthermore, most of the previous studies have focused on drug and alcohol use, whereas less is known about the relationship between mental health and debut in adolescence.

In general, the mental health problems show a consistent gender pattern in adolescence, with girls having a higher rate of depression and internalizing problems, and boys a higher rate of externalising disorders.[1] Less is known whether the associations between the drug use and mental health is gender-specific, but there are some indications that co-occurrence of other mental health problems are higher for girls than boys.~~[7]~~[4] However, in a sample of late adolescent urban youth gender did not have a moderating effect on the relationship between substance abuse and mental health, and a Finnish study did not support a gender specific association between depression and substance use.~~[21] These studies are rather small, and the results may have been hampered by lack of statistical power. It is also uncertain if the co-occurrence is specifically related to alcohol or drug dependence or~~[19, 27]

Also, it is uncertain if the co-occurrence is specifically related to alcohol or drug dependence or if it is also evident for mere alcohol or drug use.~~[7]~~[4] Overall, there is still a need for further investigation of the association between early alcohol and drug use and mental health in a general population of adolescents.~~[29]~~[28]

To that end, the aim of the present study was to

i) Describe the debut of alcohol and drug use, alcohol use patterns and potential drug problems among Norwegian adolescents using data from a recent population-based study.



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ii) To investigate the cross-sectional relationship between a) alcohol and illicit drug use and b) alcohol and drug problems and mental health among adolescents. We also investigated any interactions with age and gender on the associations of interest, as well as the association between the full spectrum of alcohol consumption and ~~binge~~frequency of drinking ~~frequency~~to intoxication in relation to mental health.

## METHODS

### Study population

This study employed information from the ung@hordaland-~~survey ("youth@hordaland")~~study of adolescents in the county of Hordaland in western Norway. All ~~adolescent~~adolescents born 1993-1995 living in Hordaland were invited to participate~~.~~ (n=19,430), and 10,220 participated, yielding a participation rate of 53%. Ung@hordaland is a population-based study, ~~and~~ carried out in close collaboration with the county council administration. The ~~majority~~fourth wave of ~~participants responded to~~ the ~~questionnaires during school hours~~longitudinal population-based study "Bergen Child Study" is also nested within ung@hordaland. The general aim of the ung@hordaland-survey was to assess mental health, lifestyle, school performance and health-service use in adolescents, with a special emphasis on the prevalence of mental health problems. The data was collected during January-February 2012. Adolescents in upper secondary education received information per e-mail, and one school hour was allocated for them to complete the questionnaire at school. Those not in school received information by mail to their home addresses. In addition, mental health facilities, juvenile detention centres and other institutions were contacted and the adolescents had the opportunity to participate. The questionnaire was web-based and covered a broad range of mental health issues, daily life functioning, use of health and social services, and demographic background variables~~, and a request for permission to obtain school data, and to link the information with national registries and parental questionnaires. Uni Health and Hordaland County Council are collaborating partners in conducting the study.~~. Upon participation electronic informed consent was obtained. The study was approved by The Regional Committee for Medical Research Ethics in Western Norway. ~~After complete description~~Hordaland County is generally regarded representative of Norway as a whole, comprising both the second largest city of Norway (Bergen), as well as large rural areas. Official statistics of the general population (not just adolescents) show that Hordaland County does not deviate in any

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substantial degree from the ~~study to the subjects, written informed consent was obtained~~national average on key parameters, including both socio-demographic indicators and several health indicators.

The current study is based on the first version of data files released in May 2012, with a total of 10,220 participants. Based on list-wise deletion of those with missing information on both ~~exposures~~independent and ~~outcomes~~dependent variables, n=1,017 were excluded, leaving 9,203 in the final study sample. Those with missing information on the ~~exposures and the outcomes,~~variables of interest were slightly younger than those with valid information on the included variables (mean difference 0.12 years, p<.001) and more likely to be males (61.6% versus 45.7% in the analysed sample, p<.001).

**Demographic information**

Information about age and gender was obtained on all participants. Furthermore, the participants indicated the perceived family socioeconomic status (SES) as i) "about the same as others" (67.9%), ii) "better than others" (25.1%) or iii) "worse than others" (7.1%), with n=172 missing responses recoded to "about the same as others".

**Identification of alcohol problems and illicit drug use**

Self-reported debut, frequency and amount of alcohol consumption and illicit drug use were included as main ~~exposure~~independent variables. We included a binary measure of alcohol debut "Have you ever tried alcohol?" (Yes/No), and illicit drug use debut: "Have you ever tried hash, marihuana or other narcotic substances?" (Yes/No). Out of the total study sample, n=11 individuals did not answer the question on illicit drug use, and they were recoded to the "No" category. Alcohol use was measured using the self-reported units of beer, cider, wine, spirits and illegally distilled spirits usually consumed during the last 14 days. Based on this information about consumption and alcohol debut, a summed variable ~~including the following~~on gender-specific ~~distribution~~distributions was constructed: "Never tried", "Non-consumption" (if reported consumption was "0"), "0.1-19.9$^{th}$", "20.0-~~39.9$^{th}$", "40.0-59.9$^{th}$", "60.0-~~79.9$^{th}$", "80.0-89.9$^{th}$", "90.0-100$^{th}$". Excessive alcohol consumption was defined as above the 90$^{th}$ percentile sum score.~~[11, 30] Frequent binge drinking~~[8, 29] Frequent intoxication (binge drinking) was defined as drinking so much that one was clearly intoxicated more than 10 times, based on the question: "Have you ever consumed so much alcohol that you were clearly intoxicated (drunk)?", with five categories ranging from "No, never" to "Yes, more than 10 times". There were n=147 missing responses on the ~~binge drinking~~intoxication item, leaving a sample of N=9,056 for this measure. In addition, potential alcohol and drug problems were identified employing the six-item inventory

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CRAFFT.[31][30] CRAFFT was specifically designed to identify alcohol and illicit drug problems among adolescents,[31][30] and have been shown to have acceptable sensitivity and specificity at a cut-off of >=2 in international studies.[32, 33][31, 32] In relation to the ung@hordaland sample, a linear relationship between CRAFFT-score and excessive alcohol consumption, binge drinkingfrequency of intoxication and debut of illicit drug use has previously been reported.[33] [32] In the current study, 28.4% of those having tried alcohol were CRAFFT-positive, while 61.1% of those having tried illicit drugs were CRAFFT-positive.

**Mental health problems**

Symptoms of depression, anxiety and ADHD were included as the main dependent variables. Depression was assessed using the short version of the Mood and Feelings Questionnaire (SMFQ).[34][33] The SMFQ comprises 13 items assessing depressive symptoms rated on a 3-point scale. The wordings of the response categories in the Norwegian translation equal the original categories of "Not true", "Sometimes true" and "True". High internal consistency between the items and a strong unidimensionality have been shown in population-based studies,[35][34] and was recently confirmed in a study based on the sample included in the present study.[36][35] For the purposes of the current study, depression was defined as a score above the 90$^{th}$ percentile of the Total SMFQ-score. It should be noted that term depression as used in the current study does not imply existence of a clinical diagnosis, such as MDD. Also, being a relatively brief self-report questionnaire, the SFMQ does not differentiate between different types of depressive disorders/conditions. The Cronbach's alpha of the SMFQ in the ung@hordaland-sample was 0.91.

Symptoms of anxiety was identified using the five-item inventory SCARED, which is short-form of the 41-item version screening inventory for anxiety disorders.[3736] The short-form of the SCARED has showed similar psychometric properties to the full version.

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Symptoms of inattention and hyperactivity were measured using sub-scores from the official Norwegian translation of the Adult ADHD Self-report Scale (ASRS),[38][37] originally constructed for use in adults, but recently validated among adolescents.[39][38] ASRS is an 18-item self-report scale, comprising 9 items on a hyperactivity-impulsivity subscale and 9 items on an inattention-subscale. The responses are given on a 5-point scale (ranging from "Never" to "Very often").

**Statistical analysis**



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Five different alcohol and drug-related binary variables were constructed as main ~~exposures: Ever~~independent variables: ever consumed alcohol (Yes/No), ever tried illicit drugs (Yes/No), those reporting ≥$90^{th}$ gender-specific percentile alcohol consumption (Yes/No), ~~binge drinking~~intoxication >10 times (Yes/No) and CRAFFT-~~caseness~~positive according to the ≥2 cutoff (Yes/No). For ~~outcome~~dependent variables the mental health questionnaires were dichotomised at the $90^{th}$ percentile, identifying those with high sum scores on the ASRS subscales of inattention (raw score range for cut-point 24-36, mean 27.2) and hyperactivity-impulsivity~~,~~ (raw score range for cut-point 20-36, mean 22.9), the SMFQ scale of depression (raw score range for cut-point 15-26, mean 19.3) and the SCARED scale of anxiety~~.~~ (raw score range for cut-point 5-10, mean 6.2).

~~First, the sample was described in relation to exposures stratified for age and gender. Second, odds ratios were computed using simple logistic regression models for the associations between exposures and outcomes, as well as logistic regression models adjusted for age and gender. In addition,~~First, the sample was described in relation to the independent variables, stratified for age and gender. Second, odds ratios were computed using crude logistic regression models for the associations of interest, as well as logistic regression models adjusted for age and gender, and then adjusted for age, gender and SES, with mental health variables both analysed separately, and collectively (i.e. entered into the same logistic regression model). In addition, as previous studies have shown differential age- and gender effects in the development of both mood disorder, anxiety disorder, behaviour disorder and substance use disorders among adolescents,[1] we investigated the potential two-way interaction with age and gender for the alcohol- and drug-related ~~exposures~~variables in relation to mental health problems. The presence of significant interactions was assessed using likelihood-ratio tests (Wald~~), and when~~). When significant interactions were identified, the associations of interest were presented stratified for age or gender. In secondary analyses, we investigated the association between the spectrum of alcohol consumption ("Never tried alcohol", "Non-consumption", "0.1-19.9$^{th}$", "20.0-~~39.9$^{th}$", "40.0-59.9$^{th}$", "60.0-~~79.9$^{th}$", "80.0-89.9$^{th}$", "90.0-100$^{th}$") and ~~binge drinking~~frequency of intoxication ("Never tried alcohol", "Never intoxicated", "Once", "2-3 times", 4-10 times" and ">10 times") categories separately for all mental health variables, employing age- and gender-adjusted logistic regression models with "Never tried" as reference group. All analyses were performed using Stata 12.0.~~[40]~~[39] Due to missing information on the frequency of intoxication question, the analyses involving this variable only included n=9,056 participants. Frequency of intoxication was included as an independent variable in order to retain as much information as possible.



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**RESULTS**

The final sample consisted of N=9,203 participants, where 54.3% were female and the mean age was 17.9 (SD 0.8) years. Table 1 and Figure 1 show the use of alcohol and illicit drugs stratified by age and gender. A total of 20.7% of the girls and 27.1% of the boys had *not* tried alcohol, whereas 8.8% of the girls and 12.5% of the boys *had* tried any illicit drug. Among the participants aged 17, 35.3% had *not* tried alcohol, compared to 16.0% aged 18 or more (p<0.001). Also, ~22% percent of the sample ~~was~~were CRAFFT-~~cases~~positive, indicating some alcohol- or drug-related problem. There was a significant age-trend for all ~~exposures~~independent variables for both genders, where increasing age was associated with increased proportion of participants having tried alcohol or illicit drugs, as well as reporting alcohol- and drug-related problems (p-values ranging from: 0.002 to <0.001).

Table 2 depicts the crude ~~and~~, age- and gender-adjusted, and age-, gender- and SES-adjusted associations between having tried alcohol, illicit drugs or reporting alcohol- and drug-related problems, in relation to mental health problems. Having ever consumed alcohol was associated with increased odds of all mental health problems in both crude and age- and gender-adjusted models, except for symptoms of anxiety (crude ORs ranging from 1.13 to 2.36). Having ever tried illicit drugs was associated with increased odds of all mental health problems in both crude and age- and gender-adjusted models (crude ORs ranging from 1.33 to 2.38). In relation to alcohol- and drug-related problems, being CRAFFT-~~caseness~~positive was associated with increased odds of all mental health problems in both the crude and the age- and gender-adjusted model (crude ORs ranging from 1.68 to 3.24). Excessive alcohol consumption was associated with all mental health problems in both crude and age- and gender-adjusted models (crude ORs ranging from 1.61 to 2.70). ~~Binge-drinking more than 10 times~~Frequent intoxication was associated with increased symptoms of depression, inattention and hyperactivity in both regression models, but not with symptoms of anxiety (ORs ranging from 0.95 to 2.08). Further adjustment for self-reported perceived family SES only slightly altered the estimated associations.

~~Table 3 shows the p-values of the~~Table 3 shows the age- and gender-adjusted associations between having tried alcohol, illicit drugs or reporting alcohol- and drug-related problems, in relation to mental health problems analysed collectively. Entering all of the mental health variables into the same logistic regression model substantially attenuated the associations of interest, but the pattern of associations were similar to entering them separately.

For the most part, no two-way age- and gender-interactions across use of alcohol and illicit drugs and mental health problems~~. For the most part, no interactions~~ were found; only seven out 40 (17.5%) investigated



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interactions were statistically significant~~.~~ (data not shown). For age, significant interactions were found with having ever consumed alcohol and frequent ~~binge drinking~~intoxication in relation to hyperactivity (p=0.002 and p=0.025, respectively). In the age-stratified analyses having ever tried alcohol was associated with increased levels of hyperactivity for 17-year-olds (OR=2.53, CI95% 1.88-3.43) and 18-year-olds (OR=2.34, CI95% 1.57-3.48), but not for 19-year-olds (OR=0.79, CI95% 0.47-1.34). Frequent ~~binge drinking~~intoxication was associated with increased levels of hyperactivity for all age-groups, ~~but~~ more strongly among 17- (OR=2.56, CI95% 1.88-3.47) and 18-year-olds (OR=2.54, CI95% 1.93-3.34) than for 19-year-olds (OR=1.55, CI95% 1.16-2.08).

For gender, significant interactions were found with having ever tried illicit drugs and excessive alcohol consumption in relation to symptoms of anxiety (p=0.021 and p<0.001, respectively), excessive alcohol consumption and symptoms of hyperactivity (p=0.021), and with ~~binge drinking~~frequent intoxication and excessive consumption and symptoms of depression (p=0.027 and p=0.018, respectively). In the gender-stratified analyses, having ever tried illicit drugs and reporting excessive consumption were associated with increased symptoms of anxiety for boys (OR=2.44, [CI95% 1.57-3.78] and OR=4.36 [CI95% 2.52-7.57], respectively), but not for girls (OR=1.30 [CI95% 0.98-1.73] and OR=1.23 [CI95% 0.87-1.73], respectively). The same pattern was evident for depression, where frequent ~~binge drinking~~intoxication was associated with increased symptoms ~~in~~among boys (OR=1.83, CI95%1.32-2.52) but not for girls (OR=1.19, CI95% 0.98-1.44). Excessive alcohol consumption was associated with increased symptoms of hyperactivity and depression, more strongly for boys (OR=3.78 [CI95% 2.65-5.40] and OR=3.57 [CI95% 2.32-5.51], respectively) than girls (OR=2.17 [CI95% 1.60-2.94] and OR=1.89 [CI95% 1.43-2.49], respectively).

Table 4 shows the associations between alcohol consumption and ~~binge drinking~~frequency of intoxication categories with never having tried alcohol as reference. For symptoms of inattention, hyperactivity and depression there was a trend towards more symptoms of mental health problems with increasing levels of usual consumption and higher frequency ~~for binge drinking~~of intoxication (all p<0.001). This trend was not found for symptoms of anxiety where there were no associations with ~~binge drinking~~intoxication categories (p-value for trend: 0.679) and alcohol consumption categories (p-value for trend: 0.~~058~~061). The only significant difference was found with excessive alcohol consumption (90$^{th}$ percentile) compared to never having tried alcohol (OR=1.60, CI95%1.15-2.23).

**DISCUSSION**



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**Main findings**

In sum, most adolescents aged 17 to 19 had tried alcohol and one-fifth of the girls and one-fourth of the boys had tried some illicit drug. Also, twenty percent of the adolescents reported some alcohol- or drug-related problems, as indicated by 2 or more points on the CRAFFT-questionnaire. There was a clear positive age-trend for having tried both alcohol and illicit drugs for both boys and girls, and debut of alcohol and illicit drug use was associated with mental health problems for both genders. Having tried illicit drugs, excessive alcohol consumption and being CRAFFT-~~caseness~~positive were associated with all mental health problems. No J- or U-shaped association was found for alcohol consumption or ~~binge drinking~~frequency of intoxication in relation to any of the mental health problems included in this study. ~~–~~There was ~~weak~~no clear evidence of any substantial age~~- or -~~, gender- or SES-confounding or ~~interaction~~modifying effect of age and gender on the estimated association between alcohol- and drug-related measures and mental health problem. Moreover, a closing gender gap on alcohol and drug use was supported.

**Strengths and limitations**

The current study holds several strengths. Firstly, it is a large well-defined population-based sample of adolescents. The sample size enabled the investigation of both main effects and potential interaction effects of age and gender. Secondly, the data collection is recent ~~which~~and allows for an updated and contemporary insight into the current status of alcohol- and drug use, presence of potential alcohol- and drug use problems, and associations with mental health problems. Thirdly, the study included different measures of alcohol- and drug use, as well as the validated CRAFFT-questionnaire for alcohol- or drug-related problems. Fourthly, we included measures of internalizing and externalizing mental health problems, using well-validated questionnaires measuring symptoms of depression and anxiety, as well as hyperactivity and inattention symptoms that are part of the ADHD-diagnosis.

The current study has also some limitations. Firstly, the study is cross-sectional, and this precludes any causal inference of the estimated associations. Previous findings indicate that mental health problems can be a consequence of alcohol- and drug use, be a risk factor for alcohol- and drug use or that both are influenced by a common cause.~~[41-43]~~[40-42] Secondly, the age-range included in the present study is limited, and a wider range would enable a more thorough investigation of age-related effects of alcohol and drug use, and probably also increase the chances of finding any moderating effects of age.~~[44] Thirdly, both data on exposures and outcomes were self-reported, which could lead to common methods bias and bias in reporting, especially~~



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~~underreporting for the exposures.~~[43] Thirdly, both data on the independent and dependent variables were self-reported, which could lead bias in reporting, especially underreporting for the independent variables. Fourthly, due to missing information, almost ten percent of the total eligible study population was not included in our analyses. The attrition from the current study could affect generalizability, and result in adolescents attending school being overrepresented. ~~Although no data on non-responders were available in the current wave of the Bergen Child Study, previous research from the former waves of the Bergen Child Study have shown that non-participants tend~~The problem with non-participation in survey research seems unfortunately to be on the rise.[44] Official data show that in 2012, 92% of all adolescents in Norway aged 16-18 attended high school,[45] compared to 98% in the current study. Based on previous research from the former waves of the Bergen Child Study (the nested within the current study), non-participants have also been shown to have more psychological problems than participants.~~[45]~~[46] It is therefore likely that the prevalence of mental health problems is underestimated in the current study. This could suggest that the non-responders also have a higher alcohol and drug consumption, which could bias our sample further. This non-participation bias is, however, not likely to reduce the associations of interest substantially.~~[46]~~[47] Finally, the assessment of illicit drug does not indicate type of drug tried and frequency, thus limiting conclusions drawn according to the relation between mental health and more specific drugs or consumption patterns. Lastly, the study is based on self-reported questionnaires assessing symptoms of both alcohol and drug problems and mental health problems, and multiple information would have been have been preferable to reduce informant bias and common method bias. Also, self-reported questionnaires do not provide information regarding the existence of a clinical diagnosis, and the lack of a clinical interview in confirming a formal diagnosis is a limitation of the present study.

**Interpretation**

The closing gender gap reported in previous studies~~,~~ was partly confirmed by the present study.~~[20]~~[18] Even though more girls in the younger age group had tried alcohol, boys showed a pattern of trying illegal drugs more often and there were more boys with problems related to alcohol and drug use, while there were no differences in patterns of problem drinking and ~~binge drinking.~~frequency of intoxication. The expected age pattern was confirmed with both more alcohol and drug use and ~~binge drinking~~frequent intoxication with increasing age. 18 years is the legal age when adolescents can buy alcohol in Norway, and thus an increase in alcohol use at this age is as expected. In the 19-years-olds more than a third reported ~~binge~~ drinking to intoxication. Even though

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this is a lower rate than reported in a previous population-based Norwegian study ~~,[23]~~[21] our findings suggest that this negative alcohol use pattern is ~~highly~~ frequent among Norwegian adolescents.

There was strong evidence for a co-occurrence of alcohol and drug problems and mental health problems among adolescents, consistent with findings in previous studies.~~[7, 25]~~[4, 23] While most studies have focused on drug abuse, we also found that even having tried alcohol or drugs in this age group are potential indicators of mental health problems for both genders. Due to the cross-sectional design of this study, we could not investigate direction of causality. But the relationship between alcohol and drug use and mental health problems in adolescence is probably complex and multidirectional.~~[24, 47]~~[22, 48] For instance, mental health problems like impulsivity and hyperactivity may possibly render an adolescent susceptible for using alcohol, but these problems may also be exacerbated by alcohol and drug use. There may also be common etiological factors that accounts for both an increased risk of mental health problems and alcohol consumption, such as parental alcohol use or social peer network. While both ADHD and depressive symptoms were consistently related to alcohol and drug use and abuse, the co-occurrence of these disorders may have impacted the association. In line with this the strength of the association was attenuated when including all of the mental health variables, while the pattern was similar and the associations were still significant. Thus, while co-occurrence of symptoms is frequent, both depressive and ADHD symptoms seems to have an independent contribution to the association between mental health and alcohol and drug use.

In general, we found little evidence of a substantial modifying effect of age or gender, which is contrary to some previous studies.~~[23, 26, 27]~~[21, 24, 25] We did, however, find weak evidence for a modifying effect of age and gender for specific mental health domains: there was some evidence for an age-differential association between alcohol and drug ~~exposures~~variables and symptoms of hyperactivity, where having tried alcohol or frequent ~~binge drinking~~intoxication were more strongly associated with symptoms of hyperactivity for younger adolescents. This could be related to a lower level of cognitive and emotional control in early adolescence compared to at an older age,~~[44] increasing the susceptibility both to alcohol use, binge drinking and mental health problems.~~[43] increasing the susceptibility both to alcohol use, drinking to intoxication and mental health problems.

We also found a gender-differential association between alcohol and drug ~~exposures~~variables and symptoms of internalizing mental health problems, where boys showed more consistent association between ~~exposures~~alcohol and drug variables and symptoms of anxiety and depression than girls. Interestingly, we found that, among girls, excessive alcohol consumption was not associated with anxiety and frequent ~~binge~~



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drinkingintoxication was not associated with depression. This is contrary to results from a previous Finnish study which found stronger associations between heavy drinking and psychosocial dysfunction among girls than among boys.[27] One factor that may have impacted on this relation is the higher rate of depressive symptoms in girls,[25] One factor that may have impacted on this relationship is the higher rate of depressive symptoms in girls,[36][35] and this may be understood in light of the "gender paradox" where the gender with the lowest prevalence rate will be more severely affected.[48] [49] The interpretation of the findings concerning interactions should, however, be done with caution as the number of tested interactions (N=40) were high, and only 17.5% were significant. Future studies should therefore investigate the reported interactions in other study samples.

In the secondary analyses, we found no indication of any curvilinear relationship between alcohol consumption and frequency of binge drinkingintoxication in relation to mental health problems. This is contrary to previous findings,[8-12][5-9] predominantly from adult populations, and may be an indication of a differential association between alcohol habits and mental health problems in adolescentadolescents versus in an adult populationadults. Also, it may be an indication of cohort-effects, as there is a tendency for lower levels of alcohol consumption and more abstention among adolescents in recent years.[4, 49][50, 51] Thus, as the abstention group grows, the group also includes more individuals who identify with being abstinent, who have a social network and actively chooses abstinence due to an increased focus on education, career or sports.[5052]

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Overall, there may be multiple reasons for discrepancies between our findings and previous studies. The recency of our data collection in comparison to a decade or so older comparison studies might have impacted the results, especially with regards to the pattern of drug and alcohol use. Also, the assessment of mental health differs across studies, with most other studies using brief general mental health measures.

**Clinical implications**

The high rate of alcohol and drug use in underageunderaged adolescents, 10 percent having tried illegal substances, as well as a pattern of negative alcohol and drug use characterised by binge frequent intoxication and drinking and large quantities of alcohol, together represent a serious public health concern that emphasizes a need of preventive interventions. The strong co-occurrence of mental health and alcohol and drug related problems suggestsuggests that assessment of alcohol and drug use and abuse should become an integral part of mental health assessment and interventions, especially in adolescentadolescents with depression and ADHD.



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In summary, it seems evident that both alcohol and drug debut, and the frequency and intensity of alcohol consumption are important and relevant indicators of mental health problems among adolescents. Investigation of the causal nature between alcohol ~~and /~~drug ~~use,~~abuse and mental health problems, as well as the access to health care and utilisation of health care among adolescents who use alcohol and drugs in hazardous ways should be addressed in future studies.

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## COMPETING INTERESTS

The authors declare that they have no competing interests.

## AUTHORS' CONTRIBUTIONS

JCS conceived the initial concept, and performed the initial analyses and literature search. JCS, BS, MH interpreted the initial analyses and wrote the first draft. AJL, KMS and RJ reviewed and revised the initial analyses and first draft, and suggested further analyses, as well as revisions of the first draft. The subsequent drafts were reviewed by all authors, and all authors read and approved the final manuscript. All authors contributed to the revision of the manuscript after peer-review.

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Figure 1: Proportion of participants having ever consumed alcohol and tried illicit drugs across gender-stratified age groups (N=9,203, girls n=4,995, boys n=4,208). Error bars represent 95% confidence intervals.

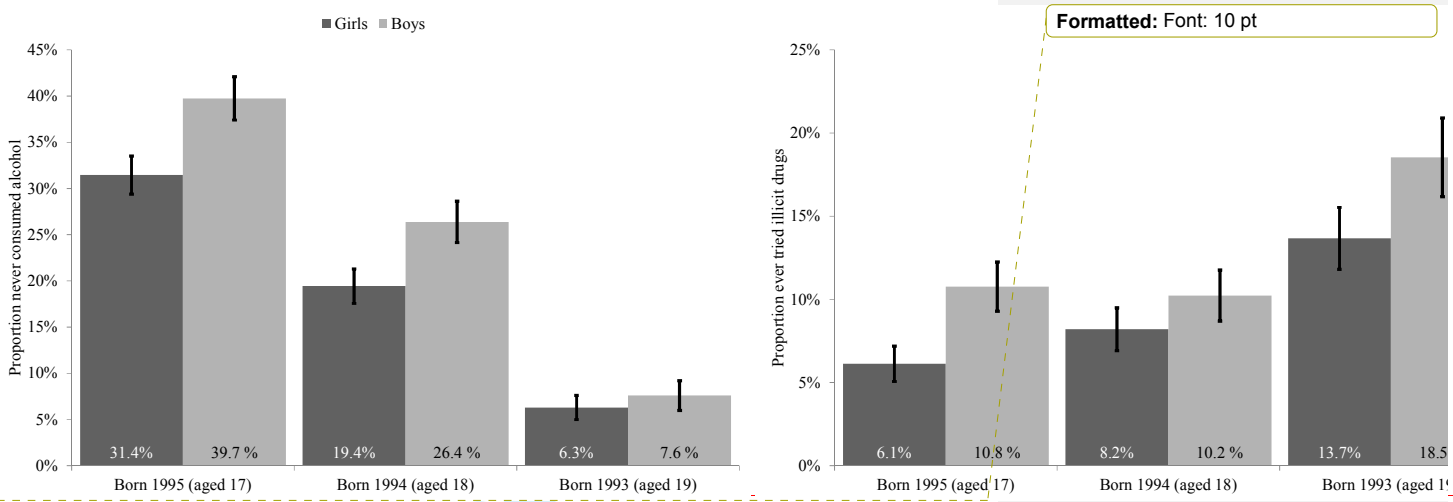


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Table 1: ~~Description~~Patterns of ~~abstention,~~ drinking ~~pattern, CRAFFT caseness~~and drug use, and problematic alcohol and drug use ~~across age cohorts~~(CRAFFT positive) in adolescents born from 1993-1995, stratified for gender. N=9,203 (girls n=4,995, boys n=4,208).

| | Total sample % (95% CI) | Born 1995 % (95% CI) | Born 1994 % (95% CI) | Born 1993 % (95% CI) | Odds ratio for age trend (95% CI) | p-value |
|---|---|---|---|---|---|---|
| **Never consumed alcohol (% yes)** | | | | | | |
| Girls | 20.7 (19.6-21.8) | 31.4 (29.4-33.5) | 19.4 (17.6-21.4) | 6.3 (5.1-7.7) | 0.42 (0.38-0.47) | <.001 |
| Boys | 27.1 (25.7-28.4) | 39.7 (37.4-42.1) | 26.4 (24.2-28.7) | 7.6 (6.1-9.4) | 0.41 (0.37-0.45) | <.001 |
| **Ever tried illicit drugs (% yes)** | | | | | | |
| Girls | 8.8 (8.1-9.6) | 6.1 (5.1-7.3) | 8.2 (7.0-9.6) | 13.7 (11.9-15.6) | 1.57 (1.39-1.77) | <.001 |
| Boys | 12.5 (11.5-13.5) | 10.8 (8.5-11.2) | 10.2 (8.8-11.9) | 18.5 (16.3-21.0) | 1.37 (1.22-1.54) | <.001 |
| **90th percentile alcohol consumption[a] (% yes)** | | | | | | |
| Girls | 7.7 (6.9-8.6) | 6.0 (4.8-7.4) | 7.7 (6.4-9.2) | 9.7 (8.2-11.5) | 1.30 (1.13-1.51) | <.001 |
| Boys | 7.4 (6.5-8.4) | 5.9 (4.6-7.6) | 5.9(5.5-8.5) | 9.6 (7.9-11.6) | 1.31 (1.10-1.55) | =.002 |
| **Frequent intoxication (>10; % yes)[b]** | | | | | | |
| Girls | 20.5 (19.4-21.6) | 10.6 (9.3-12.0) | 19.7 (17.9-21.7) | 36.1 (33.6-38.8) | 2.20 (2.01-2.41) | <.001 |
| Boys | 21.3 (20.1-22.6) | 10.7 (9.3-12.3) | 21.9 (19.9-24.1) | 37.1 (34.2-40.1) | 2.21 (2.00-2.44) | <.001 |
| **CRAFFT positive (≥2; % yes)** | | | | | | |
| Girls | 23.3 (22.2-24.5) | 20.0 (18.3-21.8) | 22.4 (20.5-24.4) | 29.5 (27.1-32.1) | 1.29 (1.19-1.40) | <.001 |
| Boys | 20.3 (19.1-21.5) | 15.8 (14.1-17.6) | 19.3 (17.4-21.4) | 29.0 (26.3-31.8) | 1.47 (1.34-1.62) | <.001 |

95 confidence intervals in parentheses

[a]Only includes those who have tried alcohol (n=7,031).

[b]Only includes those with valid response on

| ~~Total sample (95% CI)~~ | ~~Born 1995 (95% CI)~~ | ~~Born 1994 (95% CI)~~ | ~~Born 1993 (95% CI)~~ | ~~OR for age trend (95% CI)~~ | ~~p-value~~ |
|---|---|---|---|---|---|
| **~~Never consumed alcohol (yes%)~~** | | | | | |
| ~~Girls~~ | ~~20.7% (19.6-21.8)~~ | ~~31.4% (29.4-33.5)~~ | ~~19.4% (17.6-21.4)~~ | ~~6.3% (5.1-7.7)~~ | ~~0.42 (0.38-0.47)~~ | ~~<.001~~ |
| ~~Boys~~ | ~~27.1% (25.7-28.4)~~ | ~~39.7% (37.4-42.1)~~ | ~~26.4% (24.2-28.7)~~ | ~~7.6% (6.1-9.4)~~ | ~~0.41 (0.37-0.45)~~ | ~~<.001~~ |



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| | | | | | | |
|---|---|---|---|---|---|---|
| **Ever tried illicit drugs (yes%)** | | | | | | |
| Girls | 8.8% (8.1-9.6) | 6.1% (5.1-7.3) | 8.2% (7.0-9.6) | 13.7% (11.9-15.6) | 1.57 (1.39-1.77) | <.001 |
| Boys | 12.5% (11.5-13.5) | 10.8% (8.5-11.2) | 10.2% (8.8-11.9) | 18.5% (16.3-21.0) | 1.37 (1.22-1.54) | <.001 |
| **90th percentile alcohol consumption[a] (yes%)** | | | | | | |
| Girls | 7.7% (6.9-8.6) | 6.0% (4.8-7.4) | 7.7% (6.4-9.2) | 9.7% (8.2-11.5) | 1.30 (1.13-1.51) | <.001 |
| Boys | 7.4% (6.5-8.4) | 5.9% (4.6-7.6) | 5.9%(5.5-8.5) | 9.6% (7.9-11.6) | 1.31 (1.10-1.55) | =.002 |
| **Binge drinking (>10; yes%)[b]** | | | | | | |
| Girls | 20.5% (19.4-21.6) | 10.6% (9.3-12.0) | 19.7% (17.9-21.7) | 36.1% (33.6-38.8) | 2.20 (2.01-2.41) | <.001 |
| Boys | 21.3% (20.1-22.6) | 10.7% (9.3-12.3) | 21.9% (19.9-24.1) | 37.1% (34.2-40.1) | 2.21 (2.00-2.44) | <.001 |
| **CRAFFT positive (≥2; yes%)** | | | | | | |
| Girls | 23.3% (22.2-24.5) | 20.0% (18.3-21.8) | 22.4% (20.5-24.4) | 29.5% (27.1-32.1) | 1.29 (1.19-1.40) | <.001 |
| Boys | 20.3% (19.1-21.5) | 15.8% (14.1-17.6) | 19.3% (17.4-21.4) | 29.0% (26.3-31.8) | 1.47 (1.34-1.62) | <.001 |

95% confidence intervals in parentheses
frequency of intoxication (n=9,056).
CRAFFT: Screening tool for identification of problematic alcohol and drug use among adolescents.

[a]Only includes those who have tried alcohol (n=7,031).
[b]Only includes those with valid response on binge drinking (n=9,056).



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Table 2: Logistic ~~regressions~~regression models of use of alcohol and illicit drugs as risk factor for mental health problems. Mental health variables analysed separately. N=9,203 (girls n=4,995, boys n=4,208).

| | ~~ASRS Inattention OR (95%CI)~~ ASRS Inattention Odds ratio (OR) (95CI) | ~~ASRS Hyperactivity OR (95%CI)~~ ASRS Hyperactivity OR (95CI) | ~~SMFQ OR (95%CI)~~ SMFQ OR (95CI) | ~~SCARED OR (95%CI)~~ SCARED OR (95CI) |
|---|---|---|---|---|
| **Ever consumed alcohol** | | | | |
| Crude | **2.36 (1.90-2.93)** | **2.08 (1.68-2.58)** | **1.73 (1.43-2.09)** | 1.13 (0.94-1.37) |
| Adjusted for age and gender | **2.21 (1.77-2.76)** | **2.07 (1.66-2.58)** | **1.64 (1.35-1.99)** | 1.03 (0.84-1.25) |
| Adjusted for age, gender and socioeconomic status (SES) | **2.15 (1.72-2.69)** | **2.03 (1.62-2.53)** | **1.59 (1.31-1.93)** | 0.99 (0.81-1.21) |
| **Ever tried illicit drugs** | | | | |
| Crude | **2.38 (1.98-2.87)** | **2.26 (1.86-2.74)** | **1.69 (1.39-2.05)** | **1.33 (1.05-1.68)** |
| Adjusted for age and gender | **2.49 (2.06-3.02)** | **2.36 (1.94-2.89)** | **1.98 (1.62-2.42)** | **1.55 (1.23-1.98)** |
| Adjusted for age, gender and SES | **2.42 (2.00-2.93)** | **2.31 (1.90-2.82)** | **1.91 (1.56-2.34)** | **1.50 (1.18-1.91)** |
| **90$^{th}$ percentile alcohol consumption**[a] | | | | |
| Crude | **1.97 (1.55-2.51)** | **2.70 (2.14-3.40)** | **2.19 (1.74-2.75)** | **1.61 (1.21-2.14)** |
| Adjusted for age and gender | **1.96 (1.54-2.50)** | **2.76 (2.19-3.48)** | **2.27 (1.79-2.88)** | **1.64 (1.22-2.19)** |
| Adjusted for age, gender and SES | **1.98 (1.55-2.53)** | **2.77 (2.19-3.49)** | **2.29 (1.80-2.90)** | **1.64 (1.22-2.20)** |
| **~~Binge~~Intoxication >10 times**[b] | | | | |
| Crude | **1.83 (1.56-2.15)** | **2.08 (1.77-2.45)** | **1.30 (1.10-1.52)** | 0.95 (0.78-1.16) |
| Adjusted for age and gender | **1.80 (1.52-2.12)** | **2.18 (1.84-2.59)** | **1.36 (1.15-1.61)** | 0.97 (0.79-1.20) |
| Adjusted for age, gender and SES | **1.80 (1.52-2.13)** | **2.17 (1.83-2.58)** | **1.35 (1.14-1.61)** | 0.96 (0.78-1.18) |

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| **CRAFFT-~~caseness~~positive (≥2)** | | | | |
| Crude | **3.15 (2.71-3.66)** | **3.24 (2.78-3.78)** | **2.84 (2.46-3.28)** | **1.68 (1.42-1.99)** |
| Adjusted for age and gender | **3.06 (2.63-3.56)** | **3.22 (2.76-3.77)** | **2.84 (2.45-3.29)** | **1.62 (1.38-1.94)** |
| ~~95%~~ ~~confidence intervals in parentheses~~ ~~[a]Only includes those who have tried alcohol (n=7,031).~~ | | | | |
| ~~[b]Only includes those with valid response on~~ Adjusted for age, gender and SES | **3.01 (2.59-3.51)** | **3.18 (2.72-3.71)** | **2.80 (2.41-3.25)** | **1.59 (1.34-1.90)** |

Significant associations in bold.
95 confidence intervals in parentheses.
[a]Only includes those who have tried alcohol (n=7,031).
[b]Only includes those with valid response on ~~binge drinking~~frequency of intoxication (n=9,056).
CRAFFT: Screening tool for identification of problematic alcohol and drug use among adolescents.
ASRS: Adult ADHD Self-report Scale, screening inventory for attention-deficit-hyperactivity disorder. ASRS Inattention: the inattention sub-scale of the ASRS (9 items). ASRS Hyperactivity: the hyperactivity-impulsivity subscale of the ASRS (nine items).
SMFQ: The short version of the Mood and Feelings Questionnaire, screening inventory for symptoms of depression and depressive disorders.
SCARED: five-item screening inventory for symptoms of anxiety and anxiety disorders.

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Table 3: ~~Summary~~Table 2: Logistic regression models of ~~level~~use of ~~statistical significance~~alcohol and illicit drugs as risk factor for mental health problems, adjusted for age- and gender- ~~interactions across exposures and outcomes~~. Mental health variables analysed collectively. N=9,203 (girls n=4,995, boys n=4,208).

| | ~~ASRS inattention~~ | | ~~ASRS Hyperactivity~~ | | ~~SMFQ~~ | | ~~SCARED~~ | |
|---|---|---|---|---|---|---|---|---|
| | ~~Gender~~ | ~~Age~~ | ~~Gender~~ | ~~Age~~ | ~~Gender~~ | ~~Age~~ | ~~Gender~~ | ~~Age~~ |
| ~~Ever consumed alcohol~~ | ~~p=0.187~~ | ~~p=0.595~~ | ~~p=0.466~~ | ~~**p=0.002**~~ | ~~p=0.257~~ | ~~p=0.255~~ | ~~p=0.052~~ | ~~p=0.182~~ |
| ~~Ever tried illicit drugs~~ | ~~p=0.666~~ | ~~p=0.630~~ | ~~p=0.542~~ | ~~p=0.384~~ | ~~p=0.054~~ | ~~p=0.978~~ | ~~**p=0.021**~~ | ~~p=0.425~~ |
| ~~90th percentile alcohol consumption~~ | ~~p=0.752~~ | ~~p=0.359~~ | ~~**p=0.021**~~ | ~~p=0.937~~ | ~~**p=0.018**~~ | ~~p=0.639~~ | ~~**p<0.001**~~ | ~~p=0.198~~ |
| ~~Binge >10~~ | ~~p=0.083~~ | ~~p=0.427~~ | ~~p=0.514~~ | ~~**p=0.025**~~ | ~~**p=0.027**~~ | ~~p=0.889~~ | ~~p=0.245~~ | ~~p=0.452~~ |
| ~~CRAFFT-caseness (≥2)~~ | ~~p=0.413~~ | ~~p=0.263~~ | ~~p=0.293~~ | ~~p=0.190~~ | ~~p=0.100~~ | ~~p=0.840~~ | ~~p=0.991~~ | ~~p=0.464~~ |

*

| | ASRS inattention Odds ratio (OR) (95CI) | ASRS Hyperactivity Odds ratio (OR) (95CI) | SMFQ Odds ratio (OR) (95CI) | SCARED Odds ratio (OR) (95CI) |
|---|---|---|---|---|
| Ever consumed alcohol | **1.83 (1.44-2.32)** | **1.71 (1.35-2.16)** | **1.45 (1.17-1.78)** | **0.79 (0.64-0.98)** |
| Ever tried illicit drugs | **1.87 (1.50-2.32)** | **1.74 (1.40-2.17)** | **1.48 (1.18-1.86)** | 1.12 (0.86-1.46) |
| 90th percentile alcohol consumption[a] | 1.24 (0.94-1.63) | **2.30 (1.78-2.98)** | **1.88 (1.45-2.44)** | 1.18 (0.86-1.62) |
| Intoxication >10[b] | **1.45 (1.20-1.75)** | **1.95 (1.62-2.35)** | 1.18 (0.98-1.43) | **0.79 (0.63-0.99)** |
| CRAFFT-positive (≥2) | **1.97 (1.66-2.34)** | **2.27 (1.91-2.69)** | **2.17 (1.84-2.55)** | 0.99 (0.82-1.21) |

Significant ~~interactions~~associations in bold. ~~Interactions assessed using Wald likelihood ratio tests.~~
95 confidence intervals in parentheses.
[a]Only includes those who have tried alcohol (n=7,031).
[b]Only includes those with valid response on frequency of intoxication (n=9,056).
CRAFFT: Screening tool for identification of problematic alcohol and drug use among adolescents.
ASRS: Adult ADHD Self-report Scale, screening inventory for attention-deficit-hyperactivity disorder. ASRS Inattention: the inattention sub-scale of the ASRS (9 items). ASRS Hyperactivity: the hyperactivity-impulsivity subscale of the ASRS (nine items).
SMFQ: The short version of the Mood and Feelings Questionnaire, screening inventory for symptoms of depression and depressive disorders.
SCARED: five-item screening inventory for symptoms of anxiety and anxiety disorders.

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Table 4: Logistic regression models across alcohol consumption and ~~binge drinking~~frequency of intoxication categories, "Never tried alcohol" as reference. Adjusted for age and gender (N=9,203 for alcohol consumption and N=9,056 for ~~binge drinking~~frequency of intoxication).

| | ASRS Inattention Odds ratio (OR ~~(95%CI)~~ (95CI) | ASRS Hyperactivity OR (~~95%CI~~95CI) | SMFQ OR (~~95%CI~~95CI) | SCARED OR (~~95%CI~~95CI) |
|---|---|---|---|---|
| **Categories** | Alcohol consumption categories as ~~exposure~~independent variable | | | |
| Never consumed alcohol | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| Non-consumption | **1.90 (1.45-2.48)** | **1.46 (1.10-1.93)** | **1.43 (1.12-1.82)** | 1.01 (0.78-1.30) |
| 0.1-19.9th percentile | **1.61 (1.19-2.17)** | **1.69 (1.25-2.27)** | **1.44 (1.11-1.88)** | 1.00 (0.75-1.32) |
| 20.0-79.9th percentile | **2.15 (1.69-2.74)** | **1.99 (1.56-2.55)** | **1.51 (1.21-1.88)** | 0.90 (0.72-1.14) |
| 80.0-89.9th percentile | **3.77 (2.75-5.17)** | **3.56 (2.59-4.91)** | **2.21 (1.62-3.02)** | 1.39 (0.99-1.96) |
| 90.0-100th percentile | **4.16 (3.05-5.68)** | **5.28 (3.91-7.12)** | **3.47 (2.60-4.62)** | **1.60 (1.15-2.23)** |
| p-value for trend | p<0.001 | p<0.001 | p<0.001 | p=0.061 |
| **Categories** | Frequency of intoxication categories as independent variable | | | |
| Never consumed alcohol | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| ~~Non-consumption~~Never intoxicated | ~~1.90***~~ **65** (1.45~~24~~-2.48~~20~~) | ~~1.46**~~ **35** (1.~~10~~00-1.~~93~~81) | ~~1.43**~~ **30** (1.~~12~~00-1.~~82~~67) | 1.0~~1~~10 (0.~~78~~85-1.~~30~~43) |
| ~~0.1-19.9th percentile~~Once | ~~1.61**~~ **71** (1.~~19~~23-2.~~17~~38) | **2.06** (1.~~69~~** 50-2.~~27~~82) | ~~1.44**~~ **55** (1.~~11~~-1.~~88~~16-2.08) | 1.0~~0~~02 (0.~~75~~74-1.~~32~~39) |
| ~~20.0-39.9th percentile~~ | ~~1.98***~~ (1.46-2.69) | ~~1.91***~~ (1.40-2.60) | ~~1.53**~~ (1.16-2.03) | ~~0.90~~ (0.66-1.23) |
| ~~40.0-59.9th percentile~~ | ~~1.92***~~ (1.42-2.59) | ~~1.55**~~ (1.13-2.13) | ~~1.16~~ (0.87-1.56) | ~~0.97~~ (0.72-1.30) |
| ~~60.0-79.9th percentile~~ | ~~2.56***~~ (1.92-3.40) | ~~2.55***~~ (1.92-3.40) | ~~1.85***~~ (1.42-2.41) | ~~0.84~~ (0.62-1.14) |
| ~~80.0-89.9th percentile~~ | ~~3.77***~~ (2.75-5.17) | ~~3.56***~~ (2.59-4.91) | ~~2.21***~~ (1.62-3.02) | ~~1.39~~ (0.99-1.96) |
| ~~90.0-100th percentile~~ | ~~4.16***~~ (3.05-5.68) | ~~5.28***~~ (3.91-7.12) | ~~3.47***~~ (2.60-4.62) | ~~1.60**~~ (1.15-2.23) |



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|---|---|---|---|---|
| p-value for trend | p<0.001 | p<0.001 | p<0.001 | p=0.058 |
| **Categories** | | Binge drinking categories as exposure | | |
| Never consumed alcohol | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| Never binge | 1.65*** (1.24-2.20) | 1.35* (1.00-1.81) | 1.30* (1.00-1.67) | 1.10 (0.85-1.43) |
| Once | 1.71** (1.23-2.38) | 2.06*** (1.50-2.82) | 1.55** (1.16-2.08) | 1.02 (0.74-1.39) |
| 2-3 times | **2.00*** (1.51-2.63)** | **1.62** (1.21-2.15)** | **1.61*** (1.26-2.07)** | 0.88 (0.67-1.16) |
| 4-10 times | **2.49*** (1.90-3.26)** | **2.05*** (1.55-2.72)** | **1.85*** (1.44-2.36)** | 1.05 (0.81-1.38) |
| >10 times | **3.14*** (2.43-4.05)** | **3.36*** (2.61-4.33)** | **1.95*** (1.54-2.47)** | 0.98 (0.76-1.27) |
| p-value for trend | p<0.001 | p<0.001 | p<0.001 | p=0.679 |

* *p* < 0.05, ** *p* < 0.01, *** *p* < 0.001Significant associations in comparison to "Never tried alcohol"-category in bold.

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ASRS: Adult ADHD Self-report Scale, screening inventory for attention-deficit-hyperactivity disorder. ASRS Inattention: the inattention sub-scale of the ASRS (9 items). ASRS Hyperactivity: the hyperactivity-impulsivity subscale of the ASRS (nine items).
SMFQ: The short version of the Mood and Feelings Questionnaire, screening inventory for symptoms of depression and depressive disorders.
SCARED: five-item screening inventory for symptoms of anxiety and anxiety disorders.

## Figure legends

Figure 1: Proportion of participants having ~~ever~~never consumed alcohol across gender-stratified age groups (N=9,203, girls n=4,995, boys n=4,208). Error bars represent 95% confidence intervals.

~~and~~

Figure 2: Proportion of participants having ever tried illicit drugs across gender-stratified age groups (N=9,203, girls n=4,995, boys n=4,208). Error bars represent 95% confidence intervals.



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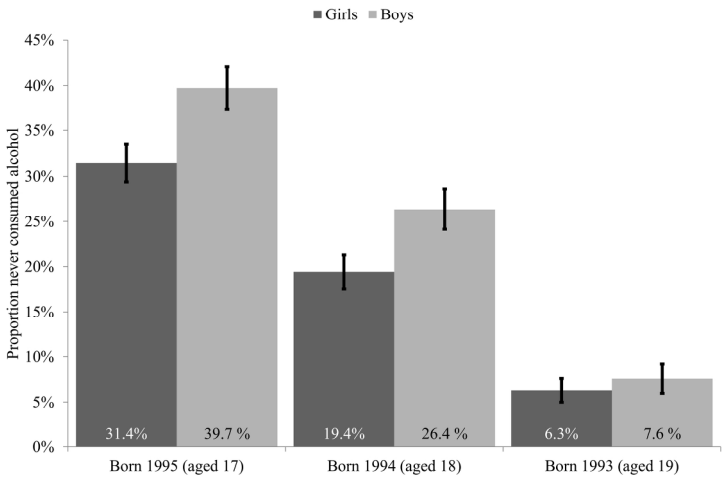


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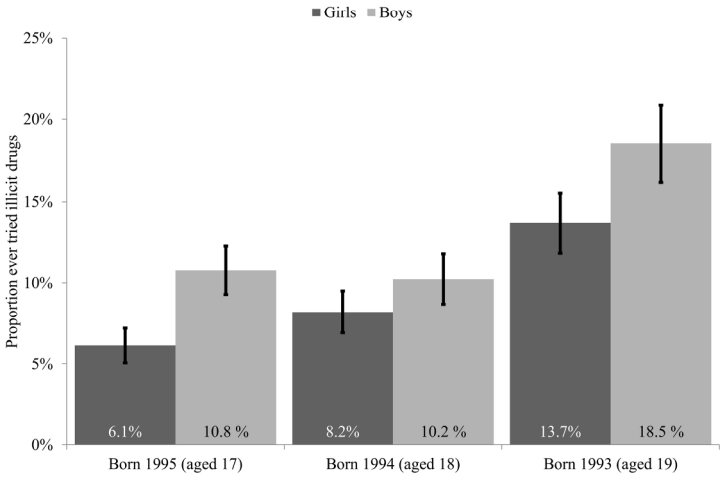


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STROBE Statement—checklist of items that should be included in reports of observational studies
**"X" indicates checked**

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 X | (*a*) Indicate the study's design with a commonly used term in the title or the abstract |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found |
| **Introduction** | | |
| Background/rationale | 2 X | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 X | State specific objectives, including any prespecified hypotheses |
| **Methods** | | |
| Study design | 4 X | Present key elements of study design early in the paper |
| Setting | 5 X | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 X | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 X | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8* X | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group |
| Bias | 9 X | Describe any efforts to address potential sources of bias |
| Study size | 10 X | Explain how the study size was arrived at |
| Quantitative variables | 11 X | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods | 12 X | (*a*) Describe all statistical methods, including those used to control for confounding |
| | | (*b*) Describe any methods used to examine subgroups and interactions |
| | | (*c*) Explain how missing data were addressed |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses |

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| | | |
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| **Results** | | |
| Participants | 13* X | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| | | (b) Give reasons for non-participation at each stage |
| | | (c) Consider use of a flow diagram |
| Descriptive data | 14* X | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| | | (b) Indicate number of participants with missing data for each variable of interest |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15 | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | X* | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures |
| Main results | 16 X | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included |
| | | (*b*) Report category boundaries when continuous variables were categorized |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 X | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| **Discussion** | | |
| Key results | 18 X | Summarise key results with reference to study objectives |
| Limitations | 19 X | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 X | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 X | Discuss the generalisability (external validity) of the study results |
| **Other information** | | |
| Funding | 22 X | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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