Patterns of alcohol use and multiple risk behaviour by gender during early and late adolescence: the ALSPAC cohort

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ABSTRACT

Background Adolescent risk behaviours such as smoking, alcohol use and antisocial behaviour are associated with increased risk of morbidity and mortality. Patterns of risk behaviour may vary between genders during adolescence.

Methods Analysis of data from a longitudinal birth cohort to assess the prevalence and distribution of multiple risk behaviours by gender at age 15–16 years with a focus on alcohol use at age 10, 13 and 15 years.

Results By age 15 years, over half of boys and girls had consumed alcohol and one-fifth had engaged in binge drinking with no clear difference by gender. At age 15–16 years, the most prevalent risk behaviours were physical inactivity (74%), antisocial and criminal behaviour (42%) and hazardous drinking (34%). Boys and girls engaged in a similar number of behaviours but antisocial and criminal behaviours, cannabis use and vehicle-related risk behaviours were more prevalent among boys, whilst tobacco smoking, self-harm and physical inactivity were more prevalent among girls.

Conclusion Multiple risk behaviour is prevalent in both genders during adolescence but the pattern of individual risk behaviour varies between boys and girls. Effective interventions at the individual, family, school, community or population level are needed to address gender-specific patterns of risk behaviour during adolescence.

Keywords Alcohol, risk behaviour, adolescence, cohort

Introduction

Modifiable risk behaviours such as smoking, alcohol intake, drug use, poor diet and physical inactivity, both individually and collectively, account for substantial morbidity and mortality throughout life.^{1–4} Critically, risk behaviours are often initiated during adolescence^{5,6} and the frequency of engagement in behaviours rises with increasing age during the teenage years,^{6–9} often continuing into early adulthood.^{10–14} A number of studies have demonstrated clustering of risk behaviours such as smoking, substance use, antisocial behaviour and sexual risk behaviour during adolescence,^{15–21} and estimates from the USA, Canada and the UK indicate that between 6 and 13% of adolescents smoke regularly, drink alcohol and use illicit drugs.^{8,9,22,23} Moreover, early initiation of risk behaviours is associated with engagement

in multiple risk behaviours during both early and late adolescence,^{5,24,25} and simultaneous engagement in such behaviours during adolescence is associated with increased morbidity and premature mortality.²⁶

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Regular alcohol use and binge drinking among adolescents are risk behaviours of particular concern. Early use of alcohol is associated with multiple risk behaviours and detrimental impacts including sexual risk behaviour, sexually transmitted infections, substance use, criminal and violent behaviour, academic underachievement, mood disorders, injury and high levels of alcohol-related attendances at hospital.^{13,27–35} Survey data also demonstrate that ~70% of young people in the UK consume alcohol and the prevalence of recent use is over 3-fold higher than recent tobacco or cannabis use. The UK has one of the highest levels of alcohol use in young people among European countries, ranking third of 35 countries in estimated alcohol consumption and prevalence of recently being drunk.³⁶

Following upward trends in alcohol use in the UK during the 1990s and early 2000s,^{37–40} data indicate that self-reported alcohol consumption and heavy drinking have fallen slightly among men and women across all age groups in recent years, including adolescents.^{8,9,41} However, alcohol-related hospital admissions have continued to rise,³⁸ rates of alcohol-related deaths in the UK have increased consistently over recent decades,^{37,42,43} and mean alcohol consumption among adolescents has risen steadily over recent years. In addition, reported alcohol consumption has increased in adolescent boys aged 11–13 years.^{8,44,45}

It is not yet clear whether such trends will continue to be sustained, and the impacts of high levels of use in adolescence, and changing patterns of consumption by gender or socio-demographic group, have yet to be fully clarified. Patterns of alcohol use vary between genders both in the UK and internationally,^{46,47} but increases in alcohol consumption particularly among young females in the UK^{37,40} have narrowed the gender gap in alcohol intake and binge drinking in young people. Among adolescents, gender-related patterns of alcohol consumption have been reported in relation to use during early adolescence or the type of drink consumed, but gender differences for a number of other measures such as mean alcohol consumption or frequency of recent use are less clear.^{8,9,31,48,49}

Given evidence demonstrating an association between alcohol use and multiple risk behaviours, it is possible that the pattern of engagement in a range of risk behaviours varies by gender at this time. This may have implications for the design and implementation of public health interventions to address single and multiple risk behaviours as well as interventions to address the resulting burden of disease. Whilst studies have demonstrated that engagement in multiple risk behaviours differs by gender during adolescence,^{5,6,16} the majority of studies focus on a relatively narrow range of behaviours,^{6,15,16,19,23,50} and findings vary

by age at measurement and the individual risk behaviours considered.

This paper aims to summarize and compare data from a prospective UK birth cohort [the Avon Longitudinal Study of Parents and Children (ALSPAC)] describing the prevalence and pattern of alcohol use and binge drinking by gender during early and later adolescence, alongside analysis of the prevalence of multiple risk behaviour by gender at age 15–16 years. Detailed analyses of data relating to the prevalence and determinants of alcohol use within the ALSPAC cohort at age 10 and 13 years have been previously reported and are included in the current analysis based on categorizations used in the original publications.^{48,49,51}

Methods

The core sample of the ALSPAC includes 14 541 women who were expecting to deliver infants between 1 April 1991 and 31 December 1992 in the former county of Avon, UK. ALSPAC parents and children have been followed-up regularly since recruitment, via data from questionnaires completed by mothers, children and teachers and via clinic assessments. The population included is representative of a primarily white population with a small proportion of individuals in ethnic minority groups (5%) and diverse socioeconomic backgrounds. Ethical approval for the study was granted from the ALSPAC Law and Ethics Committee and the local research ethics committee. Full details about the ALSPAC study and design are described elsewhere (<http://www.bristol.ac.uk/alspac>).

Alcohol use at age 10 years

The analysis excluded multiple births and births with no information regarding the early life exposures considered by the study,⁴⁹ giving a sample of 12 803 children, representing 92% of live infants. Alcohol use was assessed as a binary variable in the 6 months before assessment at age 10 years. Data regarding alcohol use were provided by 6895 children (3410 boys and 3485 girls). Methods of analysis are provided elsewhere.⁴⁹

Alcohol use at age 13 years

Data regarding alcohol use was obtained via face-to-face interview between participants aged 13 years and trained examiners between January 2005 and September 2006. Interviews included questions regarding drinking experience, age of initiation of alcohol use and frequency of use. Binge drinking was determined using a binary variable indicating whether the participant had ever consumed three or more than three drinks

in 1 day (a minimum of three units of alcohol) as recommended as a cut-off for this age group.⁵² A total of 5837 children (2960 girls and 2877 boys) attended the assessment at age 13 years and were therefore included in the analysis, representing 55.2% of the participants invited ($n = 10\,569$) and 41.8% of eligible subjects ($n = 13\,973$). The median age of participants included in the analysis was 13.8 years. Methods of analysis are described in detail elsewhere.⁴⁸

Alcohol use at age 15 years

At age 15 years, the sample included 5067 boys and girls, although the numbers included in the analysis of each outcome vary slightly owing to missing data. Data were obtained via a computer-based session at a clinic assessment which included questions regarding age at first whole drink, frequency of drinking, the number of drinks consumed on a typical day, frequency of binge drinking and symptoms of dependence. Binge drinking was analysed using an ordinal variable indicating the number of times the participant had consumed five or more drinks during a 24-h period over the last 2 years. Symptoms of alcohol dependence were defined as a binary variable indicating whether a child had recurrently (three or more times) experienced three or more dependent-like symptoms in the last 2 years. Dependent-like symptoms were defined on the basis of 12 questions which could be linked to criteria for dependence according to the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV) and International Classification of Diseases (ICD-10). Data relating to alcohol use at ages 13 and 15 years were analysed using STATA version 11.

Alcohol use and multiple risk behaviour at 15–16 years

Chi-square tests were used to analyse the association between the number of drinks the young person consumed on a typical day in the last 6 months (≤ 3 or ≥ 4) at age 15 years and each of the multiple risk behaviours tested at age 16 years (see below). The complete case sample with no missing values included 2591 individuals. The association between hazardous drinking at 16 years [defined by the alcohol use disorders identification test (AUDIT)] and each of the risk behaviours was also analysed. The latter sample included 2657 individuals.

Multiple risk behaviour at 15–16 years

Measures of the multiple risk behaviours considered were derived from a computer-based clinic session at 15 years of age and a postal questionnaire completed at age 16. All behaviours were measured at 16 years of age, with the

exception of sexual risk behaviour and antisocial and criminal behaviour, which were assessed at 15 years of age. Risk behaviours were as follows: physical inactivity (less than five episodes of physical exercise per week over the past year), sedentary behaviour (television viewing of 3 or more hours per day), unprotected sex (not using any form of contraception on the last occasion of sexual intercourse), sex before age 16 years, self-harm (ever having intentionally hurt them self at some point in their lifetime), tobacco smoking (smoking at least one cigarette per week), hazardous alcohol drinking (consuming at least hazardous levels of alcohol defined by AUDIT since age 15 years), cannabis use (using cannabis at least once per week).

Composite variables were used for antisocial and criminal behaviour, illicit (non-cannabis) drug use and vehicle-related risk. Antisocial and criminal behaviour was determined by ever having carried out one or more of the following: carrying a weapon, physically hurting somebody on purpose, taking property or breaking into a property, selling illicit drugs, damaging property either by using graffiti, setting fire to it or deliberately destroying/damaging it, using verbal or physical racial abuse, or being rude/rowdy in a public place. Drug and solvent use was defined as use of at least one of the following substances at least five times since the participant's 15th birthday: aerosols, gas, glue, solvents, poppers, amphetamines, ecstasy, lysergic acid diethylamide (LSD), magic mushrooms, cocaine, crack, heroin and ketamine. Vehicle-related risk included cycling without a helmet (not wearing a helmet on the last occasion of cycling within the last 4 weeks), scooter risk (riding a motorbike or scooter off road or without a licence on a public road) and car passenger risk (being a passenger at least once and either knowing that the driver had consumed alcohol; knowing that the driver did not have a licence to drive without supervision; or not wearing a seatbelt on the last occasion).

The complete case sample with no missing values across the variables of interest included 2657 individuals (1070 boys and 1587 girls). The Wilcoxon rank-sum test was used to test whether the median number of behaviours in which adolescents engaged differed between boys and girls; and chi-square tests of association were used to assess gender differences in the rates of individual behaviours. Data were analysed using STATA version 11.

Results

Alcohol use

At early stages of adolescence (age 10 years), the prevalence of alcohol use in the 6 months preceding assessment was

low overall at 1.8%, although the prevalence was higher in boys [2.6%, 95% confidence interval (95% CI) 2.1–3.2%] compared with girls (0.8%, 0.5–1.2%; Table 1).⁴⁹

The frequency of drinking before 12 years of age was slightly higher in boys compared with girls (Table 1). At 13 years of age, over half of boys and girls had ever had an alcoholic drink (51.6%, 49.8–53.5%; 53.7%, 51.9–55.5%, respectively) and approximately one-fifth had ever engaged in binge drinking. There was no difference in the prevalence of binge drinking by gender (Table 1). There was, however, evidence that girls were more likely to drink in the previous

6 months compared with boys (42.5%, 40.7–44.3%; 39.4%, 37.6–41.2%, respectively; $P = 0.02$).

At 15 years of age, over half of girls and boys had consumed alcohol at least once in the previous 6 months (boys, 79.2%; girls, 82.3%) and over half had engaged in binge drinking at least once (boys, 56.3%; girls, 57.9%; Table 1). Girls were more likely than boys to drink two or more drinks on a typical day when drinking and fewer girls had never had a drink in the previous 6 months. A greater proportion of girls also reported consumption of alcohol 0–19 times in the past 6 months than boys, although data

Table 1 Alcohol use at age 10, 13 and 15 years by gender

Measure of alcohol use	Boys			Girls			P*
	n	%	95% CI	n	%	95% CI	
<i>Age 10 years^a</i>							
Alcohol use in previous 6 months	—	2.6	2.1–3.2	—	0.8	0.5–1.2	—
<i>Age 13 years^b</i>							
Ever drinking with no permission	749	26.2	24.6–27.8	768	26.1	24.5–27.7	0.95
Ever whole drinking ^c	1479	51.6	49.8–53.5	1582	53.7	51.9–55.5	0.11
Whole drinking at <12 years	400	14.2	12.9–15.5	359	12.4	11.2–13.6	0.05
Ever binge drinking	577	20.4	18.9–21.9	609	21.0	19.5–22.5	0.54
Drinking with no permission in previous 6 months	683	23.9	22.3–25.5	711	24.2	22.6–25.8	0.80
Whole drinking in previous 6 months	1126	39.4	37.6–41.2	1250	42.5	40.7–44.3	0.02
<i>Age 15 years</i>							
Frequency of drinking in past 6 months							
Never	490	20.8	19.1–22.4	477	17.7	16.3–19.2	<0.01 ^d
0–19 times	1383	58.6	56.6–60.6	1727	64.2	62.4–66.0	
≥20 times	486	20.6	19.0–22.2	487	18.1	16.6–19.6	
Number of drinks on a typical day when drinking							
0–1	1354	59.1	57.1–61.1	1376	52.7	50.8–54.6	<0.01
2–3	484	21.1	19.4–22.8	643	24.6	23.0–26.3	
≥4	454	19.8	18.2–21.4	593	22.7	21.1–24.3	
Frequency of binge drinking in the last 2 years							
Never	1037	43.7	41.7–45.7	1135	42.1	40.3–44.0	0.30
1–19 times	1083	45.7	43.7–47.7	1289	47.8	45.9–49.7	
≥20 times	252	10.6	0.94–11.9	271	10.1	0.89–11.2	
Symptoms of alcohol dependence							
No experience of dependent-like symptoms	2129	91.1	89.9–92.3	2423	90.5	89.4–91.6	0.45
Experience of 3 or more dependent-like symptoms ^e	208	8.9	7.7–10.1	255	9.5	8.4–10.6	

^aData relating to alcohol use at age 10 years included from ref. 49.

^bData relating to alcohol use at age 13 years included from ref. 48.

^cA whole drink is a can of beer, a glass of wine, a bottle of alcopop, a shot of spirit or any full drink that contains alcohol.

^dChi-squared P values are reported for gender difference across ordinal variables.

^eExperience of symptoms in the past 2 years. Dependent-like symptoms were defined on the basis of 12 questions which could be linked to the criteria for dependence according to DSM-IV and ICD-10.

*Chi-squared P values are reported for gender differences.

indicated that a slightly higher proportion of boys drank >20 times in the previous 6 months (Table 1). There was no evidence of a difference by gender in the frequency of binge drinking or symptoms of alcohol dependence (Table 1).

Given the high prevalence of alcohol use at 15 years of age, we analysed the association between alcohol consumption and a range of other risk behaviours later in adolescence (age 16 years). Higher alcohol consumption at age 15 was associated with significantly higher prevalence of engagement in all of the risk behaviours at age 16 years (all $P < 0.001$), except physical inactivity, sedentary behaviour and not wearing a bicycle helmet ($P = 0.15, 0.20; 0.99$, respectively). The association was particularly evident for substance use and sexual risk behaviours for which prevalence was more than 2-fold greater among those who reported higher levels of alcohol consumption at age 15 (Supplementary data, Table S1). Among hazardous drinkers at age 16 years, the prevalence of engagement in substance use behaviours was 6-fold higher than in non-hazardous drinkers (Supplementary data, Table S1).

Multiple risk behaviour at age 15–16 years

Following identification of an association between alcohol use and multiple risk behaviours, we examined the overall prevalence of these behaviours by gender at age 15–16 years. The frequency of engagement in single and multiple risk behaviours is shown in Fig. 1. At 15–16 years of age, 40% ($n = 1059$) of adolescents engaged in between three and five behaviours (42.0% boys; 38.4% girls) and 6.2% ($n = 164$) engaged in seven or more (6.0% boys; 6.3% girls). Just 5% ($n = 125$) did not engage in any of the risk

Fig. 1 Frequency of single and multiple risk behaviours by gender in adolescents aged 15–16 years.

behaviours examined. The median number of behaviours did not differ by gender ($\chi^2 = 1.5, P = 0.14$).

The data in Table 2 indicate that the most prevalent risk behaviours were physical inactivity (74.3%), antisocial behaviour and criminal offending (42.1%) and hazardous drinking (33.7%); 28% of adolescents also engaged in car passenger-related risk behaviour. The prevalence of use of substances other than alcohol (i.e. tobacco, cannabis and drugs and solvents) was <10% among girls and boys and unprotected sex was the least prevalent risk behaviour (1.3%).

The prevalence of car passenger risk, sedentary behaviour, hazardous drinking and drug and solvent use did not differ between boys and girls (Table 2), and as observed at 13 and 15 years of age, there was no difference between boys and girls in the prevalence of binge drinking at age 16 (boys 36.1%, 33.2–39.1; girls 33.3%, 30.9–35.6; $P = 0.129$). However, a significantly greater proportion of girls reported physical inactivity, self-harm, tobacco smoking and sexual risk behaviour (all $P < 0.01$), whilst a greater proportion of boys reported antisocial behaviour and offending, cannabis use, cycling without a helmet and scooter risks (Table 2).

Within the composite measure of antisocial and criminal behaviour, we identified further differences between boys and girls in the prevalence of engagement in individual behaviours (Fig. 2). The most prevalent of these behaviours were criminal damage (boys, 29.0%; girls, 20.5%) and assault (boys, 26.3%; girls, 11.0%). All of the behaviours were more common among boys compared with girls, although there was no evidence of a marked difference in the prevalence of rowdiness and theft by gender (Fig. 2).

The prevalence of both riding a moped or scooter off road and riding without a licence were markedly more prevalent among boys compared with girls (off road: boys, 27.8%; girls, 11.9%; no licence: boys, 10.4%; girls, 2.2%). The prevalence of drug and solvent use was low overall and was similar between genders. Among inhalants, poppers were the most frequently used substance (boys, 2.2%; girls, 3.4%) and among other drugs, ecstasy (boys, 1.8%; girls, 2.0%) and cocaine (boys, 1.1%; girls, 1.3%) were the most frequently used (data not shown).

Discussion

The prevalence of alcohol use among adolescents was low overall at age 10 years, but at 13 years of age, over half of boys and girls had consumed alcohol and one-fifth had engaged in binge drinking. By age 15 years, nearly half of adolescents had engaged in binge drinking and a third

Table 2 Prevalence of risk behaviours (%) in adolescents aged 15–16 years by gender^a

Risk behaviour	All	Boys		Girls		P *
	%	%	95% CI	%	95% CI	
Inactivity						
Physical inactivity	74.3	63.7	60.9–66.6	81.4	79.5–83.3	<0.01
Daily hours of television viewed	19.5	20.7	18.2–23.1	18.8	16.9–20.7	0.23
Criminal offences and antisocial behaviour (ASB) ^b						
ASB and/or committing one or more offences	42.1	50.3	47.3–53.3	36.6	34.2–39.0	<0.01
Substance use						
Hazardous alcohol drinking	33.7	32.4	29.6–35.2	34.5	32.2–36.9	0.26
Tobacco smoking	10.0	7.1	5.6–8.6	12.1	10.5–13.7	<0.01
Cannabis use	9.1	10.6	8.7–12.4	8.1	6.8–9.5	0.03
Drug and solvent use ^c	4.6	4.4	3.2–5.6	4.7	3.6–5.7	0.70
Vehicle-related risk						
Car passenger risk ^d	27.9	26.5	23.9–29.2	28.8	26.6–31.0	0.20
Cycling without a helmet	23.9	37.9	34.9–40.8	14.6	12.8–16.3	<0.01
Scooter risks ^e	17.2	26.1	23.4–28.7	11.2	9.7–12.8	<0.01
Injuring self						
Self-harm	18.7	9.4	7.6–11.1	25.0	22.9–27.1	<0.01
Sexual behaviour						
Sex before age 16 years	13.8	10.9	9.1–12.8	15.7	13.9–17.5	<0.01
Unprotected sex	1.3	0.4	0.0–0.7	2.0	1.3–2.6	<0.01

^aThe prevalence of sexual health behaviours and antisocial and criminal behaviours were measured at age 15 years; all other behaviours were measured at age 16 years.

^bAntisocial and criminal behaviour is a composite variable defined as ever having carried out criminal damage, theft, assault, selling illicit drugs, carrying a weapon, racist abuse or rowdy behaviour in public places.

^cDrug and solvent use is a composite variable which is defined by use five or more times since age 15 years of at least one of the following: aerosols, gas, glue, solvents, poppers, amphetamines, ecstasy, LSD, magic mushrooms, cocaine, crack, heroin and ketamine.

^dCar passenger risk is a composite measure defined as being a passenger at least once and either knowing that the driver had consumed alcohol; knowing that the driver did not have a licence to drive without supervision; or not wearing a seatbelt on the last occasion.

^eScooter risk is defined as riding a motorbike or scooter off road or without a licence on a public road.

*P value based on a proportion test for gender differences.

Fig. 2 Prevalence of antisocial and criminal behaviours by gender at age 15 years.

engaged in hazardous drinking at age 16 years with no clear difference in the prevalence by gender.

In contrast to binge drinking and hazardous drinking, the prevalence of engagement in a wide range of risk behaviours varied between boys and girls at 15–16 years of age, with antisocial and criminal behaviours, cannabis use and vehicle-related risk behaviours being more prevalent among boys but tobacco smoking, self-harm and physical inactivity being more prevalent among girls. A greater proportion of girls also reported engaging in sex before the age of 16 and having unprotected sex compared with boys. Whilst the prevalence of individual behaviours differed between boys and girls, there was no evidence of a difference in the median number of behaviours between boys and girls. Engagement in the majority of the risk behaviours

(particularly substance use and sexual risk behaviour) was associated with alcohol use at 15 and 16 years of age.

The high levels of binge drinking and hazardous alcohol drinking at age 15–16 years are cause for concern. Recent guidance from the Chief Medical Officer recommends that young people do not drink alcohol at all before the age of 15 and that between 15 and 17 years of age, they should drink alcohol on no more than 1 day per week, and should not exceed recommended adult daily limits.⁴⁴ The data that we and others report⁵¹ indicate that although advice is clear, there is disparity between the recommended limits and young people's behaviour, with substantial proportions of adolescents engaging in risk behaviours at greater than recommended levels that might be harmful to health.

Drinking outside of guideline levels at 15–16 years of age has been associated with greater experience of alcohol-associated risk behaviours such as forgetfulness, alcohol-related violence and regretted or unprotected sex,³¹ and high intake has also been associated with increased likelihood of injury, sexually transmitted infections, crime, motor vehicle collisions, car crash fatality and suicide.^{4,13,27,32–34} Our data also indicate that a higher level of alcohol use at 15 years of age is associated with engagement in a number of risk behaviours at 15–16 years of age, as supported by previous studies,^{16,22,29,34,53} although the cross-sectional nature of this analysis precludes any causal inference. The lack of association between alcohol consumption and physical inactivity is comparatively less well studied and warrants further research.

The high prevalence of initiation of alcohol consumption by 13 years of age (52% boys; 54% girls), alongside reports of rising consumption among very young adolescents in the UK⁴⁵ also presents challenges for public health. Early alcohol use has been associated with greater risk of heavy drinking and dependence in adulthood,^{12,31,52} whilst binge drinking during adolescence is also associated with a 2- to 3-fold increased risk of binge drinking in adulthood.⁵⁴ Notwithstanding damage to the liver associated with consistent high levels of alcohol consumption,⁵⁵ these findings indicate that the burden of hazardous drinking and dependence may rise among young adults in coming years, concurrent with the burden of behaviours associated with alcohol use, such as unprotected sex and aggressive behaviour.

Currently, the burden of alcohol use and dependence is greater among male adolescents (boys, 7.2%; girls, <2.1%)³ and adults,^{56–58} but it is possible that the alcohol-associated health burden among females will become comparatively more evident in the coming years owing to increases in consumption and binge drinking particularly among young

females over recent decades.^{8,37,40,59} Furthermore, evidence demonstrates that the brain continues to undergo structural and functional changes during adolescence, suggesting that alcohol consumption at this stage in the life course may have important consequences for brain development, whilst the identification of differences between genders in the trajectories of brain development^{60–62} raises the possibility that alcohol-related impacts on cognitive developments may differ between males and females.^{60,63}

The reasons for changing patterns of alcohol use between genders are complex and are variable across cultures internationally suggesting that biological and socio-cultural influences such as gender equality, gender–income equity and changes in working patterns might play a role.^{47,64–66} Gender-dependent variation in factors such as abstinence from alcohol use, the type of drink consumed, pace of intake or engagement in alcohol-related risk behaviours may influence subsequent impacts to health^{8,31,67,68} and such patterns and trends will need to be monitored over the longer term.

In contrast to the similar prevalence of alcohol use and binge drinking among adolescents aged 13 and 15–16 years, we found that engagement in a range of other risk behaviours differed by gender at age 15–16 years and those behaviours more associated with violence and possible injury, such as assault, criminal damage and carrying a weapon, were markedly more prevalent among boys compared with girls. These findings indicate that among boys, there may be a greater propensity for 'sensation seeking' or more immediate gratification, although the possibility that there may also be a greater likelihood of reporting of such behaviours among boys cannot be ruled out.

Impulsivity and sensation seeking have been associated with greater likelihood of gambling onset in youth, risky sexual behaviour, smoking, alcohol use and aggression,^{69–72} and a number of studies also report clustering of 'delinquent' or antisocial behaviour with smoking, alcohol and drug use, crime and risky sexual behaviour during adolescence,^{10,16,19} all of which may individually and collectively cause harm to health. Nevertheless, studies show that violence, assault and antisocial behaviour peak at around 15 years in the UK and decline during early adulthood,⁷³ and the long-term impacts of the high prevalence of engagement in such behaviours and differences between genders are not yet clear within this cohort.

Interestingly, we also identified that behaviours with less immediate adverse impacts on health including tobacco smoking, self-harm and physical inactivity were more prevalent among girls compared with boys; a finding supported by national survey data.^{8,74,75} Prevalence estimates for

physical inactivity and smoking were similar to nationally reported rates, although the prevalence of ever having self-harmed among girls (25%) was higher compared with reported estimates.⁷⁴ The greater engagement in behaviours with longer term impacts on health among girls may reflect different underlying psychological motivations and/or coping mechanisms by gender during adolescence and further research is needed to better understand risk and protective factors for engagement in different types and clusters of behaviours by gender.

The high prevalence of physical inactivity (74%) indicates that this is a norm during adolescence and thus it could be argued that this should not be considered a risk behaviour. However, guidance from the Chief Medical Officer recommends that young people undertake at least 60 min per day of at least moderate physical activity every day, and higher impact exercise at least twice a week to reduce the risk of harm to health.⁷⁶ In our study, the data indicate that the majority of female adolescents and two thirds of male adolescents were not undertaking the minimum recommended amount of physical exercise, which increases the risk of chronic disease later in life.⁷⁶ England-wide survey also demonstrate that physical inactivity decreases up to age 15 years among girls but remains more consistent among boys, exacerbating gender differences at ages 14 and 15 years.⁷⁵ Historically, levels of physical inactivity have also been lower among younger female adults (age 16–24 years) compared with males.⁷⁶

Our data demonstrate that the prevalence of risk behaviours such as unsafe sex and illicit drug use are comparatively low among all of the behaviours examined, yet neither the harms associated with such behaviours, nor the clustering of such behaviours, should be overlooked. Global burden of disease studies estimate that risk behaviours such as unsafe sex, self-inflicted injuries and illicit drug use are key risk factors for incident disability-adjusted life years (DALYs), contributing between 2 and 4% to DALYs among 10–24 year olds globally,³ and the burden of disease, mortality and social impacts associated with clustered behaviours is likely to be markedly higher.

Limitations

Whilst the use of a birth cohort has multiple advantages for analysis of the determinants and impacts of a wide range of exposures over an extended time period in a large sample, there are limitations to these analyses which must be noted. The analysis of simultaneous engagement in a large number of behaviours reduces the sample size owing to missing data, and the ALSPAC cohort is subject to loss to follow-up at each stage. Male cohort members and those from lower

socio-economic groups are also less likely to attend assessment interviews,⁴⁸ which could lead to inaccurate prevalence estimates, and self-report measures of behaviour used in this study are subject to reporting bias. Nevertheless, cohort members are given clear assurance of anonymity and confidentiality, and the prevalence estimates of behaviours including ever having consumed an alcoholic drink at or by age 13 years, and physical inactivity at age 15–16 years, were similar to nationally reported rates.^{8,75} Since cut-off points for determining measures of behaviour associated with harm to health are unclear during adolescence for certain behaviours, it is also possible that different thresholds may be appropriate at different stages of adolescence.

Implications and conclusions

Taken together, the data presented in this paper highlight high prevalence of alcohol use by 15 years of age with little evidence of a difference by gender. The data also demonstrate high prevalence of physical inactivity, criminal offending and antisocial behaviour and hazardous drinking by 16 years of age, as well as differences between boys and girls in relation to engagement in particular behaviours, but not the number of different behaviours *per se*.

These findings have implications for policy and practice. First, effective communication of clear harm reduction messages is required to address the high prevalence of hazardous drinking and physical inactivity during adolescence. Health policies and harm reduction messages also need to account for engagement in a wide spectrum of risk behaviours during adolescence which may vary by gender and socio-demographic determinants. Further research is needed to examine the clustering of multiple behaviours, the influence of gender and the social patterning and determinants of engagement in single and multiple risk behaviours to provide insight into effective strategies by which to address risk behaviour and thus to reduce harms to health.

Supplementary data

Supplementary data are available at the *Journal of Public Health* online.

Acknowledgements

We are extremely grateful to all the families who took part in this study, the midwives for their help in recruiting them and the whole ALSPAC team, which includes interviewers, computer and laboratory technicians, clerical workers, research scientists, volunteers, managers, receptionists and nurses.

Funding

Research reported here was supported by the Economic and Social Research Council (grant RES-060-23-0011; R.M. and G.L.); the Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement (DECIPHer) which receives funding from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council (RES-590-28-0005), Medical Research Council, the Welsh Assembly Government and the Wellcome Trust (WT087640MA), under the auspices of the UK Clinical Research Collaboration (RC, RRC, MCS); Medical Research Council (grants G0800612 and G0802736; M.C.S., J.H. and M.H.); and the South West Public Health Training Scheme (G.J.M.).

References

- World Health Organization. The World Health Report 2002: reducing risks, promoting healthy life. Geneva: World Health Organization, 2002.
- Yach D, Hawkes C, Gould CL *et al.* The global burden of chronic diseases: overcoming impediments to prevention and control. *JAMA* 2004;**291**:2616–22.
- Gore FM, Bloem PJN, Patton GC *et al.* Global burden of disease in young people aged 10–24 years: a systematic analysis. *Lancet* 2011;**377**:2093–102.
- Babor T, Caetano R, Casswell S *et al.* *Alcohol: No Ordinary Commodity*, 1st edn. Oxford, UK: Oxford University Press, 2003.
- DuRant RH, Smith JA, Kreiter SR *et al.* The relationship between early age of onset of initial substance use and engaging in multiple health risk behaviors among young adolescents. *Arch Pediatr Adolesc Med* 1999;**153**(3):286–91.
- Viner RM, Haines MM, Head JA *et al.* Variations in associations of health risk behaviors among ethnic minority early adolescents. *J Adolesc Health* 2006;**38**(1):55.
- Brener ND, Collins JL. Co-occurrence of health-risk behaviors among adolescents in the United States. *J Adolesc Health* 1998;**22**(3):209–13.
- NHS Information Centre. Smoking, drinking and drug use among young people in England in 2009. In: Fuller E (ed.). London: National Centre for Social Research, 2010.
- McVie S, Bradshaw P. *Adolescent Smoking, Drinking and Drug Use*. Edinburgh: Centre for Law and Society, 2005.
- Mason WA, Hitch JE, Kosterman R *et al.* Growth in adolescent delinquency and alcohol use in relation to young adult crime, alcohol use disorders, and risky sex: a comparison of youth from low-versus middle-income backgrounds. *J Child Psychol Psychiatry* 2010;**51**(12):1377–85.
- Chen K, Kandel DB. The natural history of drug use from adolescence to the mid-thirties in a general population sample. *Am J Public Health* 1995;**85**(1):41–7.
- Pitkanen T, Lyyra A-L, Pulkkinen L. Age of onset of drinking and the use of alcohol in adulthood: a follow-up study from age 8–42 for females and males. *Addiction* 2005;**100**:652–61.
- McCambridge J, McAlaney J, Rowe R. Adult consequences of late adolescent alcohol consumption: a systematic review of cohort studies. *PLoS Med* 2011;**8**(2):e1000413.
- Chassin L, Forth DB, King KM. Trajectories of alcohol and drug use and dependence from adolescence to adulthood: the effects of familial alcoholism and personality. *J Abnorm Psychol* 2004;**113**:483–98.
- Burke V, Milligan RAK, Beilin LJ *et al.* Clustering of health-related behaviors among 18-year-old Australians. *Prev Med* 1997;**26**:724–33.
- van Nieuwenhuijzen M, Junger M, Velderman MK *et al.* Clustering of health-compromising behavior and delinquency in adolescents and adults in the Dutch population. *Prev Med* 2009;**48**:572–8.
- Wiefferink CH, Peters L, Hoeksma F *et al.* Clustering of health-related behaviours and their determinants: possible consequences for school health interventions. *Prev Sci* 2006;**7**:127–49.
- Basen-Engquist K, Edmundson EW, Parcel GS. Structure of health risk behavior among high school students. *J Consult Clin Psychol* 1996;**64**(4):764–75.
- Junger M, Stroebe W, van der Laan AM. Delinquency, health behaviour and health. *Br J Health Psychol* 2001;**6**:103–20.
- Mistry R, McCarthy WJ, Yancey AK *et al.* Resilience and patterns of health risk behaviors in California adolescents. *Prev Med* 2009;**48**:291–7.
- Pahl K, Brook DW, Morojele NK *et al.* Nicotine dependence and problem behaviours among urban South African adolescents. *J Behav Med* 2010;**33**(2):101–9.
- Leatherdale ST, Ahmed R. Alcohol, marijuana and tobacco use among Canadian youth: do we need more multi-substance prevention programming? *J Prim Prev* 2010;**31**:99–108.
- Connell CM, Gilreath TD, Hansen NB. A multiprocess latent class analysis of the co-occurrence of substance use and sexual risk behaviour among adolescents. *J Stud Alcohol Drugs* 2009;**70**(943):951.
- DuRant RH, Kahn J, Beckford PH *et al.* The association of weapon carrying and fighting on school property and other health risk and problem behaviors among high school students. *Arch Pediatr Adolesc Med* 1997;**151**(4):360–6.
- Escobedo RG, Reddy M, DuRant RH. Relationship between cigarette smoking and health risk and problem behaviors among US adolescents. *Arch Pediatr Adolesc Med* 1997;**151**(1):66–71.
- Biglan A, Brennan PA, Foster SL *et al.* *Helping Adolescents at Risk—Prevention of Multiple Problem Behaviors*. London: The Guildoford Press, 2004.
- Cook PA, Harkins C, Morleo M *et al.* *Contributions of Alcohol Use to Teenage Pregnancy and Sexually Transmitted Infection Rates*. Liverpool: Liverpool John Moores University, 2010.
- Ellickson PL, Tucker JS, Klein DJ. Ten-year prospective study of public health problems associated with early drinking. *Pediatrics* 2003;**111**(5:Pt 1):t-55.
- Stueve A, O'Donnell LN. Early alcohol initiation and subsequent sexual and alcohol risk behaviors among urban youths. *Am J Public Health* 2005;**95**(5):887–93.

- 30 Chassin L, Pitts SC, Probst J. Binge drinking trajectories from adolescence to emerging adulthood in a high-risk sample: predictors and substance abuse outcomes. *J Consult Clin Psychol* 2002;**70**(1):67–78.
- 31 Bellis MA, Morleo M, Hughes K *et al.* A cross-sectional survey of compliance with national guidance for alcohol consumption by children: measuring risk factors, protective factors and social norms for excessive and unsupervised drinking. *BMC Public Health* 2010;**10**:547–55.
- 32 Standerwick K, Davies C, Tucker L *et al.* Binge drinking, sexual behaviour and sexually transmitted infection in the UK. *Int J STD AIDS* 2007;**18**:810–3.
- 33 Baliunas D, Rehm J, Irving H *et al.* Alcohol consumption and risk of incident human immunodeficiency virus infection: a meta-analysis. *Int J Public Health* 2010;**55**:159–66.
- 34 Taylor BJ, Shield KD, Rehm JT. Combining best evidence: a novel method to calculate the alcohol-attributable fraction and its variance for injury mortality. *BMC Public Health* 2011;**11**:265.
- 35 World Health Organization. Alcohol and injuries. Emergency department studies in an international perspective. In: Cherpitel C, Borges G, Giesbrecht N *et al.* (eds). Geneva: World Health Organization, 2009.
- 36 Hibbell B, Guttormsson U, Ahlstrom S *et al.* Substance use among students in 35 European countries. The 2007 ESPAD report. Stockholm, Sweden: The Swedish Council for Information on Alcohol and Other Drugs, 2009.
- 37 British Medical Association. Alcohol use: tackling the UK epidemic. UK: BMA, 2008.
- 38 North West Public Health Observatory. Local alcohol profiles for England, 2011. <http://www.lape.org.uk> (accessed December 2011).
- 39 Rickards L, Fox K, Roberts C *et al.* *Living in Britain: Results from the 2002 General Household Survey*. Office for National Statistics, 2004.
- 40 Sweeting H, Jackson C, Haw S. Changes in the socio-demographic patterning of late adolescent health risk behaviours during the 1990s: analysis of two West of Scotland cohort studies. *BMC Public Health* 2011;**11**:829.
- 41 Robinson S, Harris H. Smoking and drinking among adults, 2009. In: Dunstan S (ed.). A report on the 2009 General Lifestyle Survey. Office for National Statistics, 2011.
- 42 Leon DA, McCambridge J. Liver cirrhosis mortality rates in Britain from 1950 to 2002: an analysis of routine data. *Lancet* 2006;**367**:52–6.
- 43 NHS Information Centre. Statistics on alcohol: England, 2011. The Health and Social Care Information Centre, Lifestyle Statistics, 2011.
- 44 Department of Health. Guidance on the consumption of alcohol by children and young people. London: Department of Health, 2009.
- 45 Smith L, Foxcroft D. *Drinking in the UK: An Exploration of Trends*. York, UK: Joseph Rowntree Foundation, 2009.
- 46 Wilsnack RW, Vogeltanz ND, Wilsnack SC *et al.* Gender differences in alcohol consumption and adverse drinking consequences: cross-cultural patterns. *Addiction* 2000;**95**:251–65.
- 47 Wilsnack RW, Wilsnack SC, Kristjanson AF *et al.* Gender and alcohol consumption: patterns from the multinational GENACIS project. *Addiction* 2009;**104**:1487–500.
- 48 Melotti R, Heron J, Hickman M *et al.* Adolescent alcohol and tobacco use and early socioeconomic position: the ALSPAC birth cohort. *Pediatrics* 2011;**127**:e948.
- 49 Macleod J, Hickman M, Bowen E *et al.* Parental drug use, early adversities, later childhood problems and children's use of tobacco and alcohol at age 10: birth cohort study. *Addiction* 2008;**103**:1731–43.
- 50 Faeh D, Viswanathan B, Chiolerio A *et al.* Clustering of smoking, alcohol drinking and cannabis use in adolescents in a rapidly developing country. *BMC Public Health* 2006;**6**:169–76.
- 51 Heron J, Macleod J, Munafo MR *et al.* Patterns of alcohol use in early adolescence predict problem use at age 16. *Alcohol Alcohol* 2012 Jan 2 [epub ahead of print] doi: 10.1093/alcalc/agr156.
- 52 Donovan JE. Estimated blood alcohol concentrations for child and adolescent drinking and their implications for screening instruments. *Pediatrics* 2009;**123**(6):e975–81.
- 53 Wagner FA, Anthony JC. Into the world of illegal drug use: exposure opportunity and other mechanisms linking the use of alcohol, tobacco, marijuana, and cocaine. *Am J Epidemiol* 2002;**155**(10):918–25.
- 54 McCarty Ca, Ebel BE, Garrison MM *et al.* Continuity of binge and harmful drinking from late adolescence to early adulthood. *Pediatrics* 2004;**114**:714–19.
- 55 Mathurin P, Deltenre P. Effect of binge drinking on the liver: an alarming public health issue? *Gut* 2009;**58**.
- 56 Meltzer H, Brugha T, Bebbington P *et al.* Adult psychiatric morbidity in England, 2007. Results of a household survey, 2007.
- 57 Morleo M, Dedman D, Farrell IO *et al.* Alcohol-attributable hospital admissions: segmentation series report 3. Liverpool, UK: North West Public Health Observatory.
- 58 Jones L, Bellis M, Dedman D *et al.* *Alcohol-attributable Fractions for England. Alcohol Attributable Mortality and Hospital Admissions*. Liverpool, UK: Centre for Public Health, Liverpool John Moores University, 2008.
- 59 Degenhardt L, Chiu W-T, Sampson N *et al.* Toward a global view of alcohol, tobacco, cannabis, and cocaine use: findings from the WHO World Mental Health Surveys. *PLoS Med* 2008;**5**.
- 60 Guerri C, Pascual M. Mechanisms involved in the neurotoxic, cognitive, and neurobehavioral effects of alcohol consumption during adolescence. *Alcohol* 2010;**44**:15–26.
- 61 Lenroot RK, Giedd JN. Sex differences in the adolescent brain. *Brain Cogn* 2010;**72**:46–55.
- 62 Giedd JN. The teen brain: insights from neuroimaging. *J Adolesc Health* 2008;**42**:335–43.
- 63 Caldwell LC, Schweinsburg AD, Nagel BJ *et al.* Gender and adolescent alcohol use disorders on BOLD (blood oxygen level dependent) response to spatial working memory. *Alcohol* 2005;**40**.
- 64 Keyes KM, Li G, Hasin DS. Birth cohort effects and gender differences in alcohol epidemiology: a review and synthesis. *Alcohol Clin Exp Res* 2011;**35**(12):2101–12.
- 65 Seedat S, Scott KM, Angermeyer MC *et al.* Cross national associations between mental disorders in the WHO world mental health surveys. *Arch Gen Psychiatry* 2009;**66**(7):785–95.

- 66 Kuntsche S, Knibbe Ra, Kuntsche E *et al.* Housewife or working mum—each to her own? The relevance of societal factors in the association between social roles and alcohol use among mothers in 16 industrialized countries. *Addiction* 2011;**106**.
- 67 Graham K, Bernards S, Knibbe R *et al.* Alcohol-related negative consequences among drinkers around the world. *Addiction* 2011;**106**:1391–405.
- 68 Graham K, Wilsnack R, Dawson D *et al.* Should alcohol consumption measures be adjusted for gender differences? *Addiction* 1998;**93**(8):1137–47.
- 69 Wilson LC, Scarpa A. The link between sensation seeking and aggression: a meta-analytic review. *Aggress Behav* 2011;**37**.
- 70 Curcio AL, George AM. Selected impulsivity facets with alcohol use/problems: the mediating role of drinking motives. *Addict Behav* 2011;**36**: 102–7.
- 71 Shin SH, Hong HG, Jeon S-M. Personality and alcohol use: the role of impulsivity. *Addict Behav* 2011;**37**:959–64.
- 72 Auger N, Lo E, Cantinotti M *et al.* Impulsivity and socio-economic status interact to increase the risk of gambling onset among youth. *Addiction* 2010;**105**.
- 73 Hales J, Nevill C, Pudney S *et al.* *Longitudinal Analysis of the Offending, Crime and Justice Survey 2003–06*. London: Home Office, 2010.
- 74 Madge N, Hawton K, McMahon EM *et al.* Psychological characteristics, stressful life events and deliberate self-harm: findings from the Child & Adolescent Self-harm in Europe (CASE) study. *Eur Child Adolesc Psychiatry* 2011;**20**.
- 75 NHS Information Centre. Health survey for England 2008. In: Craig R, Mindell J, Hirani V (eds). Physical activity and fitness. The Health and Social Care Information Centre, 2009.
- 76 Department of Health. At least five a week. Evidence on the impact of physical activity and its relationship to health. A report from the Chief Medical Officer. Health (San Francisco). London: Department of Health, 2004.