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The effects of alcohol use on academic achievement in high school

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ABSTRACT

This paper examines the effects of alcohol use on high school students' quality of learning. We estimate fixed-effects models using data from the National Longitudinal Study of Adolescent Health. Our primary measure of academic achievement is the student's grade point average (GPA) abstracted from official school transcripts. We find that increases in alcohol consumption result in small yet statistically significant reductions in GPA for male students and in statistically non-significant changes for females. For females, however, higher levels of drinking result in self-reported academic difficulty. The fixed-effects results are substantially smaller than OLS estimates, underscoring the importance of addressing unobserved individual heterogeneity.

1. Introduction

In the United States, one in four individuals between the ages of 12 and 20 drinks alcohol on a monthly basis, and a similar proportion of 12th graders consumes five or more drinks in a row at least once every two weeks (Newes-Adeyi, Chen, Williams, & Faden, 2007). Several studies have reported that alcohol use during adolescence affects educational attainment by decreasing the number of years of schooling and the likelihood of completing school (Chatterji & DeSimone, 2005; Cook & Moore, 1993; Gil-Lacruz & Molina, 2007; Koch & McGeary, 2005; McCluskey, Krohn, Lizotte, & Rodriguez, 2002; NIDA, 1998; Renna, 2007; Yamada, Kendrix, & Yamada, 1996) Other research using alternative estimation techniques suggests that the effects of teen drinking on years of education and schooling completion are very small and/or non-significant (Chatterji, 2006; Dee & Evans, 2003; Koch & Ribar, 2001).

Despite a growing literature in this area, no study has convincingly answered the question of whether alcohol consumption inhibits high school students' learning. Alcohol consumption could be an important determinant of how much a high school student learns without having a strong impact on his or her decision to stay in school or attend college. This question is fundamental and timely, given recent research showing that underage drinkers are susceptible to the immediate consequences of alcohol use, including blackouts, hangovers, and alcohol poisoning, and are at elevated risk of neurodegeneration (particularly in regions of the brain responsible for learning and memory), impairments in functional brain activity, and neurocognitive defects (Zeigler et al., 2004).

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A common and comprehensive measure of high school students' learning is grade point average (GPA). GPA is an important outcome because it is a key determinant of college admissions decisions and of job quality for those who do not attend college. Only a few studies have explored the association between alcohol use and GPA. Wolaver (2002) and Williams, Powell, and Wechsler (2003) have studied this association among college students, while DeSimone and Wolaver (2005) have investigated the effects of underage drinking on GPA during high school. The latter study found a negative association between high school drinking and grades, although it is not clear whether the effects are causal or the result of unobserved heterogeneity.

Understanding the relationship between teenage drinking and high school grades is pertinent given the high prevalence of alcohol use among this age cohort and recent research on adolescent brain development suggesting that early heavy alcohol use may have negative effects on the physical development of brain structure (Brown, Tapert, Granholm, & Delis, 2000; Tapert & Brown, 1999). By affecting the quality of learning, underage drinking could have an impact on both college admissions and job quality independent of its effects on years of schooling or school completion.

In this paper, we estimate the effects of drinking in high school on the quality of learning as captured by high school GPA. The analysis employs data from Waves 1 and 2 of the National Longitudinal Study of Adolescent Health (Add Health), a nationally representative study that captures health-related behaviors of adolescents in grades 7 through 12 and their outcomes in young adulthood. Our analysis contributes to the literature in several ways. First, we focus on the effect of drinking on academic achievement during high school. To date, and to the best of our knowledge, only one other study in the literature has analyzed the consequences of underage drinking on high school GPA. Second, rather than rely on self-reported GPA, we use objective GPA data from academic transcripts, reducing the potential for systematic biases in the estimation results. Third, we take advantage of the longitudinal nature of the Add Health data and use fixed-effects models to purge the analysis of time invariant unobserved heterogeneity. Fixed-effects techniques are superior to instrumental variables (IV) estimation when the strength and reliability of the instruments are suspect (French & Popovici, 2009). Finally, we explore a variety of mechanisms that could underlie a detrimental effect of alcohol use on grades. In addition to analyzing mediators related to exposure to education (days of school skipped), we investigate the effect of drinking on students' ability to focus on and adhere to academic objectives.

2. Background and significance

Behavioral research has found that educational performance is highly correlated with substance abuse (e.g., Bukstein, Cornelius, Trunzo, Kelly, & Wood, 2005; Hawkins, Catalano, & Miller, 1992). Economic studies that look at the link between alcohol use and educational outcomes have customarily focused on measures of educational attainment such as graduation (from high school or college), college matriculation, and years of school completed (e.g., Bray, Zarkin, Ringwalt, & Qi, 2000; Chatterji, 2006; Cook & Moore, 1993; Dee & Evans, 2003; Koch & Ribar, 2001; Mullahy & Sindelar, 1994; Renna, 2008; Yamada et al., 1996). Consistent with the behavioral research, early economic studies found that drinking reduced educational attainment. But the most rigorous behavioral studies and the early economic studies of attainment both faced the same limitation: they were cross-sectional and subject to potential omitted variables bias. Some of these cross-sectional economic studies attempted to improve estimation by using instrumental variables (IV). Cook and Moore (1993) and Yamada et al. (1996) found that heavy or frequent drinking in high school adversely affects high school and college completion. Nevertheless, the validity and reliability of the instruments in these studies are open to debate (Chatterji, 2006; Dee & Evans, 2003; French & Popovici, 2009).

By contrast, more recent economic studies that arguably use better estimation methods have found that drinking has modest or negligible effects on educational attainment. Dee and Evans (2003) studied the effects of teen drinking on high school completion, college entrance, and college persistence. Employing changes in the legal drinking age across states over time as an instrument, they found no significant effect of teen drinking on educational attainment. Koch and Ribar (2001) reached a similar conclusion applying family fixed effects and instrumental variables to NLSY data. Though they found that drinking had a significant negative effect on the amount of schooling completed among men, the effect was small. Finally, Chatterji (2006) used a bivariate probit model of alcohol use and educational attainment to gauge the sensitivity of the estimates to various assumptions about the correlation of unobservable determinants of these variables. She concluded that there is no evidence of a causal relationship between alcohol use and educational attainment when the correlation coefficient is fixed at plausible levels.

Alcohol use could conceivably affect a student's quality of learning and academic performance regardless of its impact on school completion. This possibility is suggested by Renna (2008), who uses a research design similar to that used by Dee and Evans (2003) and finds that although binge drinking does not affect high school completion rates, it does significantly increase the probability that a student graduates with a GED rather than a high school diploma. Drinking could affect learning through a variety of mechanisms. Recent neurological research suggests that underage drinking can impair learning directly by causing alterations in the structure and function of the developing brain with consequences reaching far beyond adolescence (Brown et al., 2000; White & Swartzwelder, 2004). Negative effects of alcohol use can emerge in areas such as planning and executive functioning, memory, spatial operations, and attention (Brown et al., 2000; Giancola & Mezzich, 2000; Tapert & Brown, 1999). Alcohol use could also affect performance by reducing the number of hours committed to studying, completing homework assignments, and attending school.

We are aware of five economic studies that have examined whether drinking affects learning per se. Bray (2005) analyzed this issue indirectly by studying the effect of

high school students' drinking on subsequent wages, as mediated through human capital accumulation. He found that moderate high school drinking had a positive effect on returns to education and therefore on human capital accumulation. Heavier drinking reduced this gain slightly, but net effects were still positive. The other four studies approached the question directly by focusing on the association between drinking and GPA. Three of the GPA studies used data from the Harvard College Alcohol Study. Analyzing data from the study's 1993 wave, both Wolaver (2002) and Williams et al. (2003) estimated the impact of college drinking on the quality of human capital acquisition as captured by study hours and GPA. Both studies found that drinking had a direct negative effect on GPA and an indirect negative effect through reduced study hours. Wolaver (2007) used data from the 1993 and 1997 waves and found that both high school and college binge drinking were associated with lower college GPA for males and females. For females, however, study time in college was negatively correlated with high school drinking but positively associated with college drinking.

To our knowledge, only one study has looked specifically at adolescent drinking and high school GPA. Analyzing data from the Youth Risk Behavior Survey, DeSimone and Wolaver (2005) used standard regression analysis to estimate whether drinking affected high school GPA. Even after controlling for many covariates, they found that drinking had a significant negative effect. Their results showed that the GPAs of binge drinkers were 0.4 points lower on average for both males and females. They also found that the effect of drinking on GPA peaked for ninth graders and declined thereafter and that drinking affected GPA more by reducing the likelihood of high grades than by increasing the likelihood of low grades.

All four GPA studies found that drinking has negative effects on GPA, but they each faced two limitations. First, they relied on self-reported GPA, which can produce biased results due to recall mistakes and intentional misreporting (Zimmerman, Caldwell, & Bernat, 2006). Second, they used cross-sectional data. Despite these studies' serious efforts to address unobserved individual heterogeneity, it remains questionable whether they identified a causal link between drinking and GPA.

In sum, early cross-sectional studies of educational attainment and GPA suggest that drinking can have a sizeable negative effect on both outcomes. By contrast, more recent studies of educational attainment that use improved estimation methods to address the endogeneity of alcohol use have found that drinking has negligible effects. The present paper is the first study of GPA that controls for individual heterogeneity in a fixed-effects framework, and our findings are consistent with the more recent studies of attainment that find small or negligible effects of alcohol consumption.

3. Data

Add Health is a nationally representative study that catalogues health-related behaviors of adolescents in grades 7 through 12 and associated outcomes in young adulthood. An initial in-school survey was administered to 90,118 students attending 175 schools during the 1994/1995 school year. From the initial in-school sample, 20,745 students (and their parents) were administered an additional in-home interview in 1994–1995 and were re-interviewed one year later. In 2001–2002, Add Health respondents (aged 18–26) were re-interviewed in a third wave to investigate the influence of health-related behaviors during adolescence on individuals when they are young adults. During the Wave 3 data collection, Add Health respondents were asked to sign a Transcript Release Form (TRF) that authorized Add Health to identify schools last attended by study participants and request official transcripts from the schools. TRFs were signed by approximately 92% of Wave 3 respondents (about 70% of Wave 1 respondents).

The main outcome of interest, GPA, was abstracted from school transcripts and linked to respondents at each wave. Because most of the in-home interviews during Waves 1 and 2 were conducted during the Spring or Summer (at the end of the school year) and alcohol use questions referred to the past 12 months, we linked the in-home questionnaires with GPA data corresponding to the school year in which the respondent was enrolled or had just completed at the time of the interview.

The in-home questionnaires in Waves 1 and 2 offer extensive information on the student's background, risk-taking behaviors, and other personal and family characteristics. These instruments were administered by computer assisted personal interview (CAPI) and computer assisted self-interview (CASI) techniques for more sensitive questions such as those on alcohol, drug, and tobacco use. Studies show that the mode of data collection can affect the level of reporting of sensitive behaviors. Both traditional self-administration and computer assisted self-administered interviews have been shown to increase reports of substance use or other risky behaviors relative to interviewer-administered approaches (Azevedo Simoes, Bastos, Moreira, Lynch, & Metzger, 2006; Tourangeau & Smith, 1996; Wright, Aquilino, & Supple, 1998). Several measures of alcohol use were constructed on the basis of the CAPI/CASI questions: (1) whether the student drank alcohol at least once per week in the past 12 months, (2) whether the student binged (drank five or more drinks in a row) at least once per month in the past 12 months, (3) the average number of days per month on which the student drank in the past 12 months, (4) the average number of drinks consumed on any drinking day in the past 12 months, and (5) the total number of drinks per month consumed by the student in the past year.

Individual characteristics obtained from the in-home interviews included age, race, gender, grade in school, interview date, body mass index, religious beliefs and practices, employment status, health status, tobacco use, and illegal drug use. To capture environmental changes for respondents who changed schools, we constructed indicators for whether the respondent attended an Add Health sample school or sister school (e.g., the high school's main feeder school) in each wave. We also considered family characteristics such as family structure, whether English was spoken at home, the number of children in the household, whether the resident mother and resident father worked, whether parents worked in blue- or

white-collar jobs, and whether the family was on welfare. Finally, we took into account a number of variables describing interview and household characteristics as assessed by the interviewer: whether a parent(s) or other adults were present during the interview; whether the home was poorly kept; whether the home was in a rural, suburban, or commercial area; whether the home environment raised any safety concerns; and whether there was evidence of alcohol use in the household.

Respondents to the in-home surveys were also asked several questions about how they were doing in school. We constructed measures of how often the respondents skipped school, whether they had been suspended, and whether they were having difficulties paying attention in school, getting along with teachers, or doing their homework. We analyzed these secondary outcomes as possible mediators of an effect of alcohol use on GPA.

Our fixed-effects methodology required high school GPA data for Waves 1 and 2. For this reason, we restricted the sample to students in grades 9, 10, or 11 in Wave 1 (N = 22,792) who were re-interviewed in Waves 2 and 3 (N = 14,390), not mentally disabled (N = 13,632), and for whom transcript data were available at Wave 3 (N = 10,430). In addition, we excluded 1846 observations that had missing values on at least one of the explanatory or control variables.[1] The final sample had 8584 observations, which corresponded to Wave 1 and Wave 2 responses for 4292 students with no missing information on high school GPA or other covariates across both waves. Male respondents accounted for 48% of the sample.

Table 1 shows summary statistics for the analysis sample by wave and gender. Abstracted GPA averages 2.5 for male students and 2.8 for female students,[2] with similar values in Waves 1 and 2. Approximately 9% of males and 6% of females reported drinking alcohol at least one time per week in Wave 1. The prevalence of binge drinking (consuming five or more drinks in a single episode) at least once a month is slightly higher: 11% among males and 7% among females. On average, the frequency of drinking in Wave 1 is 1.34 days per month for male respondents and 0.94 days per month for female respondents, while drinking intensity averages 2.8 drinks per episode for males and 2.2 drinks per episode for females. By Wave 2, alcohol consumption increases in all areas for both males and females. The increases for males are larger, ranging from an 18% increase in the average number of drinks per episode to a 55% increase in the fraction who binge monthly.

Of the Wave 1 respondents, 87% of males and 90% of females had skipped school at least once in the past year, with males averaging 1.47 days skipped and females averaging 1.37 days. Further, 11% of males and 7% of females had been suspended at least once. Regarding the school difficulty measures, 50% of male respondents in Wave 1 reported at least one type of regular difficulty with school: 32% had difficulty paying attention, 15% did not get along with their teachers, and 35% had problems doing their homework. Among females, 40% had at least one difficulty: 25% with paying attention, 11% with teachers, and 26% with homework.

Table 2 tabulates changes in dichotomous measures of problem drinking by gender. Among males, 82.6% did not drink weekly in either wave; 8.1% became weekly drinkers in Wave 2; 4.8% stopped drinking weekly in Wave 2; and the remaining 4.5% drank weekly in both waves. Among females, 88.5% did not drink weekly in either wave; 5.3% became weekly drinkers in Wave 2; 3.7% stopped drinking weekly in Wave 2; and 2.5% drank weekly in both waves. The trends in monthly binging were similar, with the number of students who became monthly bingers exceeding that of students who stopped bingeing monthly in Wave 2. The proportion of respondents reporting binge-drinking monthly in both waves (6.6% and 3.4% for men and women, respectively) was higher than the fraction of students who reported drinking weekly in both waves.

4. Empirical methods and estimation issues

We examined the impact of adolescent drinking on GPA using fixed-effects estimation techniques. The following equation captures the relationship of interest:

$$GPA_{it} = \alpha + \beta_a A_{it} + X'_{it}\beta_x + c_i + \varepsilon_{it} \quad (1)$$

where GPA_{it} is grade point average of individual i during the Wave t school year, A_{it} is a measure of alcohol consumption, X_{it} is a set of other explanatory variables, c_i are unobserved individual effects that are constant over time, ε_{it} is an error term uncorrelated with A_{it} and X_{it}, and α, β_a and β_x are parameters to estimate.

The coefficient of interest is β_a, the effect of alcohol consumption on GPA. The key statistical problem in the estimation of β_a is that alcohol consumption is likely to be correlated with individual-specific unobservable characteristics that also affect GPA. For instance, an adolescent with a difficult family background may react by shirking responsibilities at school and may, at the same time, be more likely to participate in risky activities. For this reason, OLS estimation of Eq. (1) used with cross-sectional or pooled longitudinal data is likely to produce biased estimates of β_a. In this paper, we took advantage of the two high school-administered waves in Add Health and estimated β_a using fixed-effects techniques. Because Waves 1 and 2 were only one year apart, it is likely that most unobserved individual characteristics that are correlated with both GPA and alcohol use are constant over this short period. Subtracting the mean values of each variable over

[1] Due to a significant fraction of missing responses, we imputed household income and household welfare status using both predicted values on the basis of other covariates and the sample mean for households that were also missing some of the predicting covariates. We added dummy variables to indicate when an observation was imputed.

[2] Grades and numerical grade-point equivalents have been established for varying levels of a student's academic performance. These grade-point equivalents are used to determine a student's grade-point average. Grades of A, A−, and B+ with respective grade-point equivalents of 4.00, 3.67, and 3.33 represent an "excellent" quality of performance. Grades of B, B−, and C+ with grade-point equivalents of 3.00, 2.67, and 2.33 represent a "good" quality of performance. A grade of C with grade-point equivalent of 2.00 represents a "satisfactory" level of performance, a grade of D with grade-point equivalent of 1.00 represents a "poor" quality of performance, and a grade of F with grade-point equivalent of 0.00 represents failure.

Table 1
Summary statistics.

Variable	Males ($N = 2049$)			Females ($N = 2243$)		
	Wave 1	Wave 2	Diff	Wave 1	Wave 2	Diff
Abstracted yearly GPA	2.53	2.51	−0.02	2.79	2.79	0.01
	0.87	*0.89*	*0.57*	*0.85*	*0.83*	*0.58*
Alcohol consumption measures						
Drinks alcohol at least one time per week[a]	0.09	0.13	0.03	0.06	0.08	0.02
			0.36			*0.30*
Binges (consumes ≥ 5 drinks) at least once per month[a]	0.11	0.17	0.06	0.07	0.09	0.02
			0.39			*0.30*
Average number of drinks consumed per month	10.50	13.78	3.28	5.90	8.17	2.28
	39.87	*45.28*	*50.9*	*27.17*	*37.56*	*40.75*
Average number of days per month alcohol is consumed	1.34	1.68	0.34	0.94	1.13	0.19
	3.83	*4.22*	*4.69*	*2.87*	*3.33*	*3.62*
Average number of drinks consumed per episode	2.81	3.32	0.51	2.20	2.34	0.13
	6.06	*7.14*	*8.17*	*5.17*	*4.81*	*5.87*
School information						
Grade level in school	10.02	11.02	1.00	10.00	10.99	0.98
	0.80	*0.82*	*0.28*	*0.80*	*0.82*	*0.27*
Attended sample school	0.99	0.94	0.04	0.98	0.94	0.04
			0.01			*0.01*
Attended sister school	0.01	0.01	−0.01	0.01	0.01	−0.01
			0.00			*0.00*
Interview date						
Interviewed in summer[a]	0.71	0.68	−0.03	0.74	0.67	−0.07
			0.65			*0.63*
Interviewed in fall[a]	0.18	0.01	−0.17	0.18	0.01	−0.17
			0.40			*0.39*
Household characteristics						
English spoken in home[a]	0.88	0.89	0.01	0.89	0.89	0.00
			0.17			*0.18*
Number of children in household	1.17	1.07	−0.10	1.26	1.12	−0.13
	1.11	*1.09*	*0.61*	*1.17*	*1.10*	*0.74*
Lived with mother[a]	0.96	0.95	−0.01	0.96	0.96	0.00
			0.18			*0.18*
Lived with father[a]	0.79	0.80	0.01	0.75	0.75	0.00
			0.27			*0.30*
Resident mother employed[a,b]	0.87	0.87	0.00	0.87	0.87	0.00
			0.36			*0.38*
Resident mother had white collar job[a,b]	0.65	0.66	0.01	0.63	0.63	0.00
			0.40			*0.40*
Resident father employed[a,b]	0.95	0.94	−0.01	0.95	0.95	0.00
			0.21			*0.20*
Resident father had white collar job[a,b]	0.41	0.40	0.00	0.39	0.38	−0.02
			0.39			*0.38*
Parent(s) on welfare (1% imputed)[a]	0.08	0.07	−0.01	0.09	0.08	−0.01
			0.28			*0.27*
Interviewer remarks						
Others present at interview[a]	0.23	0.15	−0.08	0.25	0.16	−0.09
			0.51			*0.52*
Parents present at interview[a]	0.18	0.10	−0.08	0.19	0.10	−0.09
			0.45			*0.45*
Residence is rural[a]	0.24	0.22	−0.02	0.25	0.23	−0.02
			0.37			*0.37*

Table 1 (*Continued*)

Variable	Males ($N = 2049$)			Females ($N = 2243$)		
	Wave 1	Wave 2	Diff	Wave 1	Wave 2	Diff
Residence is in suburb[a]	0.41	0.45	0.04	0.38	0.41	0.03
			0.52			*0.54*
Residence is in commercial area[a]	0.03	0.03	0.00	0.02	0.02	0.00
			0.19			0.18
Home poorly kept[a]	0.10	0.11	0.01	0.12	0.13	0.01
			0.33			*0.38*
Safety concern at home[a]	0.04	0.03	−0.01	0.04	0.02	−0.02
			0.23			*0.24*
Visible evidence of alcohol in household[a]	0.03	0.04	0.00	0.03	0.03	0.00
			0.24			*0.23*
Other individual time-varying control variables						
BMI	23.03	23.55	0.52	22.37	22.79	0.42
	4.37	*4.51*	*1.83*	*4.35*	*4.68*	*1.87*
Attends religious services[a]	0.60	0.57	−0.03	0.63	0.59	−0.04
			0.43			*0.43*
Religion is important[a]	0.39	0.36	−0.03	0.46	0.44	−0.01
			0.44			*0.44*
Employed[a]	0.60	0.65	0.04	0.58	0.61	0.03
			0.56			*0.55*
Hours worked[c]	7.65	11.61	3.97	6.28	9.95	3.67
	10.75	*12.58*	*12.97*	*9.85*	*11.45*	*11.78*
In good health (self-reported)[a]	0.96	0.97	0.01	0.92	0.94	0.02
			0.21			*0.31*
Smoker in the past 30 days[a]	0.15	0.17	0.02	0.14	0.17	0.03
			0.33			*0.32*
Days smoked in past 30 days	3.32	4.06	0.74	3.11	4.13	1.02
	8.82	*9.78*	*8.04*	*8.62*	*9.90*	*7.68*
Illegal drug use past 30 days[a]	0.15	0.17	0.02	0.13	0.15	0.01
			0.38			*0.36*
School attendance measures						
Days skipped	1.47	1.90	0.43	1.37	1.46	0.10
	5.42	*5.10*	*5.85*	*5.53*	*4.27*	*6.13*
Skipped at least one day[a]	0.87	0.88	0.01	0.90	0.92	0.02
			0.40			*0.34*
Suspended at least once[a]	0.11	0.11	0.00	0.07	0.06	0.00
			0.36			*0.29*
School difficulty measures: respondent had trouble at least once a week . . .						
. . .Paying attention in school[a]	0.32	0.34	0.02	0.25	0.27	0.01
			0.53			*0.48*
. . .Getting along with teachers[a]	0.15	0.14	−0.01	0.11	0.08	−0.03
			0.41			*0.35*
. . .Doing homework[a]	0.35	0.35	0.00	0.26	0.27	0.01
			0.54			*0.51*
. . .With one or more of the above[a]	0.50	0.52	0.02	0.40	0.41	0.01
			0.55			*0.54*
Time-invariant characteristics (OLS regressions)						
Age (in Wave 1 interview)	16.0			15.8		
	0.92			*0.93*		
Birth order	2.04			2.03		
	1.31			*1.16*		
Race/ethnicity indicators						
Black[a]	0.16			0.22		
Hispanic[a]	0.16			0.16		

Table 1 (*Continued*)

Variable	Males (N = 2049)			Females (N = 2243)		
	Wave 1	Wave 2	Diff	Wave 1	Wave 2	Diff
Other race (non-White)[a]	0.18			0.18		
Foreign-born[a]	0.10			0.10		
Resident mother college-educated[a,b]	0.47			0.44		
Resident father college-educated[a,b]	0.50			0.47		

Note: Based on responses to survey questions regarding most recently completed school year. Standard deviations in italics (suppressed for dummy variables).

[a] Dummy variable = 1 if statement is true.

[b] Resident mother's (father's) employment status and education are conditional on parent's presence in household; white collar job indicator is conditional on employment.

[c] Hours worked equals zero for unemployed individuals.

Table 2
Tabulation of changes in dichotomous measures of alcohol use by gender.

Change from W1 to W2 in	Males (N = 2049)	Females (N = 2243)
Weekly drinking		
0 to 0 (change = 0)	82.6%	88.5%
0 to 1 (change = +1)	8.1%	5.3%
1 to 0 (change = −1)	4.8%	3.7%
1 to 1 (change = 0)	4.5%	2.5%
Monthly binge		
0 to 0 (change = 0)	78.3%	87.8%
0 to 1 (change = +1)	10.4%	5.5%
1 to 0 (change = −1)	4.8%	3.3%
1 to 1 (change = 0)	6.6%	3.4%

time, Eq. (1) can be rewritten as:

$$(GPA_{it} = \overline{GPA_i}) = \beta_a(A_{it} - \bar{A}_i) + (X_{it} - \bar{X}_i)'\beta_x + \varepsilon_{it} \quad (2)$$

Eq. (2) eliminates time invariant individual heterogeneity (c_i) and the corresponding bias associated with OLS estimation of Eq. (1).

We estimated Eq. (2) using different sets of time-varying controls (X_{it}).[3] We began by controlling only for unambiguously exogenous variables and progressively added variables that were increasingly likely to be affected by alcohol consumption. The first set of controls included only the respondent's grade level, indicators for attending the sample school or sister school, and the date of the interview. In a second specification, we added household characteristics and interviewer remarks about the household and the interview. This specification includes indicators for the presence of parents and others during the interview and thus controls for a potentially important source of measurement error in the alcohol consumption variables.[4] The third specification added to the second specification those variables more likely to be endogenous such as BMI, religious beliefs/practices, employment, and health status. A fourth specification included tobacco and illegal drug use. By adding these behavioral controls, which could either be mediators or independent correlates of the drinking-GPA association, we examined whether the fixed-effects estimates were influenced by unmeasured time variant individual characteristics.

The fifth and sixth specifications were aimed at assessing possible mechanisms flowing from changes in alcohol use to changes in GPA. Previous research has found that part of the association between alcohol consumption and grades can be explained by a reduction in study hours. Add Health did not directly ask respondents about study effort. It did, however, ask about suspensions and days skipped from school. These school attendance variables were added to the set of controls to test whether an effect of alcohol use on human capital accumulation worked *extensively* through the quantity of, or exposure to, schooling. Alternatively, an effect of alcohol use on grades could be explained by temporary or permanent alterations in the structure and functioning of an adolescent's developing brain with resulting changes in levels of concentration and understanding (an *intensive* mechanism). To test for the mediating role of this pathway, we added a set of dichotomous variables measuring whether the student reported having trouble at least once a week with each of the following: (i) paying attention in school, (ii) getting along with teachers, and (iii) doing homework.

Finally, we considered the number of days the student skipped school and the likelihood of having difficulties with school as two alternative outcomes and estimated the association between these variables and alcohol use, applying the same fixed-effects methodology as in Eq. (2). To analyze difficulties with school as an outcome, we constructed a dichotomous variable that is equal to one if the student faced at least one of the three difficulties listed above. We estimated the effect of alcohol use on this variable using a fixed-effects logit technique.

Separate regressions were run for male and female respondents. The literature shows that males and females behave differently both in terms of alcohol use (Ham & Hope, 2003; Johnston, O'Malley, Bachman, & Schulenberg, 2007; Schulenberg, O'Malley, Bachman, Wadsworth, & Johnston, 1996; Wechsler, Davenport, Dowdall, Moeykens, & Castillo, 1994) and school achievement (Dwyer &

[3] Note that some demographics (e.g., race, ethnicity) and other variables that are constant over time do not appear in Eq. (2) because they present no variation across waves.

[4] Of particular concern is the possibility that measurement error due to misreporting varies across waves—either because of random recall errors or because of changes in the interview conditions. (For example, the proportion of interviews in which others were present declined from roughly 42% to 25% between Wave 1 and Wave 2.) Such measurement error could lead to attenuation bias in our fixed-effects model. On the other hand, reporting biases that are similar and stable over time are eliminated by the fixed-effects specification.

Johnson, 1997; Jacob, 2002; Kleinfeld, 1998). These gender differences are clearly evident in the summary statistics presented in Table 1. Furthermore, the medical literature suggests that there may be gender differences in the impact of alcohol consumption on cognitive abilities (e.g., Hommer, 2003).

In addition to examining differential effects by gender, we tested for differential effects of alcohol use along three other dimensions: age, the direction of change in alcohol use (increases vs. decreases), and initial GPA. These tests, as well as other extensions and robustness checks, are described in Section 6.

5. Results

Table 3 shows the fixed-effects estimates for β_a from Eq. (2). Each cell depicts a different model specification defined by a particular measure of alcohol use and a distinctive set of control variables. Rows (a)–(d) denote the alcohol use variable(s) in each specification, and Columns (1)–(6) correspond to the different sets of covariates. Control variables are added hierarchically from (1) to (3). We first adjusted only by grade level, sample school and sister school indicators, and interview date (Column (1)). We then added time-varying household characteristics and interviewer assessments (Column (2)), followed by other individual time-varying controls (Column (3)). Column (4) adds controls for the use of other substances, which could either be correlates or consequences of alcohol use. Columns (5) and (6) consider other potential mediators of the effects found in (1)–(3) such as days skipped, suspensions from school, and academic difficulties.

The results for males provide evidence of a negative yet small effect of alcohol use on GPA. No major changes were observed in the estimates across the different specifications that incrementally added more controls, suggesting that the results are probably robust to unmeasured time-varying characteristics. In what follows, therefore, we describe the results in Column (3), which controls for the greatest number of individual time-varying factors (with the exception of tobacco and illicit drug use). Weekly drinking and monthly binge drinking are both negatively associated with GPA, but neither of these coefficients is statistically significant (Rows (a) and (b)). The continuous measure of alcohol consumption has a statistically significant coefficient (Row (c)), suggesting that increasing one's alcohol intake by 100 drinks per month reduces GPA by 0.07 points, or 2.8% relative to the mean. The results in Row (d) suggest that variation in both the frequency and the intensity of alcohol use contributes to the estimated effect on grades. An increase of one day per month in drinking frequency reduces GPA by 0.005 points, and consumption of one additional drink per episode reduces GPA by 0.004 points.

Columns (4)–(6) report the estimates of interest after controlling for use of other substances, days skipped or suspended from school, and difficulties with school. Relative to the effects identified in Column (3), controlling for tobacco and illegal drug use reduces the negative effect of total number of drinks on GPA by 9% or 0.006 GPA points (see row (c), Column (4)). Adding the school attendance variables to the set of controls in Column (3) results in a point estimate of −0.06 or 0.01 GPA points below the coefficient in Column (3) (see Column (5)). Adding the school difficulty variables results in a reduction in GPA of 0.007 GPA points or a 10% decrease relative to the estimate in Column (3). While not shown in the table, the inclusion of both school difficulty and attendance variables as controls explains approximately 20% of the effect of alcohol use on grades, with the alcohol use estimates remaining statistically significant at the 10% level.

For females, the estimated coefficients are much smaller than those for males, and for two measures (binge-drinking and drinking frequency), the estimates are actually positive. However, none of the coefficients are statistically significant at conventional levels.[5] Interestingly, after controlling for substance use, difficulties with school, and school attendance, the estimates become less negative or more positive. But they remain statistically non significant.

Table 4 shows the effect of alcohol use on the number of school days skipped during the past year. These results are qualitatively similar to the findings for GPA, suggesting some small and statistically significant effects for males but no significant effects for females. For males, increasing the number of drinks per month by 100 leads to an additional 0.72 days skipped ($p < 0.10$) when controlling for household features, interviewer comments, and individual characteristics such as body mass index, religiosity, employment, and health status (see Column (3), Row (c)). Controlling for tobacco and illegal drug use reduces the coefficient slightly to 0.69 days. The results in Row (d) suggest that this effect is driven mainly by variation in drinking intensity, with an additional drink per episode resulting in an increase of 0.06 days skipped.

Table 5 contains estimates of the relationship between alcohol use and our dichotomous measure of having difficulty in school. For males, we found one small but statistically significant effect: consumption of an additional 100 drinks per month is associated with a 4% increase in the probability of having trouble in school. For females, the estimated coefficients are all positive and larger than those found for males, and four out of five are statistically significant. The probability of having trouble in school is roughly 11% higher for females who drink weekly relative to those who do not, and there is a similar effect for monthly binge drinking (Rows (a) and (b)). Furthermore, the likelihood of difficulties increases by 7% with an additional 100 drinks per month (Row (c)). These findings suggest that female students suffer adverse consequences from alcohol consumption, even if these effects do not translate into lower grades. Finally, in Row (d), we see that these adverse effects are driven by increases in drinking frequency rather than drinking intensity.

Our main results thus far point to two basic conclusions. After controlling for individual fixed effects, alcohol use in

[5] We tested the significance of these differences by pooling males and females and including an interaction of a gender dummy with the alcohol consumption measure in each model. We found statistically significant differences in the effects of monthly bingeing, drinks per month, and drinking days per month.

Table 3
Fixed-effects estimates; dependent variable = GPA.

Incrementally added controls	(1) Grade level + sample or sister school + interview date	(2) +Time-varying household chars. + interviewer remarks	(3) +BMI, religion, employment, health	(4) Controls as in Column (3) + drugs and tobacco	(5) Controls as in Column (3) + school attendance variables	(6) Controls as in Column (3) + school difficulty variables
Males						
(a) Drinks weekly = 1	−0.056	−0.058	−0.059	−0.040	−0.048	−0.047
	(0.039)	(0.039)	(0.039)	(0.039)	(0.038)	(0.038)
(b) Binges monthly = 1	−0.060^{+}	−0.060^{+}	−0.058	−0.040	−0.051	−0.048
	(0.036)	(0.036)	(0.035)	(0.035)	(0.035)	(0.035)
(c) #Drinks/month (100s)	−0.074*	−0.073*	−0.071*	−0.065*	−0.060^{+}	−0.064*
	(0.034)	(0.034)	(0.033)	(0.032)	(0.033)	(0.032)
(d) #Days drink/month	−0.005^{+}	−0.005^{+}	−0.005^{+}	−0.004	−0.004	−0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
#Drinks/episode	−0.004^{+}	−0.004^{+}	−0.004^{+}	−0.004^{+}	−0.004^{+}	−0.004^{+}
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Females						
(a) Drinks weekly = 1	−0.008	−0.004	−0.005	0.020	−0.001	0.005
	(0.049)	(0.049)	(0.048)	(0.048)	(0.047)	(0.047)
(b) Binges monthly = 1	0.043	0.048	0.046	0.071^{+}	0.060	0.056
	(0.043)	(0.043)	(0.042)	(0.043)	(0.042)	(0.043)
(c) #Drinks/month (100s)	0.014	0.011	0.013	0.030	0.020	0.022
	(0.045)	(0.044)	(0.043)	(0.042)	(0.043)	(0.041)
(d) #Days drink/month	0.004	0.004	0.004	0.005	0.005	0.005
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
#Drinks/episode	−0.003	−0.003	−0.002	−0.001	−0.002	−0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)

Notes: See Table 1 for list of control variables in each model specification. Robust standard errors in parentheses; (+) significant at 10%; (*) significant at 5%; (**) significant at 1%.

Table 4
Fixed-effects estimates; dependent variable = school days skipped.

Incrementally added controls	(1) Grade level + sister or sample school + interview date	(2) +Time-varying household characteristics and interviewer remarks	(3) +BMI, religion, employment, health status	(4) +Tobacco and illegal drug use
Males				
(a) Drinks weekly = 1	0.721	0.680	0.687	0.579
	(0.492)	(0.491)	(0.496)	(0.510)
(b) Binges monthly = 1	0.681	0.709	0.712	0.592
	(0.452)	(0.453)	(0.452)	(0.471)
(c) #Drinks/month (100s)	0.774*	0.731+	0.722+	0.690+
	(0.373)	(0.382)	(0.384)	(0.383)
(d) #Days drink/month	0.060	0.055	0.055	0.050
	(0.037)	(0.036)	(0.036)	(0.036)
#Drinks/episode	0.058*	0.057*	0.057*	0.056*
	(0.028)	(0.028)	(0.028)	(0.028)
Females				
(a) Drinks weekly = 1	0.599	0.534	0.556	0.412
	(0.720)	(0.726)	(0.724)	(0.702)
(b) Binges monthly = 1	0.817	0.864	0.898+	0.748
	(0.528)	(0.528)	(0.530)	(0.535)
(c) #Drinks/month (100s)	0.397	0.450	0.433	0.336
	(0.520)	(0.508)	(0.495)	(0.477)
(d) #Days drink/month	0.062	0.060	0.063	0.053
	(0.067)	(0.064)	(0.064)	(0.063)
#Drinks/episode	0.002	0.005	0.002	−0.008
	(0.042)	(0.040)	(0.039)	(0.037)

Notes: Robust standard errors in parentheses; (+) significant at 10%; (*) significant at 5%; (**) significant at 1%.

high school has a relatively minor influence on GPA. But there are also some interesting gender differences in these effects. For males, we find small negative effects on GPA that are partially mediated by increased school absences and difficulties with school-related tasks. For females, on the other hand, we find that alcohol use does not significantly affect GPA, but female drinkers encounter a higher probability of having difficulties at school.

Our basic estimates of the effects of drinking on GPA complement those of Koch and Ribar (2001), who find small effects of drinking on school completion for males and non-significant effects for females. However, our analysis of school-related difficulties suggests that females are not immune to the consequences of drinking. Namely, females are able to compensate for the negative effects of drinking (e.g., by working harder or studying more) so that their grades are unaffected. This interpretation is consistent with Wolaver's (2007) finding that binge drinking in college is associated with increased study hours for women but with reduced study hours for men. It is also reminiscent of findings in the educational psychology and sociology literatures that girls get better grades than boys, and some of this difference can be explained by gender differences in classroom behavior (Downey & Vogt Yuan, 2005) or by greater levels of self-discipline among girls (Duckworth & Seligman, 2006).

When interpreting our results, there are some important caveats to keep in mind. First, we must emphasize that they reflect the contemporaneous effects of alcohol use. As such, they say nothing about the possible cumulative effects that several years of drinking might have on academic performance. Second, we can only examine the effect of alcohol use on GPA for those students who remain in school. Unfortunately, we cannot address potential selection bias due to high school dropouts because of the high rate of missing GPA data for those students who dropped out after Wave 1.[6] Third, we acknowledge that our fixed-effects results could still be biased if we failed to account for important time-varying individual characteristics that are associated with GPA differentials across waves. It is reassuring, however, that our results are generally insensitive to the subsequent inclusion of additional time-varying (and likely endogenous) characteristics, such as health status, employment, religiosity, tobacco use, and illicit drug use. Finally, we cannot rule out possible reverse causality whereby academic achievement affects alcohol use. Future research using new waves of the data may provide further insight on this issue. In the next section, we discuss some additional issues that we are able to explore via robustness checks and extensions.

[6] If alcohol use has small or negligible effects on school completion – as found by Chatterji (2006), Dee and Evans (2003), and Koch and Ribar (2001) – then such selection bias will also be small.

Table 5
Fixed-effects logit estimates; dependent variable = difficulty with school.

Incrementally added controls	(1) Grade level + sample or sister school + interview date	(2) +Time-varying household characteristics and interviewer remarks	(3) +BMI, religion, employment, health status	(4) +Tobacco and illegal drug use
Males				
(a) Drinks weekly = 1	0.020	0.014	0.011	0.000
	(0.032)	(0.032)	(0.032)	(0.032)
(b) Binges monthly = 1	0.044	0.039	0.034	0.023
	(0.029)	(0.029)	(0.029)	(0.029)
(c) #Drinks/month (100s)	0.039*	0.037*	0.035+	0.033+
	(0.019)	(0.019)	(0.019)	(0.019)
(d) #Days drink/month	0.001	0.000	−0.000	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)
#Drinks/episode	0.002	0.002	0.002+	0.002
	(0.001)	(0.001)	(0.001)	(0.001)
Females				
(a) Drinks weekly = 1	0.110**	0.106*	0.107*	0.099*
	(0.042)	(0.042)	(0.042)	(0.043)
(b) Binges monthly = 1	0.112*	0.115*	0.113*	0.103*
	(0.045)	(0.045)	(0.045)	(0.045)
(c) #Drinks/month (100s)	0.075*	0.071*	0.072*	0.067+
	(0.034)	(0.035)	(0.034)	(0.035)
(d) #Days drink/month	0.010**	0.010**	0.010**	0.010**
	(0.003)	(0.003)	(0.003)	(0.004)
#Drinks/episode	0.004	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)

Notes: Dependent variable is a dummy variable equal to one if respondent had trouble at least once a week with one or more of the following: (1) paying attention in school, (2) getting along with teachers, or (3) doing homework. Robust standard errors in parentheses; (+) significant at 10%; (*) significant at 5%; (**) significant at 1%.

6. Robustness checks and extensions

6.1. OLS versus fixed effects

In addition to running fixed-effects models, we estimated β_a using OLS. Separate regressions were run by gender and by wave. We first regressed GPA on measures of alcohol use and the full set of time-varying controls used in the fixed-effects estimation (see Column (3), Table 3). Next, we added other time-invariant measures such as demographics, household characteristics, and school characteristics. Finally, we controlled for tobacco and illegal drug use. The comparison between fixed-effects and OLS estimates (Table A1) sheds light on the extent of the bias in $\widehat{\beta}_a^{OLS}$. For males, OLS estimates for Wave 1 were 3 to 6 times larger (more negative) than fixed-effects estimates (depending on the measure of alcohol use), and OLS estimates in Wave 2 were 3 to 4 times larger than those from the fixed-effects estimation. The bias was even more pronounced for females. Contrary to the results in Table 3, OLS estimates for females were statistically significant, quantitatively large, and usually more negative than the estimates for males.

6.2. Outlier analysis

Concerns about misreporting at the extreme tails of the alcohol use distributions led us to re-estimate the fixed-effects model after addressing these outliers. A common method for addressing extreme outliers without deleting observations is to "winsorize" (Dixon, 1960). This technique reassigns all outlier values to the closest value at the beginning of the user-defined tail (e.g., 1%, 5%, or 10% tails). For the present analysis, we used both 1% and 5% tails. As a more conventional outlier approach, we also re-estimated the models after dropping those observations in the 1% tails. In both cases we winsorized or dropped the tails using the full Wave 1 and Wave 2 distribution (in levels) and then estimated differential effects.

After making these outlier corrections, the estimates for males became larger in absolute value and more significant, but the estimates for females remained statistically non-significant with no consistent pattern of change.[7] For males, dropping the 1% tails increased the effect of 100 drinks per month on GPA to −0.15 points (from −0.07 points when analyzing the full sample). Winsorizing the 5% tails further increased the estimated effect size to −0.31 points.

We offer two possible interpretations of these results for males. First, measurement error is probably more substantial among heavier drinkers and among respondents with the biggest changes in alcohol consumption

[7] These results are not presented in the tables but are available from the authors upon request.

across waves, which could cause attenuation bias at the top end.[8] Second, the effect of drinks per month on GPA could be smaller among male heavier drinkers, suggesting non-linear effects. Interestingly, neither of these concerns appears to be important for the analysis of females.

6.3. Differential effects

Thus far we have reported the differential effects of alcohol use on GPA for males and females. Here, we consider differential effects along three other dimensions: age, direction of change in alcohol use (increases vs. decreases), and initial GPA. To examine the first two of these effects, we added to Eq. (2) interactions of the alcohol use measure with dichotomous variables indicating (i) that the student was 16 or older, and (ii) that alcohol use had decreased between Waves 1 and 2.[9] For males, the negative effects of drinking on GPA were consistently larger among respondents who were younger than 16 years old. None of the interaction terms, however, were statistically significant. We found no consistent or significant differences in the effect of alcohol consumption between respondents whose consumption increased and those whose consumption decreased between Waves 1 and 2. All results were non-significant and smaller in magnitude for females. It should be noted, however, that the lack of significant effects could be attributed, at least in part, to low statistical power as some of the disaggregated groups had less than 450 observations per wave.

To examine whether drinking is more likely to affect low achievers (those with initial low GPA) than high achievers (higher initial GPA), we estimated two fixed-effects linear probability regressions. The first regression estimated the impact of alcohol use on the likelihood of having an average GPA of C or less, and the second regression explored the effect of drinking on the likelihood of having a GPA of B− or better. For males, we found that monthly binging was negatively associated with the probability of obtaining a B− or higher average and that increases in number of drinks per month led to a higher likelihood of having a GPA of C or worse. Frequency of drinking, rather than intensity, was the trigger for having a GPA of C or worse. For females, most coefficient estimates were not significant, although the frequency of drinking was negatively associated with the probability of having a GPA of C or worse.

6.4. Self-reported versus abstracted GPA

One of the key advantages of using Add Health data is the availability of abstracted high school grades. Because most educational studies do not have such objective data, we repeated the fixed-effects estimation of Eq. (2) using self-reported GPA rather than transcript-abstracted GPA. To facilitate comparison, the estimation sample was restricted to observations with both abstracted and self-reported GPA ($N = 2164$ for males and 2418 for females).

The results reveal another interesting contrast between males and females. For males, the results based on self-reported grades were fairly consistent with the results based on abstracted grades, although the estimated effects of binging and drinking intensity were somewhat larger (i.e., more negative) when based on self-reported grades. But for females, the results based on self-reported grades showed positive effects of alcohol consumption that were statistically significant at the 10% level for three out of five consumption measures (monthly binging, total drinks per month, and drinks per episode). Furthermore, with the exception of the frequency measure (drinking days per month), the estimated effects were all substantially larger (i.e., more positive) when based on self-reported GPA. This suggests that females who drink more intensively tend to inflate their academic performance in school, even though their actual performance is not significantly different from that of those who drink less. Males who drink more intensely, on the other hand, may tend to deflate their academic accomplishments.

6.5. Analysis of dropouts

In Table 3, we estimated the effects of alcohol consumption on GPA conditional on being enrolled in school during the two observation years. While increased drinking could lead an adolescent to drop out of school, reduced drinking could lead a dropout to re-enroll. Our GPA results do not address either of these possible effects. Of those who were in 9th grade in Wave 1, roughly 2.3% dropped out before Wave 2. Of those who were in 10th and 11th grades in Wave 1, the dropout rates were 3.7% and 5.0%, respectively. Our core estimates would be biased if the effect of alcohol use on GPA for non-dropouts differed systematically from the unobserved effect of alcohol use on GPA for dropouts and re-enrollers in the event that these students had stayed in school continuously.

To determine whether dropouts differed significantly from non-dropouts, we compared GPA and drinking patterns across the two groups. Unfortunately, dropouts were much more likely to have missing GPA data for the years they were in school,[10] so the comparison itself has some inherent bias. Nevertheless, for those who were not missing Wave 1 GPA data, we found that mean GPA was significantly lower for dropouts (1.11) than for those students who stayed in school at least another year (2.66). Dropouts were also older in Wave 1 (16.9 vs. 15.9 years old) and more likely to be male (54% vs. 48%). They also consumed alcohol more often and with greater intensity in the first wave. While there is evidence of differences across the two groups in Wave 1, it is unclear whether dropouts would have differed systematically with respect to changes in GPA and in drinking behavior over time if they had stayed in school. Due to the small number of dropout observations

[8] Examination of the outliers showed that only 15% of those who reported a total number of drinks above the 95th percentile of the distribution did so in both waves.

[9] These fixed-effects regressions were adjusted by the same set of controls as in Table 3, Column (3).

[10] More than two-thirds of those who dropped out between Waves 1 and 2 were missing Wave 1 GPA data.

with Wave 1 GPA data, we could not reliably estimate a selection correction model.

6.6. Attrition and missing data

As described in the data section, a large fraction of the Add Health respondents who were in 9th, 10th, or 11th grade in Wave 1 were excluded from our analysis either because they did not participate in Waves 2 or 3, did not have transcript data, or had missing data for one or more variables used in the analysis. (The excluded sample consisted of 7104 individuals out of a total of 11,396 potentially eligible.) Mean characteristics were compared for individuals in the sample under analysis ($N = 4292$) and excluded respondents ($N = 7104$) in Wave 1. Those in the analysis sample had higher GPAs (both self-reported and abstracted, when available) and were less likely to have difficulties at school, to have been suspended from school, or to have skipped school. They were less likely to drink or to drink intensively if they drank. They were more likely to be female and White, speak English at home, have highly educated parents, have a resident mother or father at home, and be in good health. They were less likely to have parents on welfare, live in commercial areas or poorly kept buildings, and smoke and use drugs.

The above comparisons suggest that our estimates are representative of the sample of adolescents who participated in Waves 2 and 3 but not necessarily of the full 9th, 10th, and 11th grade sample interviewed at baseline. To assess the magnitude and sign of the potential attrition bias in our estimates, we considered comparing fixed-effects estimates for these two samples using self-reported GPA as the dependent variable. But self-reported GPA also presented a considerable number of missing values, especially for those in the excluded sample at Wave 2. Complete measures of self-reported GPA in Waves 1 and 2 were available for 60% of the individuals in the analysis sample and for less than 30% of individuals in the excluded sample.

As an alternative check, we used OLS to estimate the effects of alcohol use on self-reported GPA in Wave 1 for the excluded sample, and compared these to OLS coefficients for our analysis sample in Wave 1. The effects of alcohol use on self-reported grades were smaller for individuals excluded from our core analysis. Because the excluded individuals tend to consume more alcohol, the finding of smaller effects for these individuals is consistent with either of the two explanations discussed in Section 6.2. First, the effect of consuming alcohol on GPA could be smaller for those who drink more. And second, measurement error is probably more serious among heavier drinkers, potentially causing more attenuation bias in this sample.

To summarize, the analysis described above suggests that some caution should be exercised when extrapolating the results in this paper to other populations. Due to missing data, our analysis excludes many of the more extreme cases (in terms of grades, substance use, and socioeconomic status). However, our analysis suggests that the effects of alcohol use on grades are, if anything, smaller for these excluded individuals. It therefore supports our main conclusions that the effects of alcohol use on GPA tend to be small and that failure to account for unobserved individual heterogeneity is responsible for some of the large negative estimates identified in previous research.

7. Conclusion

Though a number of investigations have studied the associations between alcohol use and years of schooling, less is known about the impact of adolescent drinking on the process and quality of learning for those who remain in school. Moreover, studies that have examined the impact of drinking on learning have faced two important limitations. First, they have relied on self-reported grades as the key measure of learning and are therefore subject to potential biases that result from self-reporting. Second, they have relied on cross-sectional data and suffer from potential biases due either to unobserved individual heterogeneity or to weak or questionable instrumental variables.

In the present study, we contribute to the existing literature by exploiting several unique features of the nationally representative Add Health survey. First, we measure learning with grade point averages obtained from the respondents' official school transcripts. Second, we exploit Add Health's longitudinal design to estimate models with individual fixed effects. This technique eliminates the bias that results from time-invariant unobserved individual heterogeneity in the determinants of alcohol use and GPA. Finally, we explore a variety of pathways that could explain the association between alcohol use and grades. In particular, we examine the effects of alcohol consumption on both the quantity of schooling – as measured by days of school skipped – and the quality – as measured by difficulties with concentrating in school, getting along with teachers, or completing homework.

The main results show that, in general, increases in alcohol consumption result in statistically significant but quantitatively small reductions in GPA for male students and in statistically non-significant changes for females. For both males and females, comparisons of the fixed-effects models with standard cross-sectional models suggest that large biases can result from the failure to adequately control for unobserved individual heterogeneity. Our findings are thus closely aligned with those of Koch and Ribar (2001) and Dee and Evans (2003), who reach a similar conclusion regarding the effects of drinking on school completion.

Our analysis also reveals some interesting gender differences in how alcohol consumption affects learning in high school. Our results suggest that for males, alcohol consumption has a small negative effect on GPA and this effect is partially mediated by increased school absences and by difficulties with school-related tasks. For females, however, we find that alcohol use does not significantly affect GPA, even though it significantly increases the probability of encountering difficulties at school. Gender differences in high school performance are well documented in the educational psychology and sociology literatures, yet no previous studies have estimated gender differences in high school learning that are directly associated with alcohol use. Our study is therefore unique in that regard.

Table A1
OLS cross-sectional estimates; dependent variable = GPA.

	Estimates based on Wave 1			Estimates based on Wave 2		
	(1) Controls as in Table 3, column (3)	(2) +Time-invariant demographics, household characteristics, and school fixed effects	(3) +Tobacco and illegal drug use	(4) Controls as in Table 3, column (3)	(5) +Time-invariant demographics, household characteristics, and school fixed effects	(6) +Tobacco and illegal drug use
Males						
(a) Drinks weekly = 1	−0.332**	−0.330**	−0.194**	−0.214**	−0.317**	−0.157*
	(0.062)	(0.068)	(0.070)	(0.059)	(0.065)	(0.062)
(b) Binges monthly = 1	−0.358**	−0.399**	−0.219**	−0.189**	−0.309**	−0.157**
	(0.057)	(0.068)	(0.069)	(0.049)	(0.053)	(0.054)
(c) #Drinks/month (100s)	−0.203**	−0.237**	−0.137*	−0.146**	−0.257**	−0.169**
	(0.048)	(0.055)	(0.057)	(0.051)	(0.056)	(0.047)
(d) #Days drink/month	−0.017**	−0.019**	−0.012*	−0.013*	−0.017**	−0.008
	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)
#Drinks/episode	−0.012**	−0.016**	−0.009*	−0.005+	−0.012**	−0.008**
	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Females						
(a) Drinks weekly = 1	−0.363**	−0.349**	−0.083	−0.346**	−0.334**	−0.115+
	(0.074)	(0.082)	(0.085)	(0.063)	(0.068)	(0.066)
(b) Binges monthly = 1	−0.355**	−0.398**	−0.081	−0.302**	−0.277**	−0.052
	(0.067)	(0.075)	(0.075)	(0.060)	(0.067)	(0.067)
(c) #Drinks/month (100s)	−0.221**	−0.353**	−0.125+	−0.201**	−0.256**	−0.110*
	(0.080)	(0.083)	(0.075)	(0.052)	(0.060)	(0.054)
(d) #Days drink/month	−0.025**	−0.009	−0.004	−0.024**	−0.023**	−0.009
	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
#Drinks/episode	−0.011**	−0.001	−0.010*	−0.010**	−0.014**	−0.005
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)

Notes: Robust standard errors in parentheses; (+) significant at 10%; (*) significant at 5%; (**) significant at 1%.

Finally, our study also highlights the potential pitfalls of using self-reported grades to measure academic performance. Not only do we find evidence that use of self-reports leads to bias; we also find that the bias differs by gender, as drinking is associated with grade inflation among females and grade deflation among males. Hence, the conceptual discoveries uncovered in this research may be as important for future investigations as the empirical results are for current educational programs and policies.

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Appendix A.

See Table A1.

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