Addictive Behaviors 35 (2010) 337–342

Contents lists available at ScienceDirect

Addictive Behaviors

Social network effects in alcohol consumption among adolescents

Mir M. Ali [a,*], Debra S. Dwyer [b,1]

[a] Department of Economics, University of Toledo, Toledo, OH 43606-3390, USA
[b] School of Health, Technology & Management and Department of Economics, Stony Brook University, Stony Brook, New York 11794-8204, USA

ARTICLE INFO

Keywords:
Adolescent drinking
Peer measurements
Peer influence

ABSTRACT

In this paper we seek to empirically quantify the role of peer social networks in explaining drinking behavior among adolescents. Using data from a nationally representative sample of adolescents we utilize a multivariate structural model with school-level fixed effects to account for the problems of contextual effects, correlated effects and peer selection to purge the potential biases from the estimates of peer influence. Our peer group measures are drawn not only from the nomination of close friends, but also from classmates. Drinking behavior among the peer groups was constructed using the peers' own report of their alcohol consumption. Controlling for parent level characteristics, and other demographic parameters, we find that a 10% increase in the proportion of classmates who drink will increase the likelihood of drinking participation and frequency by approximately four percentage points. We also find evidence to show that the influence of close friends, while still significant, diminishes in magnitude after accounting for unobserved environmental confounders. Our findings support the literature that peer effects are important determinants of drinking behavior even after controlling for potential biases. Effective policy aimed at reducing alcohol consumption among adolescents would consider these significant peer effects.

1. Introduction

Alcohol consumption among adolescents is a major public health concern in the United States (Kosterman, Hawkins, Guo, Catalon, & Abbott, 2000; Johnston, O'Malley, Bachman, 2003). A 2000 Center for Disease Control and Prevention (CDC) study revealed that a third of all youths surveyed report beginning to drink before the age of 13. In addition, a high prevalence of alcohol use and a trend toward earlier onset have been observed among middle and high school students (Guo, Elder, Cai, & Hamilton, 2009). Besides being associated with poor outcomes such as type II diabetes, coronary artery disease, cardiac arrhythmias and stroke (Puddey, Rakic, Dimmitt, & Beilin, 1999), adolescent drinking is also correlated with risk behaviors, such as poor school performance, violence, delinquency and suicide (Windle, 2003; Moore et al., 2005).

Research on adolescent substance use has consistently identified a strong relationship between adolescent behavior and the behavior of their peers (Clark & Loheac, 2007; Evans, Gilpin, Farkas, Shenassa, & Piere, 1995; Lundborg, 2006; Norton, Lindrooth, & Ennett, 1998). From a policy perspective, the potential existence and the magnitude of the social network effects are of interest since "peer effects may serve to amplify the effects of interventions" (Lundborg, 2006). However, peer effects are difficult to estimate and causal interpretations must be undertaken with caution since individuals in most cases choose with whom to associate (Bullers, Cooper, & Russell, 2001; Kremer & Levy, 2008). In other words, estimates without accounting for peer selection are unable to identify accurately whether an individual's behavioral choices in some way vary with behavior of the reference group (Manski, 1993). Peer selection implies that the correlation in behavior could be attributed to the similarity among individuals, whereas, peer influence implies that the correlation is due to the peer behavior. Disentangling the peer influence from spurious unobserved factors associated with peer selection (Alexander, Piazza, Mekos, & Valente, 2001; Bullers et al., 2001) is important if we are to accurately predict the success of policies aimed at reducing alcohol consumption among adolescents. Thus, if there are common underlying attributes of individuals within a peer group that drive behavior more than peer influence, policies aimed at taking advantage of peer influence may not realize the desired effects (Ali & Dwyer, 2009).

Building on the existing literature on peer effects we extend our analysis by empirically quantifying the role of the peer social network to explain alcohol consumption behavior among adolescents. Our peer measures are drawn not only from the nomination of close friends, but also from classmates within a grade. This allows us to identify the differences in effects that could be exerted by different compositions of reference groups. It is also important to note that our second reference group is not driven by selective peer sorting (Clark & Loheac, 2007; Fletcher, in press) and might be more relevant for policy purposes, since most interventions (the DARE program for

* Corresponding author. Tel.: +1 419 530 5148; fax: +1 419 530 7844.
E-mail addresses: mir.ali3@utoledo.edu (M.M. Ali), debra.dwyer@stonybrook.edu (D.S. Dwyer).
[1] Tel.: +1 631 638 1009; fax: +1 631 444 6474.

0306-4603/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.addbeh.2009.12.002

example) aimed towards reducing adolescent risky behaviors are implemented at the school level. Further we implement two stage least-squares modeling approaches with school-level fixed effects to purge potential biases from the peer estimates in order to give it a causal interpretation.

2. Estimating social networks

A standard linear regression using an average contemporaneous measure by a reference group (for example, by the school level, by workplace or by closest friends identified by the individuals) as a proxy for social interactions is easy to estimate. However, such measures of peer networks, or social interactions, have quite a few problems of interpretation (Manski, 1993). A significant effect of a peer indicator could be the consequence of three different interpretations according to Manski (1993). While there may be subtle differences, defining effective policies would vary depending on which is the driving force behind the significant peer effect. The three interpretations Manski (1993) offers are as follows:

a. Endogenous effect — This effect occurs when individual behavior responds to the behavior of others in their reference group. For example, an individual is more likely to consume alcohol if there is a high rate of drinking among the reference group because seeing friends consume alcohol could act as a cue and stimulate a desire for that substance (Kremer & Levy, 2008). The influence is coming from the peer behaviors themselves — and their behaviors influence each other. Targeting the individual to change the behavior would be an effective policy in this case — and would have a multiplier effect. So even if only some of the individuals are part of the intervention — the influence would spread to their peers.
b. Exogenous or contextual effect — This occurs when individual behavior responds to the exogenous characteristics of the reference group. For example, suppose there is a high rate of alcohol usage among the adult population in a community and the dominating influence on peer drinking is parent drinking. Spillover occurs even to the individuals whose parents do not drink so that there is a peer effect on top of any parent effect. But targeting only the adolescent will not get at the root of the problem, nor will it have the multiplier effect discussed above since children of alcoholic parents will continue to consume alcohol despite the behavior of their peers.
c. Correlated effect — This occurs when individuals in the same group behave similarly because they have similar unobserved characteristics or they face similar institutional characteristics. For example, children from like socioeconomic backgrounds will sort to each other and children with similar propensities to drink will be more likely to drink because of those like attributes. Again, if one of them stops drinking because of an intervention, it is not likely to impact the others since something unobserved is driving them all to have higher propensities of alcohol usage.

In sum, given these alternative interpretations of a significant peer effect, standard regressions of individual engagement in a particular activity on group means are unable to distinguish between the endogenous, exogenous and correlated effects and successful policy will vary depending on what is driving the peer effect. This identification difficulty, coined as the 'reflection problem' by Manski (1993), occurs because group behavior by definition is the aggregation of individual behavior, i.e. group behavior affects individual behavior and vice versa due to the simultaneity in choices. Thus for the purpose of devising effective policy it is important to purge these biases from peer effect estimates to identify whether peer influence is more important than peer selection (Norton et al., 1998).

In this paper we are able to make progress in identifying the role of peer networks in drinking behavior on a couple of different fronts. First, we adopt a framework that models not only drinking, but accounts for the reflection problem as well; namely two stage least-square regression with school-level fixed effects, to deal with the potential bias from peer selection and omitted variables. Second, the compositions of our reference groups are based on two distinct measures. One reference group comes from the individual's nomination of their closest friends. Another reference group consists of those who are in the same school and grade as the respondents (grade-level peers henceforth). These peer measures are not based on individuals' self-reports which are subject to potential biases (Engels, Scholte, Lieshout, Kemp, & Overbeek, 2006) but are drawn from the responses of the peers themselves. In addition, we estimate the influence of social networks on two different measures of alcohol consumption to provide a robustness check of our estimates. We hypothesize that the influence of close (nominated) friends will decline in magnitude under our preferred specifications whereas the more exogenous grade-level peers will continue to exert a significant influence.

3. Data

We utilize data from the National Longitudinal Study of Adolescent Health (Add Health). Add Health consists of data on adolescents in 132 schools nationwide between grades 7 and 12. The in-school portion of the first wave of the survey (1994) contains a cross-section of data on about 90,000 adolescents. A subset of the initial sample (20,745 respondents) was also interviewed in their homes with follow-up surveys in 1996 and in 2002, when most respondents had made a transition to adulthood. The primary data for our analysis comes from the first wave (1994) of the in-home survey portion of Add Health. Parents were also interviewed in the first wave of the in-home sample and this component of the survey is the key in how we deal with the problem of unobserved correlated variables that may bias the estimate of the peer effect. A primary advantage of the data set is that Add Health asked respondents to nominate their five closest male and five closest female friends and since these friends were also part of the survey we were able to construct peer measures of drinking from the responses of the friends themselves.

The average number of nominated friends per individual is 2.54 and approximately 85% of the friends are from the same school as the respondent. Thus, the sample of our analysis with nominated peers consists of 6549 adolescents with at least one nominated friend interviewed in Add Health. The sample size of our grade-level peer analysis consists of 20,097 individuals. The loss in observations is due to invalid school identification codes. Table 1 reports descriptive statistics from the first wave of the data.

3.1. Measures of adolescent drinking

The dependent variable of our analysis consists of two indicators of alcohol usage commonly used in the literature (Guo et al., 2009; Clark & Loheac, 2007; Fite, Colder, & O'Connor, 2006; Lundborg, 2006; Norton et al., 1998; Kremer & Levy, 2008; Kawaguchi, 2004). Our first measure is a dichotomous variable to indicate participation in drinking behavior and the second is a continuous variable showing the frequency or intensity of this participation. The respondents were asked, "During the last 12 months, on how many days did you drink alcohol?" The participation indicator was set equal to 1 if the adolescent responded positively to this question and 0 otherwise. The intensity variable was measured as a six-point scale or score recorded as 0, 1, 2, 3, 4 and 5 for never drinks, once in the last year, once a month, 2–3 times last month, 1–2 times a week, and 3 or more times a week, respectively (Guo et al., 2009).

3.2. Measures of peer drinking

We construct two different measures of peer drinking for each reference group. For the nominated friends we created a variable pertaining to the percentage of friends who participated in drinking in

Table 1
Descriptive statistics for Wave I (1994).

Variables	Mean	Standard Deviation
Dependent variables		
Participation	0.465	0.498
Intensity	1.069	1.443
Peer measures		
Nominated peers: participation	0.514	0.441
Nominated peers: intensity	1.163	1.279
Grade-level peers: participation	0.465	0.188
Grade-level peers: intensity	1.070	0.523
Demographics		
Age	15.152	1.738
Grade	9.669	1.635
Male	0.495	0.500
White	0.614	0.487
Black	0.232	0.422
Hispanic	0.169	0.375
Religious	0.570	0.495
Born USA	0.723	0.448
First born	0.491	0.500
Siblings	0.801	0.400
Parent characteristics		
Parent drink	1.354	1.362
Easy access to alcohol	0.293	0.455
Chose location because of school	0.393	0.488
Child age when moved	8.745	5.752
Mother college	0.246	0.431
Father college	0.210	0.407
Both parents work fulltime	0.291	0.454
Lives with both biological parents	0.498	0.500
Welfare	0.226	0.418

the last twelve months and another variable indicating the average of the friends' drinking score. The grade-level peer drinking measures were the percentage of students (excluding the respondent) in the respondent's grade and school that participated in drinking and the average drinking score of those students (excluding the respondent) in the same grade and school.

3.3. Parental measures and demographics

The parent survey of Add Health allowed us to control for a number of parent characteristics including intensity of parent drinking, parent education, whether the adolescent lives with both biological parents, whether both the parents work fulltime and whether the family collects welfare benefits. In addition, parental measures such as whether the parents chose their residence because of the school district and how old the adolescent was when they first moved were also accounted for in the analysis. Other controls we include are socio-demographic factors like age, race, grade level, gender, whether they consider religion to be important, whether they were born in the U.S., if they have siblings and whether they have easy access to alcohol at home.

4. Empirical model

We estimate a model of peer effects where drinking behavior by adolescent i at school s during time t, Y_{ist} (a participation indicator or drinking frequency) is given by

$$Y_{ist} = \beta_0 + \beta_1 F_{ist} + \beta_2 X_{ist} + \beta_3 P_{ist} + \beta_4 S_{ist} + \varepsilon_{ist} \quad (1)$$

where F_{ist} refers to our peer drinking measures, pertaining either to the adolescent's nomination of close friends or their classmates. X_{ist} is a vector of personal or demographic characteristics and P_{ist} is a vector of parent and family characteristics. S_{ist} is a vector of school dummy variables that control for unobserved school type (school-level fixed effects) or confounding factors that are common to all individuals within the same school. For example, this could include environmental factors such as lower opportunity costs of drinking related to low prices and easy availability (Truong & Strum, 2009).

We are primarily interested in the endogenous effect β_1, which indicates the extent of peer influence on an individual's decision to consume alcohol. If β_1 is estimated to be positive, then any policy intervention that alters the drinking behavior of the individual within a reference group or social network would have an effect on non-treated adolescents' drinking behavior that are in the same social network (Manski, 1993). As indicated before, the estimated coefficient of β_1 would be biased if the correlated effects and the contextual effects are not controlled for. Estimating our models with S_{ist}, the school-level fixed effects, potentially mitigates the correlated effects. However, a two stage least-square regression is also necessary in this empirical analysis because of the reflection problem. The reflection problem, as discussed in Section 2, arises because peer behavior affects individual behavior and vice versa. Manski (1993) demonstrated that most estimates of β_1 are not identified without utilizing instrumental variables or other similar methodologies. This is because the fundamental assumption for consistency of least-squares estimation to give β_1 a causal interpretation is violated. There is something in the error term, ε, that is correlated with both F and Y so that $E(\varepsilon|F) \neq 0$. The instrumental variable estimator (IV) provides a consistent estimator under the assumption that the instruments (z) are variables that are correlated with the regressor, F, that satisfy $E(\varepsilon|z) = 0$ (Newhouse & McClellan, 1998). It is possible to obtain the instrumental variable estimator through the two stage least-square (2SLS) method, which is just a two stage model that first deals with accurately capturing the component of the peer variable we want (stage 1) and putting that cleaned-up indicator of the peer variable into the drinking regression (stage 2).

Key to implementing the IV technique is finding instruments that have two properties. First, they affect (cause variation in) the variable whose effect we want to know about; in our case the peer measure. Second, these instruments must have no direct effect on the outcome measure (Y_{ist} in Eq. (1)) so they must be independent of the latent factors that drive that outcome. For our instrument we propose four variables: (i) the percentage of peers who have parents who drinks, (ii) the percentage of peers who have easy access to alcohol at home, (iii) the percentage of peers who live with both biological parents and (iv) the percentage of peers whose parents were welfare recipients. These peer level variables directly impact peer behavior but do not predict individual behavior. The intuition behind the instruments is that, while individuals who have parents who drink are more likely to consume alcohol, the proportion of individual's friends who have drinking parents will only directly affect the friend but not the individual. Similar intuition applies to the other instruments. Combined with the school-level fixed effects, the IV or 2SLS procedure will enable us to obtain unbiased peer effect estimates. We also undertake several tests to verify the validity of our instruments.

5. Results

We begin by presenting OLS results for the effects of peer drinking on individual drinking behavior. Least-square estimates of coefficients in linear probability models are consistent estimates if standard errors are adjusted for the presence of heteroskedasticity (Angirst & Kruger, 1999). We report standard error estimates that are robust to any form of heteroskedasticity. Linear probability also converges to normal when samples are large (Mittelhammer, Judge, Miller, 2000). Table 2 presents our OLS results using Wave I (1994) data for the nominated and grade-level peers for both alcohol consumption measures. For the purpose of completeness we provide estimates for all our control variables and discuss their effect on the alcohol consumption measures.

Table 2
Determinants of alcohol consumption (OLS).

Variables	Nominated peers		Grade-level peers	
	Participation	Intensity	Participation	Intensity
Peer drinking	0.238***	0.316***	0.446***	0.414***
	(0.014)	(0.013)	(0.026)	(0.028)
Age	0.014	0.096***	0.017***	0.093***
	(0.009)	(0.025)	(0.005)	(0.014)
Grade	0.053***	0.073***	0.028***	0.041***
	(0.009)	(0.026)	(0.005)	(0.016)
Male	0.009	0.133***	0.001	0.127***
	(0.011)	(0.032)	(0.007)	(0.019)
White	0.066***	0.165***	0.065***	0.168***
	(0.017)	(0.048)	(0.010)	(0.029)
Black	−0.038*	−0.078	−0.055***	−0.126***
	(0.021)	(0.058)	(0.012)	(0.035)
Hispanic	0.030*	0.099**	0.039***	0.108***
	(0.017)	(0.048)	(0.020)	(0.029)
Religious	−0.041***	−0.145***	−0.050***	−0.173***
	(0.012)	(0.034)	(0.007)	(0.020)
Born USA	0.073***	0.175***	0.075***	0.197***
	(0.015)	(0.043)	(0.009)	(0.026)
First born	−0.062***	−0.158***	−0.051***	−0.159***
	(0.013)	(0.037)	(0.008)	(0.022)
Siblings	−0.085***	−0.177***	−0.070***	−0.164***
	(0.018)	(0.050)	(0.010)	(0.029)
Parent drink	0.068***	0.056***	0.080***	0.085***
	(0.012)	(0.013)	(0.007)	(0.007)
Easy access to alcohol	0.121***	0.327***	0.118***	0.329***
	(0.013)	(0.035)	(0.007)	(0.022)
Chose location because of school	0.010	−0.015	−0.004	−0.035
	(0.012)	(0.033)	(0.007)	(0.019)
Child age when moved	−0.004***	−0.010***	−0.004***	0.011***
	(0.001)	(0.040)	(0.001)	(0.002)
Mother college	−0.011	0.011	−0.007	−0.018
	(0.014)	(0.040)	(0.008)	(0.024)
Father college	−0.038***	−0.080*	−0.022**	−0.053**
	(0.015)	(0.043)	(0.009)	(0.026)
Parents work fulltime	0.037***	0.051**	0.039***	0.044**
	(0.013)	(0.036)	(0.007)	(0.022)
Lives with both biological parents	−0.064***	−0.177***	−0.059***	−0.167***
	(0.015)	(0.038)	(0.008)	(0.022)
Welfare	−0.005	−0.015	0.025	0.024
	(0.015)	(0.042)	(0.048)	(0.044)
N	6549	6549	20,097	20,097
Adjusted R^2	0.1691	0.1950	0.1428	0.1313

Notes: Beta weights are reported with standard errors in parentheses. Significance is defined as follows: ***$p<0.01$; **$p<0.05$; *$p<0.10$. Interpretation of the beta weights would be a 1% increase in the variable would result in the beta % impact on alcohol participation or consumption. An easier interpretation would be to examine at 10% increase in the variable. So for example, a 10% increase in peer drinking leads to a roughly more than 2% increase in adolescent participation in the behavior.

The results indicate a positive and statistically significant effect of peer drinking behavior on individual behavior. We see that a 10% increase in close friends drinking will increase the likelihood of drinking by more than 2% (coefficient = 0.238, p-value = 0.000) and a 10% increase in drinking among grade-level peers is associated with a 4% increase in individual drinking (coefficient = 0.446, p-value = 0.000). The intensity or frequency of drinking is also highly correlated with peer drinking and the effect is larger for grade-level peers. This result is consistent with the previous literature (Lundborg, 2006; Kawaguchi, 2004). We can also see that older adolescents and those who are at a higher grade are more likely to participate in drinking behaviors. Adolescents who are White and Hispanic are more likely to participate in drinking whereas adolescents who are Black are less likely to drink. Being religious is inversely related to drinking. Among parent level characteristics, it is the easy access to alcohol at home that has the greatest positive effect on the drinking behaviors. In fact, with the exception of the peer effect, this indicator has the largest impact on adolescent participation in drinking and its impact on how much the adolescent drink is almost as important as the peer effect. Intensity of parent drinking is also positively related to individual drinking and increases the likelihood of being a drinker by 0.7% on average. Living in a two parent household also decreases the participation and frequency of drinking. Having parents with at least a college degree is negatively related to drinking and having both parents who work fulltime outside the home is positively related with drinking. These demographic and parent level characteristics have an effect of similar magnitude across all model specifications, which is as expected.

These peer estimates however cannot be interpreted to signify causality because of the reasons outlined in Section 2. Thus, we pursue an IV estimation strategy to identify the causal effect of peer behavior on individual behavior. Our IV results are reported in Table 3 and since the other control variables exhibit similar effects we only report the coefficients of our main variable of interest. We also implemented two over-identification tests, the Sargan over-identification test (Sargan, 1958) and the Basmann over-identification test (Basmann, 1960), to check the validity of our instruments. These are tests of the joint null hypothesis that the excluded instruments are valid instruments, i.e., uncorrelated with the error term and correctly excluded from the estimated equation. In both tests we fail to reject validity, thus all four of the instruments pass the tests under all model specifications. In other words, the over-identification statistics are not significant, indicating no over-identification issues with our instruments and rendering them to be valid.

From our results we see that the magnitude of the peer estimates is actually magnified under the IV specifications. This indicates that after correcting for the reflection problem, peer effects become more important. However, these IV models were estimated without controls for school-level unobservable factors or environmental confounder (correlated effects) that could simultaneously affect individual and peer outcomes, thus biasing the estimated coefficients. Our IV estimation with school-level fixed effects shows coefficients which are smaller in magnitudes compared to the OLS estimates. Peer participation in drinking is no longer statistically significant for the nominated peers and the drinking frequency variable is much smaller and significant only at the 5% level (p-value = 0.024). The grade-level peer measures are still significant at the 1% level and even though they decline in magnitude compared with the OLS estimates, the decline is not by much. This indicates that holding everything else constant, an increase in drinking among individual's classmates by 10% will result in an increase in the likelihood of individual drinking and the frequency of alcohol consumption by approximately 4% (coefficient = 0.405, p-value = 0.005). This result is consistent with our hypothesis that, if peer selection was important, we would expect the peer effects to be less in magnitude or non-existent under the IV fixed effects specification. Since the grade-level peer measures are not driven by selective peer sorting (Clark & Loheac, 2007; Fletcher, in press), the decline in their magnitude was minimal. Other factors remain important with no statistically significant difference in interpretations or relative importance.

6. Discussion

In this paper, we estimated models of adolescent drinking behavior to identify the role of social networks or peer groups on drinking propensities and frequencies. In particular, we used a two stage least squares with school-level fixed effects methodology to purge potential biases from the estimates of peer effects. Our estimation strategy allowed us to account for the contextual effects, correlated effects and the reflection problem, which are present in empirically measuring social influence.

Our findings indicate that peer effects are important determinants of drinking and could be utilized as a potential policy tool to reduce alcohol consumption rates among adolescents. Specifically, our results suggest that an increase in the proportion of classmates who drink by 10% will increase the likelihood of drinking by approximately four percentage points. These findings suggest that public health interventions at the school level might be more cost-effective than previous estimates have

Table 3
Determinants of alcohol consumption (2SLS).

Variables	Participation		Intensity	
	Instrumental variable	Instrumental variable with school-level fixed effects	Instrumental variable	Instrumental variable with school-level fixed effects
Nominated peers				
Peer drinking	0.300***	0.160	0.342***	0.237**
	(0.082)	(0.098)	(0.087)	(0.105)
Sargan over-identification test	0.1788	0.3573	0.1758	0.1566
Basmann over-identification test	0.1800	0.3687	0.1769	0.1653
N	6549	6549	6549	6549
Grade-level peers				
Peer drinking	0.495***	0.405***	0.409***	0.405***
	(0.066)	(0.145)	(0.074)	(0.133)
Sargan over-identification test	0.5469	0.6913	0.1348	0.2847
Basmann over-identification test	0.5474	0.6941	0.1351	0.2884
N	20,097	20,097	20,097	20,097

Notes: Beta weights are reported with standard errors in parentheses. Significance is defined as follows: ***$p<0.01$; **$p<0.05$; *$p<0.10$. Covariates include all variables from Table 1. The focus is on peer effects and the estimated effects of other factors are as expected.

suggested, since health promoting behavior in one person may spread to others. We also found evidence to show that the influence of close friends diminishes in magnitude under our preferred specification, supporting a theory predicting the presence of non-random peer selection. Another significant finding was the importance of controlling for unobserved environmental confounders confirming a correlation between those factors and the peer measures. Estimates without controlling for such environmental factors resulted in larger estimated effects of peer influence even when the bi-directionality of the peer effects was accounted for.

This work not only lends further evidence in support of the existing literature documenting the impact of peer effects on drinking, but also improves on the accuracy of the magnitudes of estimated effects and expands how those effects vary across different peer group compositions. Most of the previous studies did not conduct their analysis based on different measures of the peer group, but have rather focused either on school and grade-level peers only (Norton et al., 1998; Lundborg, 2006) or on nominated peers (Bullers et al., 2001; Guo et al., 2009) or on perceived peer measures (Kawaguchi, 2004). Although Clark and Loheac (2007) used both the nominated and grade-level peers, they relied on lagged values of peer behavior to account for the reflection problem. However, this could be problematic since it is not clear what the optimal lag period should be. Also compared to the previous studies our estimates appear to be conservative. This could primarily be due to the inclusion of school-level fixed effects in our two stage least-squares models. School-level fixed effects could be capturing environmental factors related to alcohol availability. Consistent with Truong and Strum (2009) this implies that environmental interventions are warranted to curtail teenage drinking via limiting access to commercial sources of alcohol and stricter licensures and enforcement of minimum-age drinking laws. Our results also indicate that policy interventions at the school level might be more effective since the existence of grade-level peer (classmates) influence may serve to amplify the effects of interventions.

While we are able to address some of the issues surrounding the estimation of social networks, there are some limitations. Even though we follow much of the literature in our measure of the dependent variable (Guo et al., 2009; Clark & Loheac, 2007; Fite et al., 2006; Lundborg, 2006; Norton et al., 1998; Kremer & Levy, 2008; Kawaguchi, 2004), it might be possible that the influence of peer network varies with different measures of drinking behaviors. For example, adolescents who binge drink more frequently could very well be affected differently by peers compared to those who do not drink as heavily but perhaps more frequently. A possible extension of the study could be to look into how peer effects differ under various drinking intensities or frequencies. Another area of interest would be to identify age groups that may be at higher risk of peer influence that extends into adulthood.

Role of Funding Sources
This research was not funded by any external or internal source.

Contributors
Both authors contributed equally in writing the manuscript and interpreting the results. M.M. Ali analyzed the data.

Conflict of Interest
We have no conflict of interest.

Acknowledgements
We would like to thank Elizabeth A. Vanner at the Department of Health, Technology and Management, Stony Brook University for her helpful comments. This research uses data from Add Health, a program project designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris, and funded by a grant P01-HD31921 from the National Institute of Child Health and Human Development, with cooperative funding from 17 other agencies. Special acknowledgment is due to Ronald R. Rindfuss and Barbara Entwisle for their assistance in the original design. Persons interested in obtaining data files from Add Health should contact Add Health, Carolina Population Center, 123 W. Franklin Street, Chapel Hill, NC 27516-2524 (addhealth@unc.edu).

References

Alexander, C., Piazza, M., Mekos, D., & Valente, T. (2001). Peers, schools, and adolescents cigarette smoking. *Journal of Adolescent Health*, *29*(1), 22−30.
Ali, M. M., & Dwyer, D. S. (2009). Estimating peer effects in adolescent smoking behavior: A longitudinal analysis. *Journal of Adolescent Health*, *45*(4), 402−408.
Angirst, J., & Kruger, A. (1999). Empirical strategies in labor economics. In O. Ashenfelter, & D. Card (Eds.), *Handbook of labor economics* (pp. 1277−1366). Amsterdam: Elsevier.
Basmann, R. L. (1960). On finite sample distributions of generalized classical linear identifiability test statistics. *Journal of the American Statistical Association*, *55*(292), 650−659.
Bullers, S., Cooper, M. L., & Russell, M. (2001). Social network drinking and adult alcohol involvement: A longitudinal exploration of the direct of influence. *Addictive Behaviors*, *26*, 181−199.
Clark, A., & Loheac, Y. (2007). It wasn't me, it was them! Social influence in risky behavior by adolescents. *Journal of Health Economics*, *26*(4), 763−784.
Engels, R., Scholte, R., Lieshout, C., Kemp, R., & Overbeek, G. (2006). Peer group reputation and smoking and alcohol consumption in early adolescence. *Addictive Behaviors*, *31*, 440−449.
Evans, N., Gilpin, E., Farkas, A. J., Shenassa, E., & Piere, J. P. (1995). Adolescents' perception of their peers' health norm. *American Journal of Public Health*, *85*(8), 1064−1069.
Fite, P. J., Colder, C. R., & O'Connor, R. M. (2006). Childhood behavior problems and peer selection and socialization: Risk for adolescent alcohol use. *Addictive Behaviors*, *31*, 1454−1459.
Fletcher J. (in press). Social interactions and smoking: An IV/FE approach. *Health Economics*.
Guo, G., Elder, G. H., Cai, T., & Hamilton, N. (2009). Gene–environment interactions: Peer alcohol use moderates genetic contribution to adolescent drinking behavior. *Social Science Research*, *38*, 213−224.

Johnston, L. D., O'Malley, P. M., & Bachman, J. G. (2003). *Monitoring the future national survey results on drug use, 1975–2002Secondary school students (NIH Pub. No. 03-5375)*, *Vol. 1*. (pp.) Bethesda, MD: National Institute of Drug Abuse.

Kawaguchi, D. (2004). Peer effects on substance use among American teenagers. *Journal of Population Economics*, *17*, 351−367.

Kosterman, R., Hawkins, J. D., Guo, J., Catalon, R. F., & Abbott, R. D. (2000). The dynamics of alcohol and marijuana initiation: Patterns and predictors of first use in adolescence. *American Journal of Public Health*, *90*, 360−366.

Kremer, M., & Levy, V. (2008). Peer effects and alcohol use among college students. *Journal of Economic Perspectives*, *22*(3), 189−206.

Lundborg, P. (2006). Having the wrong friends? Peer effects in adolescent substance use. *Journal of Health Economics*, *25*, 214−233.

Manski, C. (1993). Identification of endogenous social effects: The reflection problem. *Review of Economic Studies*, *60*(3), 531−542.

Mittelhammer, R. C., Judge, G., & Miller, D. J. (2000). Econometric foundations: Cambridge University Press.

Moore, A. A., Gould, R., Reuben, D. B., Greendale, G. A., Carter, M. K., Zhou, K., & Karlamangla, A. (2005). Longitudinal patterns and predictors of alcohol consumption in the United States. *American Journal of Public Health*, *95*, 458−465.

Newhouse, J., & McClellan, M. (1998). Econometrics in outcomes research: The use of instrumental variables. *Annual Review of Public Health*, *19*, 17−34.

Norton, E., Lindrooth, R., & Ennett, S. (1998). Controlling for the endogeneity of peer substance use on adolescent alcohol and tobacco use. *Health Economics*, *7*, 439−453.

Puddey, I. B., Rakic, V., Dimmitt, S. B., & Beilin, L. J. (1999). Influence of pattern of drinking on cardiovascular disease and cardiovascular risk factors—A review. *Addiction*, *94*, 649−663.

Sargan, J. D. (1958). The estimation of economic relationships using instrumental variables. *Econometrica*, *26*, 393−415.

Truong, K. D., & Strum, R. (2009). Alcohol environments and disparities in exposure associated with adolescent drinking in California. *American Journal of Public Health*, *99*, 264−270.

Windle, M. (2003). Alcohol use among adolescents and young adults. *Epidemiology in Alcohol Research*, *27*, 79−86.