Friend Selection and Influence Effects for First Heavy Drinking Episode in Adolescence

JOHN M. LIGHT, PH.D.,[a,*] KATHRYN L. MILLS, PH.D.,[a,b] JULIE C. RUSBY, PH.D.,[a] & ERIKA WESTLING, PH.D.[a]

[a]*Oregon Research Institute, Eugene, Oregon*
[b]*Department of Psychology, University of Oregon, Eugene, Oregon*

ABSTRACT. Objective: Heavy alcohol consumption has both immediate and longer-term risks for adolescents. Using a dynamic network modeling approach, this study investigated the role of adult supervision and affiliation with heavy drinking friends in predicting the risk of a first heavy drinking episode in a community sample of adolescents. **Method:** Two cohorts of ninth grade youth (n = 1,220, 48% male) from seven communities were surveyed three times over the course of the school year (fall, winter, and spring), each time assessing their friendship networks, whether they had ever experienced a heavy drinking episode, frequency of heavy drinking over the past month, and the amount of unsupervised time spent with each of their friends over the past month. **Results:** Participants were more likely to form friendships with classmates with similar recent heavy drinking behavior, but similarity on adult supervision of time spent with friends had no effect on friendship selection. A negative interaction was observed between these two similarity effects, implying that they were antisynergistic. Risk for a first heavy drinking episode was greater for youth with friends who had experienced such an episode already. This effect was no stronger if these friends had more such episodes in the previous 30 days but was marginally stronger if the friends reported less adult supervision. **Conclusions:** Heavy drinking–related friendships increase the risk of a first heavy drinking episode. Adult supervision of time spent with friends may reduce this risk. Results support interventions that target the spread of heavy drinking through adolescent social ecosystems, in addition to targeting the most at-risk individuals. (*J. Stud. Alcohol Drugs, 80,* 349–357, 2019)

ALCOHOL USE AMONG adolescents remains a significant public health problem. Myriad studies have demonstrated that even moderate use can be immediately dangerous, exposing the adolescent drinker to a variety of risks (e.g., Colder et al., 2002). Such risks are magnified in heavy drinking episodes (HDEs; Bonomo et al., 2001; Hingson & Zha, 2018), often referred to as binge drinking (definitions vary but generally require four to six standard drinks in a row, sometimes depending on biological sex). There is growing evidence that heavy drinking in adolescence carries with it greater short-term and longer-term risks compared with more normative adolescent drinking.

Although it is less common than more moderate alcohol use, heavy drinking is by no means rare. Using nationally representative survey data, Vaughn et al. (2018) found that the percentage of mid-adolescents of varying ethnicities reporting any past-30-day HDEs (5+ drinks) to be in a range of 8%–15% for ages 14–16 years, rising to 25%–30% by age 18. Using World Health Organization data, Kuntsche et al. (2013) reported that most youth (e.g., more than 70% in the United States) who ever drink will have an HDE by age 18. Such findings suggest that heavy drinking is not simply a problem confined to high-risk populations or social environments, but rather is broadly embedded in adolescent social systems throughout Western countries.

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*Correspondence may be sent to John M. Light at the Oregon Research Institute, 1776 Millrace Drive, Eugene, OR 97403, or via email at: jlight@ori.org.

Studies have identified such short-term heavy drinking–related risks as other substance use, injuries, fighting, and poor academic performance (Kuntsche et al., 2013), risky driving (Marcotte et al., 2012), and unsafe or ill-considered sexual behavior (Hale & Viner, 2016). These and other risks may stem from short-term impairment in neurological regulation such as executive functioning (Lisdahl et al., 2013) and prospective memory (Heffernan et al., 2010), with a causal connection supported by animal models (Hiller-Sturmhöfel & Spear, 2018) as well as some longitudinal studies among humans (e.g., Tapert et al., 2002). Besides impaired memory and judgment, heavy drinking adolescents may be more prone to developing more positive alcohol expectations (Jester et al., 2015; Stamates et al., 2016; Windle & Windle, 2018). A related body of evidence suggests that among heavy adolescent drinkers, such effects can be longer lasting, for instance, into the college years (Reifman & Watson, 2003) and beyond (McCarty et al., 2004; Tapert et al., 2002; Temmen & Crockett, 2018; Windle & Windle, 2018).

Furthermore, and critically, such effects may be cumulative; the more heavy drinking during adolescence, the more likely and long-lasting the risks (Enstad et al., 2017; Jurk et al., 2016; Kuntsche et al., 2013; Temmen & Crockett, 2018; Wellman et al., 2014), but even relatively infrequent heavy drinking does not appear to be without risk (Kuntsche et al., 2013). Therefore, the age at which such behavior is first experienced is likely a major determinant of both long- and short-term consequences, and understanding predictors of earlier first HDE is thus important.

Very little research has investigated risk factors for first HDE. Jester et al. (2015) related more positive alcohol ex-

pectancies in childhood to earlier first HDE in a study of Midwest U.S. families at high risk for alcohol dependence. We located only one previous study of socio-environmental risks: In a longitudinal, community-sample study of 382 Norwegian adolescents, Enstad et al. (2017) found that the timing of first "intoxication" was more strongly predicted by self-reported deviant peer affiliation than was the timing of first alcohol use. A few studies have reported effects of having heavy drinking friends on HDE frequency (Andrews et al., 2002; Hahm et al., 2012). None of these studies attempted to control for friendship selection, however. Peer exposure is a known risk factor for adolescent timing of first alcohol use (Burk et al., 2012; Knecht et al., 2010 ; Light et al., 2013) as well as for the amount of drinking (Burk et al., 2012; Knecht et al., 2010), but peer exposure per se is never risky unless that exposure influences behavior. Methodologically, inferring influence effects is complicated by the fact that adolescents typically select friends based in part on similar substance use patterns. Influence effects are thus confounded with selection unless the latter is controlled (Bauman & Ennett, 1996; Kandel, 1985).

It is evident, then, that little is yet known about whether—and if so, how—risk factors for a first HDE spread through adolescent social ecologies. The purpose of the current analysis was to advance our knowledge of such risks by examining data from a longitudinal social network study. The data comprised community samples in light of our interest in how heavy drinking behavior is affected by social dynamics in typical adolescent social environments. Such insights may be useful in devising successful prevention programs. Our methods allowed us to avoid reliance on adolescents' reports of their friends' behavior (which can be biased; Bauman & Ennett, 1996), instead measuring exposure to heavy drinking friends through social network friendship nominations. We also used an analysis approach that controls for selection effects by modeling them simultaneously with influence effects.

We focused specifically on two environmental risk factors: having friends who had previously experienced a first HDE and the amount of time spent with such friends in the absence of adult supervision. Although previous studies have identified similar risk factors for alcohol use (e.g., Light et al., 2013), their relevance for heavier drinking is untested and not obvious. As noted by Enstad et al. (2017), youth alcohol consumption in small amounts is less likely to be done in a peer context, without adults present, than is the case for heavier drinking; hence, friend exposure and lack of adult supervision might be even more important predictors of a first HDE. Less-supervised adolescents (e.g., after school on weekdays) are more prone to behavior problems, independent of parenting practices or involvement (Gage et al., 2005).

A social learning theory perspective (e.g., Bandura, 1971) on social influence implies that positive reinforcement from and modeling of others' behavior requires some degree of social closeness (Urberg et al., 2003). However, such mechanisms do not require that the relationship be exclusive or involve a great deal of mutual self-disclosure. To the extent that social influence is transmitted dyadically, we thus think of it as occurring in friendship relationships where the individuals in question know each other reasonably well.

In sum, our objective in this analysis is to address socio-environmental risk factors—friends' behavior and adult supervision, individually and together—for the timing of first HDE. Our study uses recently developed modeling methods, designed to separate effects of friendship selection from effects of friend influence, and makes use of longitudinal social network data.

Method

Participants

Participants were drawn from five rural and six nonrural middle schools within seven school districts in Oregon. Two cohorts of eighth grade students from these communities were recruited for study participation. Cohort 1 was recruited from six middle schools in three school districts in spring 2014, and Cohort 2 was recruited from five schools in four school districts in spring 2015. The only eligibility requirements were being enrolled in the participating school at the time of the survey and the ability to read in English or Spanish. An implicit consent procedure was used: Families of all eighth grade students enrolled in participating schools received mailed packets describing the study and a prepaid-postage opt-out card to request that their teenager not be included in the study. All students for whom no opt-out card was received were eligible to participate. Students provided their assent before completing each survey and could opt out of any survey at any time. Students new to the school were recruited at each assessment wave using the same procedures as those recruited initially. Of 1,333 eligible participants over all three waves of data collected in the ninth grade, 1,220 (92%) completed at least one survey and were included in the present analysis. Of participating youth included in the present study, 48% were male, 37% were Latino/Hispanic (59% of non-Hispanic participants were predominantly White), and 56% were in Cohort 2. The research protocol was reviewed and approved by the corresponding author's institutional review board.

Data collection procedures

Online questionnaires were completed on computers at school during the fall, winter, and spring of the ninth grade year. A research assistant was present during the surveys to remind students that the surveys were voluntary and confidential as well as to monitor and answer any questions. Students were not compensated for completing the surveys.

Participants reported on their own alcohol use and social relationships. Some characteristics were obtained only at the student's initial assessment (e.g., ethnicity, sex) because they were considered unlikely to change.

Measures

Friendship network. Because each district represented the public school system for a community with one high school campus per district, each was treated as a separate network. Within each district, network ties were inferred from participants' selections of up to 25 classmates they "spent free time with" in the previous 30 days from a complete list of eligible participants, updated 2–4 weeks before each survey wave. At each wave, after these selections were made, participants were asked several additional questions about each of these free-time relationships. These included a checkbox to indicate whether the selected individual was "one of my best friends," and these relationships (up to a limit of 10) were used to define the friendship network. This definition is comparable to other recent studies of adolescent social networks and alcohol use (e.g., Burk et al., 2012; Knecht et al., 2010; Osgood et al., 2013). Selections of the participant by other students were defined as in-ties. This procedure generated "directed" best-friend networks *N,* where each network member *i* had the opportunity to choose each other member *j.* The resulting networks were represented by 21 binary matrices (one for each of the 3 waves and 7 districts) with (*i,j*)th entries set to 1 if ego *i* chose alter *j,* and 0 otherwise. From these matrices, a number of effects were defined as predictors.

Unsupervised time. The survey included several questions about participants' friend nominations. One asked how many days out of the previous 30 the participant had spent with the nominated alter when "no adults were present for some or all of the time." This frequency was recoded into four categories: 0 (*no days*), 1 (*1–2 days*), 2 *(3–5 days*), and 3 (*6 or more days*) when used as a dyadic variable applying to each pair of individuals in a network. It was recoded into three categories numbered 0 (*no days*), 1 (*1–9 days*), and 2 (*10 or more days*) when used as an average characteristic of each individual (see Analytical Procedures section). This measure differs from "parental monitoring," which pertains to parents' knowledge of what their child is doing, rather than addressing supervision by friends' parents, teachers, coaches, and other adults in supervisory roles.

First heavy drinking episode. In this study, heavy drinking was defined as five or more drinks in a row. The same cut-off was used for males and females, because ninth graders' median body weight is the same for both at this age (about 15 years old). If any prior lifetime HDEs were reported up to and including a given wave, this variable was coded 1 for that wave and 0 otherwise. Left censoring occurred if a prior HDE was reported from the individual's first available wave onward, right censoring if no HDEs were reported for any wave, and interval censoring occurred because the time of the event could only be located at some time between two waves, or longer if the participant had not responded to a past survey. Censoring is characteristic of time-to-event measures (Cox, 1972; Yamaguchi, 1991).

HDE past-30-day frequency. At each wave, participants reported whether they had previously drunk alcohol in their lives and, if so, the number of days, if any, in which an HDE occurred in the past 30 days. The frequency was recoded into three ordered categories of 0 (*no lifetime use reported, or no reported use in the last 30 days*), 1 (*1–9 days*), or 2 (*10 or more days*).

Same biological sex. Participants were asked to choose a sex (male or female) on their first survey. This information was used to create a dyadic "same sex" matrix at each wave.

Modeling approach

Stochastic actor-oriented modeling (SAOM; Snijders et al., 2010) was applied to the data from each school district, using the R package RSiena (v.1.2-4; Ripley et al., 2018) for estimation. A SAOM separately estimates social influence effects on timing of the first HDE net of friend selection effects (Steglich & Snijders, 2010). The model includes two multinomial logistic regression equations, one predicting the probability of change or maintenance of friendship relationships and the other the probability of changing from no previous lifetime HDEs to one or more. Change is represented as a continuous time Markov process, where change can occur at any time, and with probabilities that depend only on the immediate state of the system. A parameter is interpreted as the log-odds of change as a function of the effect it is associated with. Parameters of the two equations are estimated simultaneously, to optimize agreement between a set of effect-associated, model-generated aggregate change statistics from both equations, and the same statistics calculated from the data. Hence the model gives separate estimates of influence and behavior effects based on a best fit of model to data.

Unlike more standard linear modeling approaches that have been used to examine selection and influence effects (e.g., from the behavior genetics literature, such as Cruz et al., 2012; Edwards et al., 2015), SAOM can be thought of as a kind of agent-based model (Axelrod, 1997). In such models, the interaction dynamics among individuals are modeled, and these dynamics generate predicted emergent, system-level change. In contrast, regression, SEM, and related linear modeling approaches usually simply describe linear relationships between variables, and emergent system properties cannot be examined by, for instance, simulation (Snijders & Steglich, 2015). Moreover, the model is "actor-oriented" because change can be interpreted as decisions individuals (actors) make regarding friendships and behavior. These features make SAOM an especially appropriate

TABLE 1. Definitions of stochastic actor-oriented modeling effects

Effect	Interpretation
Friendship network model	
1. Rate	Expected number of latent tie changes between waves for best friend choices
2. Outdegree	Number of alters chosen by ego
3. Reciprocity	Number of alters chosen by ego who also chose ego
4. Transitive triplets	i^a creates or maintain $i \rightarrow j$, given $i \rightarrow h$ and $h \rightarrow j$ (i.e., triadic closure)
5. 3 Cycles	Whether the cycle $i \rightarrow h \rightarrow j \rightarrow i$ tends to form
6. Same sex	A tie $i \rightarrow j$ where i's sex and j's sex are the same
7. Similarity: DNS/d	Similarity between i and j on 30-day frequency of days spent with nominated friends (d means dyadic), without adult supervision
8. Similarity: HDF	Similarity between i and j on heavy drinking frequency (HDF)
9. Similar DNS/d × Similar HDF	Interaction between (7) and (8)
10. Same subunit	Tendency for i to choose j if j is in the same school subunit
First HDE model	
11. Rate	Expected number of latent changes between waves for first heavy drinking behavior (HDE)
12. HDE Alters	Number of HDE+[b] alters j chosen by ego i (i.e., exposure to heavy drinkers)
13. Alters w/previous HDE × HDF	Moderating effect of alters' recent heavy drinking frequency on exposure to HDE+ alters
14. HDE Alters × DNS/n	Moderating effect of alters' unsupervised time with friends (not necessarily ego; n means nondyadic) on exposure to HDE+ alters

Notes: HDE = heavy drinking episode; DNS = days with no adult supervision. [a]i refers to ego (relationship nominator), j to alter (relationship target), h to some other individual $\neq i$ or j; [b]an individual who has previously experienced an HDE.

modeling framework for addressing questions about specific mechanisms of change, such as how relationships with previously heavy drinking peers, and the adult supervision typical for activities with those peers, affect the likelihood of a first such event.

In the analysis presented below, the time-to-first-HDE equation was a Cox regression (Cox, 1972; Greenan, 2015), a type of event history model (Yamaguchi, 1991). In such models, parameters reflect the direction and magnitude of different values of their associated predictors on the rate of first HDE; a higher positive rate means a higher probability of an earlier first HDE.

Analytical procedures

In SAOM, effects are functions of the network and possibly also individually based survey data and are thus simply measured variables. The effects included in our model are shown in Table 1.

The network equation predictors included ego-alter HDE similarity as well as ego-alter unsupervised time similarity, each of which tested for ego-alter homophily on the relevant characteristic. An interaction of these two similarity effects tested for synergy in predicting a best friend tie.

To address the risk associated with exposure to alters with previous HDEs (hereafter, "HDE+") and unsupervised time with these alters, we tested three exposure predictors, a main effect and two interaction effects. The main effect was the number of HDE+ individuals among the participant's selected friends. The two additional effects conditioned the main effect on alters' HDE frequency in the previous 30 days and alters' average unsupervised occasions (differing from the dyad-specific supervision effect in the network equation, because RSiena does not allow a similar dyadic effect for behavior modeling).

To arrive at a single model, we combined two pooling methods. First, a full pooling method referred to as "structural zeros" was used for the five smaller ($n \approx 100$ each) school districts 1–5. This approach uses a matrix of relationships for each wave for all five districts together, with interdistrict choices not permitted. The model assumes that all parameters are identical across districts, as the full-pooling description implies, and is useful when individual networks are difficult to model individually (Light et al., 2016).

The two larger school districts ($n \approx 350$ each) were modeled separately. The resulting set of three network models, one from each of the two larger districts and one representing the combined five smaller districts, were then meta-analyzed using standard methods (e.g., Hedges & Olkin, 1985). Further details are available in Snijders & Baerveldt (2003) and the RSiena manual (Ripley et al., 2018).

Results

Descriptive statistics

Participation rates (surveys completed among all survey-eligible students) for each of the three survey waves were

TABLE 2. Descriptive statistics of district networks and students by wave

Variable	Wave	Overall	District 1	District 2	District 3	District 4	District 5	District 6	District 7
No. of participants	W1	1,170	91	80	104	96	87	355	357
	W2	1,186	92	84	106	96	87	350	371
	W3	1,166	91	83	106	96	83	351	356
Density: No. of outgoing friend nominations as % of max. possible	W1	23%	22%	24%	26%	17%	25%	28%	17%
	W2	16%	14%	14%	16%	14%	17%	21%	12%
	W3	13%	17%	14%	15%	12%	8%	18%	9%
% reciprocated ties (ego and alter mutually choose each other)	W1	33%	43%	41%	41%	24%	37%	34%	22%
	W2	31%	44%	17%	36%	31%	44%	32%	23%
	W3	30%	39%	26%	34%	32%	21%	33%	21%
Average outdegree (no. of outgoing friendship nominations)	W1	2.35	2.18	2.41	2.60	1.68	2.43	2.80	1.68
	W2	1.61	1.42	1.40	1.50	1.33	1.63	2.00	1.20
	W3	1.39	1.63	1.37	1.43	1.08	0.76	1.72	0.89
Jaccard indices: Change in ties from previous wave[a]	W1	–	–	–	–	–	–	–	–
	W2	–	0.29	0.23	0.30	0.18	0.26	0.23	0.19
	W3	–	0.25	0.25	0.31	0.20	0.18	0.22	0.20
% of participants who have ever had a heavy drinking episode	W1	15%	9%	22%	16%	17%	26%	14%	12%
	W2	24%	19%	30%	24%	27%	35%	24%	23%
	W3	33%	24%	43%	32%	35%	44%	30%	32%
Median no. of days (of last 30) spent unsupervised time with friends	W1	3.0	2.0	3.0	2.0	2.0	1.0	3.0	2.0
	W2	2.0	2.0	3.0	1.0	2.0	1.0	3.0	3.0
	W3	2.0	1.0	3.0	2.0	2.0	2.0	2.0	3.0
% isolates (no outgoing or incoming ties)	W1	10%	11%	10%	9%	14%	7%	7%	13%
	W2	18%	14%	17%	22%	19%	15%	13%	23%
	W3	21%	15%	18%	16%	20%	33%	13%	30%

Notes: No. = number; W = wave; max. = maximum. [a]The Jaccard index is a measure of change in ties in relation to total number of ties that could have changed.

87%, 81%, and 82%, respectively. The prevalence of any HDEs in the 30 days before assessment was about 11% in the sample as a whole for all three waves. This is similar to large, statistically representative studies of U.S. adolescents (e.g., Vaughn et al., 2018), suggesting that heavy drinking in the current sample is relatively typical of other geographical regions of the United States. The percentage of participants ever reporting an HDE more than doubles over the three observation periods, showing that the ninth grade year (ages about 15–16) is a particularly risky period. For individuals with any reported HDEs during this time (n = 331, 27% of all participants), average HDE frequency in the 30 days before each survey varied from 2.33 (Wave 1) to 2.46 (Wave 3), with 75th centiles between 1 and 2. Furthermore, 74% of these ever-HDE participants reported at least two such episodes (understating the percentage who ever will, because some additional future HDEs were not yet observed). For individuals who report any HDE+ friends during the observation period, 40% of their friends were HDE+ at Wave 1, rising to 58% by Wave 3, and these friends averaged between 1 and 2 HDEs in the 30 days before each survey. Similarly, most participants reported relatively few days during which they spent unsupervised time with friends; medians by district and wave ranged from 1.88 to 4.89. Both this measure and the HDE frequency measure were strongly right-skewed—a nontrivial minority of participants in all districts and waves spent considerable unsupervised time with friends.

Table 2 gives descriptive statistics for the sample as a whole and for each of the individual participating school districts, numbered 1 through 7. The smaller districts (1–5) had between 83 and 105 participants each. The two larger districts (6–7) ranged from 351 to 371 participants. Participation per wave was 1,166 to 1,186, comprising 1,220 unique individuals. Both network density [number of directed ties out of the $n(n-2)$ possible] and average outdegree declined somewhat across waves in all districts but varied little by district. Reciprocated tie percentage showed no longitudinal trend but was somewhat larger, on average, in the smaller schools 1–5, suggesting more cohesive networks. Friendship stability (the Jaccard index: number of unchanging ties as a percentage of all possible ties) ranged from 0.18 to 0.31 with no strong time trend. Approximately one fifth of students for each wave were isolates (neither making nor receiving any ties) and thus more weakly connected to the larger grade-wide network in their schools (by affiliations but not best friends).

Modeling

Meta-analysis results are shown in Table 3. Our objective was to examine how adult supervision and exposure to alters with varying degrees of recent HDE frequency affect the risk of a ninth grader experiencing a first HDE.

Network dynamics. The strategy of meta-analyzing three individual SAOMs representing the study's two largest school districts, plus a pseudodistrict comprising the five smaller districts, generated a set of network tie parameter estimates similar to those found in comparable studies (e.g., Knecht et al., 2010; Light et al., 2013). Further, "nuisance"

Table 3. SAOM meta-analyses of rate of first heavy drinking episode (HDE)

	Final model				
	Parameter *M*		Parameter variance		Fisher's test[b]
Variable	Estimate	*SE*	Estimate	$\chi^2(2)$	$\chi^2(6)$
Network dynamics					
Rate 1–2	8.275***	0.768	1.331 ***	10.1	
Rate 2–3	6.659***	1.010	1.750***	16.8	
Outdegree	-4.147***	0.301	0.521***	94.1	9,910***
Reciprocity	2.601***	0.150	0.260**	9.7	1,832***
Transitive triplets	1.975***	0.190	0.330*	6.4	655.5***
3 Cycles	-0.630***	0.069	0.119	1.5	85.47***
Same sex	0.580***	0.062	0.108	5.5	266.4***
Similarity on days no adult					
Supervision (dyadic)	0.020	0.101	0.175***	17.1	14.90*
Similarity on heavy drinking frequency	0.445**	0.161	0.279	4.1	27.92***
Similarity on Days No Adult Supervision					
× Similarity on Heavy Drinking Frequency	-0.300*	0.126	0.224	2.7	20.51**
Same subunit	1.095***	0.080	–	–	–
Behavior dynamics					
Rate 1–2	0.092***	0.012	0.293	1.8	
Rate 2–3	0.756**	0.027	0.046	5.2	
Exposure to alters with prior HDE					
on ego rate of HDE onset	0.678*	0.317	0.549	2.4	23.65***
Exposure to alters with prior HDE and					
more frequent recent HDE on					
ego rate of HDE onsets	0.011	0.390	0.676	1.1	3.62
Exposure to less-supervised alters with prior					
HDE on ego rate of HDE onset	0.606	0.366	0.635	2.0	14.59*

[a]One school was organized into administrative subunits; this effect applies only to that school; [b]probability that all district-specific parameters are zero (vs. nonzero in the observed direction).
*$p < .05$; **$p < .01$; ***$p < .001$.

(control) effect estimates (numbers 2–6 in Table 1) were statistically significant and in the expected directions (e.g., Light et al., 2013). Taken together, these results provided some informal reassurance that the modeling strategy was viable.

Turning to effects of substantive interest, the statistically significant similarity interaction parameter (b = -0.30, p = .003) suggests that the risk of a first HDE created by exposure to HDE+ alters (b = 0.445, $p < .001$) is attenuated the more those friendships are supervised. There was no evidence that ego friendship choices were based on similarity of adult supervision (b = 0.020, p >.80), but that effect was kept in the model to allow a clearer interpretation of the interaction effect (Gelman & Hill, 2007). Although the pooling of the small districts, which averages out their variability, probably leads to this variance being underestimated, for most parameters, variability was nevertheless statistically significant or nearly so. The network model parameters with nonsignificant variability included three-cycles, same sex, HDE similarity, and the interaction between unsupervised time with friends and HDE similarity.

Behavior dynamics. The behavior part of the model identified a significant risk of earlier HDE experience associated with exposure to HDE+ alters (b = 0.678, $p < .05$). This effect was not significantly moderated by alters' prior-30-day HDE frequency (b = 0.011, $p > 0.90$). It was also not significantly moderated by alters' prior-30-day adult supervision, but this interaction was in the hypothesized direction (b = 0.606) and at a level of significance ($p < .10$) that qualifies as at least weak evidence of such moderation. Indeed, an argument could be made that the theoretical implausibility of finding negative moderation—that associating with more-supervised alters is actually riskier—suggests a one-tailed test would be appropriate, in which case the p value for this effect would fall below .05. Furthermore, the Fisher test that this parameter was nonpositive in all submodels was significantly rejected ($p < .05$).

Discussion

Most recent studies of the social network dynamics of alcohol use in adolescent populations (e.g., Burk et al., 2012; Knecht et al., 2010; Light et al., 2013; Van Ryzin & Dishion, 2014) have found both selection and influence effects; adolescents tend to start drinking because they affiliate with friends who drink, especially when these friends are not closely supervised by their parents or other adults. Once adolescents have started drinking, there is a tendency for them to select other drinkers as new friends, and/or are differentially likely to retain other drinkers as friends, thus reinforcing the behavior (Van Ryzin & Dishion, 2014; Veenstra et al., 2013).

In this study, we examined whether similar bidirectional dynamics exist for timing of a first HDE specifically, because heavy drinking is certainly riskier in the short run and likely more predictive of deleterious longer-term consequences than more normative levels of drinking. These expectations were largely confirmed. The network model showed that, like alcohol use generally, similar heavy drinking frequency is a predictor of friendship selection; however, by itself, adult supervision similarity is not. Nevertheless, the more adolescent friendships are supervised by adults, the less likely that heavy drinking similarity predicts the friendship. The influence model found that the more alters the adolescent is exposed to who have experienced an HDE previously, the earlier he or she is likely to experience an HDE as well. Influence may be attenuated to the extent that these friendships are better supervised.

However, friends' recent heavy drinking does not affect the likelihood of a first HDE. This suggests that the relevant influence mechanism in play is not greater exposure to risky occasions, that is, where a friend was drinking heavily. More likely, exposure to heavy drinking friends influences the adolescent's alcohol use expectations, perhaps also demonstrating that heavy drinking is normative (cf. Janssen et al., 2018; Smith et al., 2014; Trucco et al., 2011). If so, network interventions could be designed to maximize indirect influence effects by identifying centrally located and credible individuals as intervention targets. If the intervention were successful in shifting the target individual's attitudes about heavy drinking, influence mechanisms would spread such changes through the peer environment. Network interventions targeting health risk behaviors have shown promise for HIV risk (Latkin et al., 2013), drug abuse (Li et al., 2012), bullying and aggression (Paluck & Shepherd, 2012; Paluck et al., 2016), and other risky behaviors (Valente, 2010). Additionally, the critical role of adult supervision of adolescent activities with peers appears again, having been identified in many past studies of adolescent problem behavior (e.g., Dishion et al., 2003; Rusby et al., 2018). We find that the influence of exposure to heavy drinking friends is attenuated and possibly eliminated if such friendships are sufficiently supervised. Perhaps network interventions could include an adult component highlighting the importance of this effect. Supervision provided by any adult—for example, school or community activities coordinators or other parents—could attenuate the risk of substance-naïve youth affiliations with peer users (Koning et al., 2009; Tilton-Weaver et al., 2013), a useful counterbalance to the difficulties of enlisting the cooperation of parents of the most at-risk youth (Dishion et al., 2003; Enstad et al., 2017; Kerr et al., 2010).

Another possibility is that the tendency to experience heavy drinking earlier than one's friends is not so much about heavy drinking per se as it is about being an "early adopter" of risky behavior more generally. This interpretation is consistent with Kuntsche et al.'s (2013) finding that any amount of heavy drinking seems to confer risk for later problematic outcomes, as well as our failure to find a stronger influence effect as a function of the frequency of the adolescent's friends' recent heavy drinking. Because heavy drinking is correlated with other risky behaviors, disentangling it from these other behaviors is difficult but would help clarify, for instance, whether optimal prevention strategies should target alcohol use per se or broader patterns of risky behavior.

This study explicitly targeted heavy drinking in a community sample of mid-adolescents with drinking patterns similar to those found in statistically representative data sets. However, little detailed reporting is available on the pattern of heavy drinking among youth in typical community settings. In the present sample, heavy drinking appears to be common, pervasive, and not typically just one-time experimentation. Most adolescents who reported any heavy drinking during their ninth grade year reported more than one such episode and generally had friends who also drank heavily on a regular basis, that is, several times a month or more. Our findings help us to understand the social influence–driven nature of this clearly problematic behavior.

Study limitations include region (the U.S. Pacific Northwest; rural or suburban communities) and ethnicity, primarily White non-Hispanic and White Hispanic youth. Social networks were assessed only within grade level, so effects involving different-age youth were not assessed. There are also modeling challenges involving how best to use all available data, particularly from smaller networks. The structural-zero pooled model used for the five smaller districts in this study seemed adequate, but more flexible pooling strategies may be superior. Critical measures (HDE, adult supervision, friendship nominations) relied on single-item participant self-reports, which would be improved by corroboration and ideally operationalized by multi-item constructs. Another limitation of the present study is that friendship closeness was not investigated. In a longitudinal study on adolescent substance use with multivariate repeated measures, Mason et al. (2017) found that friendship closeness moderated peer influence on tobacco and marijuana use, but not alcohol use. Further investigation of the effect of friendship closeness in the context of peer network studies is warranted.

Nevertheless, it appears that the risk of a first HDE is increased by exposure to more heavy drinking friends—the more such exposure, the greater the risk. Further, there is evidence that in at least some social ecosystems, this risk can be attenuated by sufficient adult supervision, which appears to reduce the tendency for heavier drinkers to become or remain friends, as well as reducing the effect of exposure to existing heavier-drinking friends. Future studies should continue to address this more system-oriented type of intervention in conjunction with individually based help for the most at-risk youth.

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