Social Networks and Sexual Orientation Disparities in Tobacco and Alcohol Use

MARK L. HATZENBUEHLER, PH.D.,[a,*] KATIE A. MCLAUGHLIN, PH.D.,[b] AND ZIMING XUAN, SC.D.[c]

[a]*Department of Sociomedical Sciences, Mailman School of Public Health, Columbia University, New York, New York*
[b]*Department of Psychology, University of Washington, Seattle, Washington*
[c]*Department of Community Health Sciences, School of Public Health, Boston University, Boston, Massachusetts*

ABSTRACT. Objective: The purpose of this study was to examine whether the composition of social networks contributes to sexual orientation disparities in substance use and misuse. **Method:** Data were obtained from the National Longitudinal Study of Adolescent Health (Add Health), a nationally representative cohort study of adolescents (N = 20,745). Wave 1 collected extensive information about the social networks of participants through peer nomination inventories. **Results:** Same- and both-sex–attracted youths had higher frequency/quantity of tobacco use in their peer networks than did opposite-sex–attracted youths, and both-sex–attracted youths had higher frequency/quantity of alcohol use and misuse in their peer networks than opposite-sex–attracted youths. Among same- and both-sex–attracted youths, greater frequency/quantity of tobacco use in one's social network predicted greater use of cigarettes. In addition, greater frequency/quantity of peers' drinking and drinking to intoxication predicted more alcohol use and alcohol misuse in the both-sex–attracted group. These social network factors mediated sexual orientation–related disparities in tobacco use for both- and same-sex–attracted youths. Moreover, sexual orientation disparities in alcohol misuse were mediated by social network characteristics for the same-sex and both-sex–attracted youths. Importantly, sexual minority adolescents were no more likely to have other sexual minorities in their social networks than were sexual majority youths, ruling out an alternative explanation for our results. **Conclusions:** These findings highlight the importance of social networks as correlates of substance use behaviors among sexual minority youths and as potential pathways explaining sexual orientation disparities in substance use outcomes. (*J. Stud. Alcohol Drugs, 76,* 117–126, 2015)

SEXUAL ORIENTATION DISPARITIES in adolescent substance use are well documented. One meta-analysis indicated that the odds of substance use among lesbian, gay, and bisexual (LGB) youths are, on average, 190% higher than for heterosexual youths (Marshal et al., 2008). Rates of tobacco use also are higher among sexual minority youths (i.e., youths who identify as LGB or who engage in same-sex behaviors and report same-sex attractions) than among their heterosexual peers (e.g., Austin et al., 2004; Pollard et al., 2011). The Institute of Medicine (2011) released a report on the health of sexual minorities, which noted the dearth of evidence on the factors responsible for the development and maintenance of sexual orientation health disparities, including substance use and substance use disorders.

To address this research gap, the present study examined the role of the composition of peer networks as a factor related to sexual orientation–related disparities in adolescent substance use outcomes. We focused on peer networks among adolescents for several reasons. Adolescence is a time in which social roles change dramatically (Eccles, 1999). Relationships with parents become less close and more conflictual (Steinberg, 1988), and relationships with peers become increasingly important and occupy more time (Buhrmester & Furman, 1987; Larson & Richards, 1991).

Peer relationships exert an important influence on engagement in risky behaviors (for a review, see Sussman et al., 2007). Experimental evidence indicates that the mere presence of peers increases risk-taking behavior among adolescents but has no effect on risk behavior in adults (Gardner & Steinberg, 1995). In particular, friendship networks are strongly related to adolescent substance use, including trajectories of tobacco use (Pollard et al., 2010) and alcohol consumption (Ali & Dwyer, 2010).

Despite the fairly robust literature on the importance of peer networks as a social determinant of substance use in general samples of adolescents, there is a paucity of research on the role of such networks in explaining (a) substance use outcomes among sexual minority youths and (b) sexual orientation disparities in substance use. Indeed, studies of peer relationships among LGB youths have focused almost exclusively on peer violence/victimization as well as social rejection from peers (Garofalo et al., 1999; Russell et al., 2001). We expand this research to consider how other characteristics of peer relationships—specifically, the social networks within which LGB adolescents are embedded—contribute to substance use within this population and to sexual orientation disparities in substance use outcomes.

Although no study to our knowledge has used social network analysis to understand correlates of drinking in sexual minority adolescents, previous research suggests that

Received: January 4, 2014. Revision: August 10, 2014.

This research was supported by National Institute on Drug Abuse Grant K01 DA032558.

*Correspondence may be sent to Mark L. Hatzenbuehler at the Department of Sociomedical Sciences, Mailman School of Public Health, Columbia University, 722 West 168th Street, Room 549B, New York, NY 10032, or via email at: mlh2101@columbia.edu.

social networks may offer unique insights into patterns of substance use in this population. For instance, LGB high school students have more permissive social norms for drinking as well as more positive alcohol expectancies than do heterosexual students (Hatzenbuehler et al., 2008). One potential explanation for this finding is that the development of permissive social norms and positive alcohol expectancies among sexual minorities emerges via exposure to adolescent social networks that engage in higher levels of drinking. This hypothesis has not been empirically tested, however.

In this study, we address three important questions regarding the role of social networks in explaining sexual orientation differences in substance use outcomes. First, we examine whether the composition of adolescent social networks—and in particular, the extent to which members of these networks engage in greater frequency/quantity of substance use—is associated with individual-level substance use in sexual minority youths. Based on previous research (Hatzenbuehler et al., 2012; Ueno, 2005), we hypothesized that sexual minority adolescents' social isolation and rejection from central social networks places them in marginalized or "deviant" peer networks in which substance use is common and more acceptable (Fergusson et al., 2002; Moffitt, 1993; Monahan et al., 2009; Pepler et al., 2010).

In turn, based on sociological (Sutherland & Cressey, 1974) and psychological (Bandura, 2001) theories on the influence of social norms and social learning on individual behaviors, we expected that involvement in peer networks with greater substance use would be associated with higher substance use behavior among sexual minority youths, just as it is for heterosexuals (Ali & Dwyer, 2010; Pollard et al., 2010). Given that sexual minority adolescents are more isolated than heterosexual youths (e.g., Eisenberg & Resnick, 2006; Hatzenbuehler et al., 2012; Safren & Heimberg, 1999), we also tested whether more isolated social networks are associated with greater substance use among sexual minority adolescents. This affords the opportunity to examine whether high frequency/quantity of substance use in adolescents' social networks is specifically related to substance use outcomes as compared with other aspects of peer networks (namely, social isolation).

Second, we determine whether social networks explain, at least in part, the relationship between sexual orientation and substance use outcomes. This research question explores peer networks as a mediator of sexual orientation disparities in substance use (Figure 1). Evidence for mediation would not only provide a contribution to the literature on social determinants of sexual orientation health disparities, but it would also suggest extensions of social network theory and analysis to the area of health disparities more broadly, which has been relatively neglected as an area of study (e.g., Millett et al., 2007).

Third, we evaluate whether associations between social networks and substance use outcomes are stronger for sexual minority youths than for majority youths. This research question therefore considers sexual orientation as a moderator of the relationship between social networks and substance use outcomes; this addresses whether there is something unique about sexual minority status that potentiates the effect of social network characteristics on substance use outcomes (Figure 2). In other words, is network frequency/quantity of substance use associated with individual-level substance use more strongly among sexual minority adolescents than among majority adolescents?

One prior study found that sexual orientation moderated the relationship between characteristics of peer networks (i.e., social isolation) and depressive symptoms, such that isolated social networks were more strongly associated with depression among sexual minority boys than among non–sexual minority boys (Hatzenbuehler et al., 2012). It remains unknown, however, whether substance-using social networks are a more robust risk factor for substance use problems among sexual minority adolescents than among their majority peers.

We address these research questions by using comprehensive social network data collected in a nationally representa-

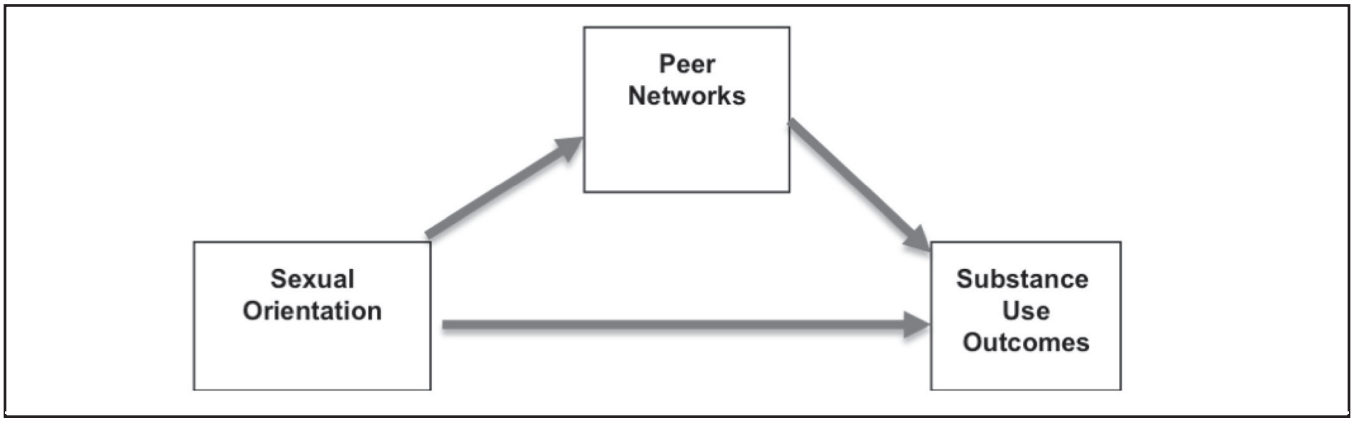

FIGURE 1. Mediation model depicting peer networks as a mechanism explaining the relationship between sexual orientation and substance use outcomes.

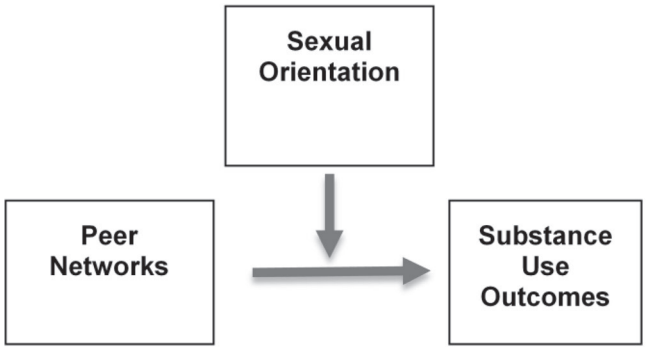

FIGURE 2. Moderation model depicting sexual orientation modifying the relationship between peer networks and substance use outcomes

tive study of adolescents, the National Longitudinal Study of Adolescent Health (Add Health). Previous studies have documented sexual orientation disparities in substance use behaviors using data from Add Health (Russell et al., 2002). We extend this work by exploring one potential mechanism to explain these disparities—namely, the composition of social networks. Add Health is the only national-level data set to provide information on social networks and to simultaneously include information on sexual minority status, providing a rare opportunity to study the social networks of sexual minority youths and to determine the consequences of these networks for substance use outcomes.

Method

Sample and procedure

Data were drawn from Add Health, a longitudinal study of a nationally representative adolescent sample. The first wave was conducted in 1995 and included adolescents in Grades 7–12 (N = 90,118) selected using a multistage, stratified, cluster sampling strategy. Adolescents completed in-school interviews, and a core subsample (n = 20,745; response rate: 78.9%) completed in-depth home interviews, which provided measurement of sensitive health-risk behaviors, including substance use. The in-home interview was conducted with automated computer-assisted interviewing technology, which increased the chances of self-reporting sensitive health-risk behaviors, including substance use (Turner et al., 1998).

The data for our analysis were drawn from both the in-school and in-home interviews. Of the 20,745 students who completed the in-home interview, we excluded 6,426 participants who did not complete the in-school interview, were not in the school network roster, or attended schools for which friendship data were not included, yielding a final sample size of 14,319. A more detailed description of the Add Health sample can be found elsewhere (Bearman et al., 1995). Institutional Review Board approval was granted by the University of North Carolina for consent and field procedures and by the Columbia and Harvard Schools of Public Health for analysis.

Measures

Sexual attraction variable. The Wave 1 in-home survey included two questions on romantic attraction: (a) "Have you ever had a romantic attraction to a female?" and (b) "Have you ever had a romantic attraction to a male?" Youths reporting no romantic attractions (11.4%) were excluded, as were those with missing data (n = 107). Analyses compared three groups: (a) youths who reported attractions exclusively to members of the same sex (n = 151), which we refer to as "same-sex–attracted youths"; (b) youths reporting attractions to both males and females (n = 708), which we refer to as "both-sex–attracted youths"; and (c) youths reporting attractions exclusively to members of the opposite sex (n = 13,353), which we refer to as "opposite-sex–attracted youths." The term *sexual minority youths* refers to youths who report same- and both-sex attractions.

Dependent variables. Substance use was assessed in the in-home survey. For the purposes of this study, use of substances was measured in three ways. First, the frequency (number of days out of the past 30 that the respondent smoked cigarettes) and quantity (number of cigarettes smoked on those days) of tobacco use was assessed, and the product of these values was calculated to create a summary measure of tobacco use (Russell et al., 2002). Second, an ordinal measure of drinking frequency was based on 1 for *every day/almost every day,* 2 for *3–5 days/week,* 3 for *1 or 2 days/week,* 4 for *2 or 3 days/month,* 5 for *once a month or less (3–12 times in past 12 months),* 6 for *1 or 2 days in past 12 months,* and 7 for *never.* We reversed the value of the scale so that a high value was indicative of greater frequency of drinking. We then multiplied this by alcohol quantity (usual number of drinks per drinking episode) to create a summary score of alcohol use, an approach that has been used in other studies with the Add Health sample (e.g., Daw et al., 2013).

Third, respondents indicated the number of times in the past year that their alcohol use caused them problems in seven life domains (e.g., problems at school or work). Responses ranged from 0 (*never*) to 4 (*five or more times*). The total number endorsed for each domain was calculated and summed, which was evaluated as a continuous measure of alcohol misuse (range: 0–28).

Social network variables. As part of the in-school survey, each student was asked to name his or her five best male and five best female friends. Students could name friends from both inside and outside the school (only 15% of all respondents' friends did not attend their school or sister school), and the network variables were constructed using only those nominations in which both the sender (i.e.,

TABLE 1. Descriptive statistics for the substance-using social networks variables, stratified by sexual orientation status

Variable	Overall sample	Same-sex–attracted	Both-sex–attracted	Opposite-sex–attracted
Tobacco use				
M	1.106	1.344	1.350	1.092
Mdn	0.700	0.935	0.920	0.700
SD	1.248	1.460	1.398	1.234
Alcohol use				
M	1.186	1.205	1.311	1.181
Mdn	1.000	1.000	1.135	1.000
SD	0.908	0.909	0.958	0.903
Alcohol misuse				
M	0.665	0.691	0.768	0.659
Mdn	0.430	0.450	0.500	0.420
SD	0.771	0.742	0.856	0.766

Notes: M = mean; *Mdn* = median; *SD* = standard deviation.

ego or respondent) and receiver (i.e., alter) of the friendship nomination were uniquely identifiable students who completed the in-school questionnaire (Carolina Population Center, 2001). These nominations were used to create social network variables that captured the pattern and structure of peer networks.

In social network analyses, there are three possible types of ego-centered (i.e., respondent) networks, which are composed of a set of alters (i.e., a student in the same school as the ego who is eligible to be nominated as a friend): (a) the ego-send network, which is composed of the alters that are nominated by the ego; (b) the ego-receive network, composed of alters nominating the ego; and (c) the ego send- and receive-network, which is a combination of the ego's send and receive networks. For all analyses, we present results for the ego's send- and receive-network, which provides a more comprehensive index of the ego's peer group.

For the current study, we examined whether the peers of sexual minority youths (same- and both-sex–attracted adolescents) were more likely to smoke, drink, and drink to intoxication than were peers of opposite-sex–attracted youths. We calculated the mean value of the frequency of tobacco use, alcohol use, and drinking to intoxication items for the social networks of both sexual minority and opposite-sex–attracted youths. These measures are standardized by the size of the network. Mean values exclude ego and any alters with missing values on the peer substance use variables. Importantly, the respondent is not included in the creation of the social network variables involving substance use (i.e., the respondent's own substance use does not contribute to the frequency/quantity of use in his or her network). Table 1 presents the descriptive statistics for the three substance use social network variables, stratified by sexual orientation status.

In specificity analyses, we also analyzed whether more isolated social networks were associated with greater substance use among sexual minority adolescents to determine if the results were specific to substance-using social networks. We calculated two measures of social isolation: (a) in-degree, which is the number of students in the school who nominated the participant and (b) out-degree, which is the number of students in the school who were nominated by the participant. Previous studies with this sample have documented sexual orientation differences in socially isolated peer networks. Specifically, same-sex–attracted and both-sex–attracted females nominated a significantly smaller number of friends than opposite-sex–attracted females; moreover, both-sex–attracted males nominated fewer friends than opposite-sex–attracted males (Hatzenbuehler et al., 2012).

Statistical analysis

Mediation analyses were conducted in four steps. First, we determined whether sexual orientation–related disparities in tobacco use, alcohol use, and alcohol misuse were present. Second, we examined differences in the social network variables among the same-sex–, both-sex–, and opposite-sex–attracted youths, using analysis of variance for group differences and independent samples *t* tests for post hoc analyses. Third, we evaluated whether the social network variables predicted substance use outcomes among the full sample as well as among sexual minority youths (separately for same-sex–attracted and both-sex–attracted youths), using linear regression. Fourth, mediation analyses tested whether social networks explained the association between sexual orientation and substance use outcomes.

Linear regression models were conducted for these analyses, which were adjusted for age, sex, and race/ethnicity. Sobel's (1982) standard error approximation was used to test the significance of the intervening-variable effect. To examine whether the association of network frequency of substance use with individual-level substance use was stronger for sexual minority adolescents than for non–sexual minorities, we created multiplicative interactions between sexual orientation and network substance use.

Social network variables were not normally distributed and were therefore log-transformed for all analyses. Less than 5% of the final sample was missing data on any of the social network variables; given the minimal amount of missing data, these responses were handled using listwise deletion. Statistical analyses were conducted using SUDAAN 10.0 to adjust variance estimates for the complex survey design of Add Health (Software for Survey Data Analysis, 2008). Statistical significance was evaluated using .05-level, two-sided tests.

Results

Sexual orientation disparities in substance use

We found evidence for sexual orientation–related disparities in substance use and misuse (Table 2). Compared with

Table 2. Disparities in substance use comparing sexual minority youths with opposite-sex–attracted youths in the National Longitudinal Study of Adolescent Health

Outcomes	Same-sex–attracted youths (n = 151)	Both-sex–attracted youths (n = 708)	Opposite-sex–attracted youths (n = 13,353)	χ^2	p
Any tobacco use	30.75%	39.11%	26.13%	10.43	<.0001
Any alcohol use	52.00%	60.15%	46.32%	12.88	<.00001
Any alcohol misuse	33.81%	45.03%	30.74%	13.54	<.00001

Note: Percentage of sexual minority and opposite-sex–attracted youths engaging in any tobacco use, alcohol use, or alcohol misuse.

opposite-sex–attracted youths, same- and both-sex–attracted youths were significantly more likely to smoke, drink, and engage in alcohol misuse (all ps < .0001).

Composition of social networks of sexual minority youths

The networks of sexual minority youths were significantly more likely to be composed of individuals who smoke, drink, and drink to intoxication than the networks of opposite-sex–attracted adolescents. Specifically, the frequency/quantity of smoking among peers was significantly higher for the social networks of same-sex–attracted youths (t = 2.05, p = .04) and both-sex–attracted youths (t = 3.38, p = .001) compared with opposite-sex–attracted youths. Moreover, among the social networks of both-sex–attracted youths, the frequency/quantity of drinking (t = 2.42, p = .02) and drinking to intoxication (t = 2.85, p = .01) was significantly higher than among the social networks of opposite-sex–attracted youths. In contrast, there were no differences in the frequency/quantity of drinking (t = -0.76, p = .45) or drinking to intoxication (t = -0.08, p = .94) between the same-sex–attracted and opposite-sex–attracted youths.

Social networks and substance use

Within-group analyses of sexual minority youths (Table 3) indicated that the composition of their social networks was associated strongly with substance use behaviors, particularly among the both-sex–attracted youths. Greater frequency/quantity of peer smoking was significantly associated with frequency of smoking among the same- and both-sex–attracted youths. Moreover, among the both-sex–attracted youths (but not the same-sex–attracted youths), having greater frequency/quantity of drinking in one's social network was significantly associated with greater alcohol use. Further, greater frequency of drinking to intoxication was significantly associated with higher levels of alcohol misuse among the both-sex–attracted youths. Similar results were obtained in the opposite-sex–attracted youths and in the full sample, such that greater frequency/quantity of smoking, drinking, and heavy drinking in one's social network was significantly associated with each of the substance use outcomes.

In contrast to the results for the substance-using social networks, having more socially isolated peer networks was not associated with any of the substance use outcomes among sexual minority youths (all p > .05). This result was observed for both social isolation variables (i.e., nominating others and being nominated by others).

Mediation analyses

In the analyses above, the first three steps of mediation were established: (a) the predictor (sexual orientation) was associated with the outcome (tobacco and alcohol use, alcohol misuse), (b) the predictor was associated with the mediator (higher substance-using social networks), and (c) the mediator was associated with the outcome. In the final mediation analyses (Table 4), we examined the degree of attenuation in the association between sexual orientation and substance use after adding social network factors to the model, controlling for sociodemographic characteristics (age, sex, race/ethnicity).

For tobacco use outcomes, we found support for mediation among the both-sex–attracted youths. There was

Table 3. Social networks and substance use

	Full sample (N = 14,319)		Same-sex–attracted youths (n = 151)		Both-sex–attracted youths (n = 708)		Opposite-sex–attracted youths (n = 13,353)	
Outcomes	β (*SE*)	p	β (*SE*)	p	β (*SE*)	p	β (*SE*)	p
Tobacco use	14.76 (1.44)	<.001	25.50 (11.04)	.02	16.82 (3.64)	<.001	14.59 (1.49)	<.001
Alcohol use	1.99 (0.19)	<.001	-6.00 (4.75)	.21	2.39 (0.70)	.0009	2.03 (0.18)	<.001
Alcohol misuse	0.46 (0.03)	<.001	-0.20 (0.42)	.63	0.49 (0.13)	.0002	0.47 (0.03)	<.001

Notes: These analyses examined associations between the frequency/quantity of substance users (tobacco, drinking, and drinking to intoxication, respectively) in one's social network and frequency of substance use.

TABLE 4. Mediation models examining reduction in associations between sexual orientation and substance use behaviors

	Model 1[a]		Model 2[b]	
Variable	β (*SE*)	*p*	β (*SE*)	*p*
Tobacco use				
Attraction				
Same-sex attraction	26.90 (14.93)	.07	21.07 (17.82)	.24
Both-sex attraction	31.49 (9.14)	.00	14.62 (10.58)	.17
Opposite-sex attraction	ref.		ref.	
Age	15.19 (1.12)	<.01	10.45 (0.98)	<.01
Sex				
Male	6.09 (3.35)	.07	2.11 (3.31)	.53
Female	ref.		ref.	
Race/ethnicity				
Black	-60.20 (4.28)	<.01	-37.05 (3.96)	<.01
Hispanic	-41.44 (5.44)	<.01	-28.10 (4.00)	<.01
Others	-23.62 (7.34)	<.01	-13.75 (5.70)	.02
White	ref.		ref.	
Density of smokers in social network	–	–	11.47 (1.34)	<.01
Alcohol use				
Attraction				
Same-sex attraction	2.88 (1.97)	.15	2.56 (3.59)	.48
Both-sex attraction	3.63 (1.20)	<.01	3.92 (1.69)	.02
Opposite-sex attraction	ref.		ref.	
Age	1.81 (0.13)	<.01	1.57 (0.16)	<.01
Sex				
Male	2.56 (0.44)	<.01	2.35 (0.56)	<.01
Female	ref.		ref.	
Race/ethnicity				
Black	-4.41 (0.56)	<.01	-3.20 (0.70)	<.01
Hispanic	-1.25 (0.67)	.06	-0.43 (0.72)	.55
Others	-1.86 (0.84)	.03	-1.36 (0.96)	.16
White	ref.		ref.	
Density of drinkers in social network	–	–	1.38 (0.19)	<.01
Alcohol misuse				
Attraction				
Same-sex attraction	0.86 (0.43)	.05	0.18 (0.55)	.75
Both-sex attraction	1.17 (0.27)	<.01	0.87 (0.30)	.004
Opposite-sex attraction	ref.		ref.	
Age	0.42 (0.03)	<.01	0.28 (0.03)	<.01
Sex				
Male	0.16 (0.07)	.02	0.19 (0.10)	.06
Female	ref.		ref.	
Race/ethnicity				
Black	-1.04 (0.13)	<.01	-0.85 (0.11)	<.01
Hispanic	-0.25 (0.17)	.15	0.00 (0.16)	.99
Others	-0.38 (0.16)	.02	-0.27 (0.17)	.12
White	ref.		ref.	
Density of peers who drink to intoxication in social network	–	–	0.36 (0.03)	<.01

Notes: Ref. = reference. [a]Model 1 presents the association between sexual orientation and substance use outcomes, controlling for age, sex, and race/ethnicity; [b]Model 2 presents the association between sexual orientation and substance use outcomes, controlling for age, sex, race/ethnicity, and frequency/quantity of substance-using peers in social network. The attenuation in the association between sexual minority status and substance use between Model 1 and Model 2 demonstrates the magnitude of the mediation effect.

a 53.6% reduction in the association between both-sex attraction and tobacco use in the final mediation models. Sexual orientation–related disparities in tobacco use were eliminated for this group after accounting for frequency/quantity of smoking in respondents' social networks (β = 14.62, p = .17), and the Sobel's test indicated that the mediation effect was statistically significant (z = 2.92, p = .003). After we controlled for sociodemographics, same-sex attraction was marginally associated with tobacco use (β = 26.90, p = .07).

We nonetheless examined the role of frequency/quantity of smoking in same-sex–attracted youths' social networks

Table 5. Proportion of networks comprising sexual minorities, by sexual orientation status

Variable	β	*SE*	*p*
Proportion of friends who are same-sex attracted that the respondent nominates			
Same sex	-0.08	0.15	.62
Both sex	-0.07	0.10	.51
Opposite sex (ref.)			
Proportion of friends who are both-sex attracted that the respondent nominates			
Same sex	1.69	1.61	.30
Both sex	0.46	0.36	.20
Opposite sex (ref.)			
Proportion of friends who are opposite-sex attracted that the respondent nominates			
Same sex	0.12	3.57	.97
Both sex	-1.94	1.89	.31
Opposite sex (ref.)			
Proportion of friends who are same-sex attracted that nominate the respondent			
Same sex	0.24	0.31	.44
Both sex	-0.07	0.09	.46
Opposite sex (ref.)			
Proportion of friends who are both-sex attracted that nominate the respondent			
Same sex	0.11	0.60	.85
Both sex	0.32	0.44	.47
Opposite sex (ref.)			
Proportion of friends who are opposite-sex attracted that nominate the respondent			
Same sex	3.19	3.65	.38
Both sex	-0.71	2.42	.77
Opposite sex (ref.)			

Note: Ref. = reference.

as a mediator of this effect, as it is argued that mediation should be examined even for associations that do not reach statistical significance (MacKinnon et al., 2002). The association between same-sex attraction and smoking was reduced by 21.7% when frequency/quantity of smoking in respondents' social networks was controlled for (β = 21.07, p = .24), and the Sobel's test indicated that the mediation effect was statistically significant (z = 2.88, p = .004).

In addition, among the both-sex–attracted youths, there was a 25.6% reduction in the association between both-sex attraction and alcohol misuse in the final mediation models (β = 0.87, p = .004), which was a significant mediation effect (Sobel's z = 4.08, p < .001). Among the same-sex–attracted group, the association between same-sex attraction and alcohol misuse was reduced by 79.1% and was no longer significant after controlling for frequency of alcohol misuse in respondents' social networks (β = 0.18, p = .75), also a significant mediation effect (Sobel's z = 1.97, p = .049). In contrast, we did not find support for mediation for alcohol use in either the same- or the both-sex–attracted groups.

Moderation analyses

The two-way interaction (Sexual Orientation × Social Networks) was not significant for any of the outcomes: tobacco use for same-sex–attracted (β = 8.5, *SE* = 9.97, p = .40) and for both-sex–attracted (β = 1.69, *SE* = 4.05, p = .68); alcohol use for same-sex–attracted (β = -7.78, *SE* = 4.39, p = .08) and for both-sex–attracted (β = 0.05, *SE* = 0.68, p = .94); and alcohol misuse for same-sex–attracted (β = -0.59, *SE* = 0.38, p = .13) and for both-sex–attracted (β = 0.01, *SE* = 0.12, p = .93). Consequently, we find no evidence that the relationship between substance-using networks and substance use outcomes differs between sexual minority and majority adolescents.

Testing alternative explanations

An alternative explanation for these findings is that the social networks of sexual minority youths are simply more densely populated by other sexual minorities, who are already more likely to smoke, use alcohol, and drink to intoxication than majority youths. If that were true, what appears as a broad social network effect of substance-using peers would instead be attributable to the specific nature of sexual minority peer groups—that is, that they are composed largely of other sexual minorities.

To test this alternative hypothesis, we examined the number of peers that the sexual minority youths nominated as well as the number of sexual minority peers that were nominated by other youths. Support for the alternative hypothesis would require that sexual minority youths are more likely to nominate and be nominated by other sexual minorities compared with majority youths. We did not find support for this hypothesis, however. The proportion of networks that comprises sexual minorities was not significantly different across sexual minority individuals and majority individuals (Table 5). Thus, the relationship between social networks and substance use in sexual minority youths is not attributable to a greater number of sexual minority peers in their networks.

Discussion

In the current study, we used the lens of social network theory (Bearman & Moody, 2004; Christakis & Fowler, 2007) to consider the influence of social networks on the prevalence of substance use and substance use disorders among sexual minority youths. Same- and both-sex–attracted youths have greater frequency/quantity of tobacco use in their peer networks than do opposite-sex–attracted youths, and both-sex–attracted youths have greater frequency/quantity of alcohol use and higher rates of alcohol misuse in their peer networks than do opposite-sex–attracted youths. Having a greater number of tobacco-using peers was strongly as-

sociated with higher rates of tobacco use among same- and both-sex–attracted youths.

Moreover, a greater number of peers who drank and drank to intoxication predicted more alcohol use and alcohol misuse in the both-sex–attracted group, but mediation was only observed for alcohol misuse. Stress (McCreary & Sadava, 1998, 2000) and discrimination (Hatzenbuehler et al., 2011) are more strongly predictive of alcohol problems than of alcohol use. To the extent that membership in substance-using networks is reflective of stress processes in sexual minorities (e.g., social rejection from low-substance-using peer groups), this research would suggest that these networks would predict alcohol misuse more strongly than alcohol use. Future studies are needed to more fully explain why social networks mediate relations between sexual orientation and alcohol misuse but not measures of frequency/quantity of alcohol use.

In contrast to previous studies, which have failed to find a reduction in the association between sexual orientation and substance use after controlling for a variety of individual-level risk factors (Austin et al., 2004; Ziyadeh et al., 2007), we observed that greater frequency/quantity of substance use in one's social network mediated the relation between sexual orientation and tobacco use for both- and same-sex–attracted youths. Sexual orientation disparities in alcohol misuse also were mediated by social network characteristics for same-sex and both-sex–attracted adolescents.

An alternative explanation for these findings is that sexual minority youths are more likely to be friends with other sexual minority youths. If this were true, the higher rates of substance use among sexual minority youths would not be attributable to substance-using networks per se, but instead to the fact that sexual minority youths (who are more likely to smoke and drink than majority youths) are overrepresented in their peer networks. Importantly, however, our data indicate that sexual minorities were not more likely to nominate—or be nominated by—other sexual minority peers than were majority youths. Thus, there is little evidence for this alternative explanation in these data.

In previous studies using data from Add Health (Hatzenbuehler et al., 2012), sexual minority youths were shown to be more isolated than opposite-sex–attracted adolescents. In the current study, having more socially isolated peer networks did not increase risk of substance use among sexual minority youths, indicating that the results are specific to substance-using networks. In addition, we tested whether substance-using social networks were more strongly associated with substance use outcomes for sexual minority youths than for majority youths. There was no evidence for moderation; thus, it appears that peer network frequency/quantity of substance use increases risk of substance use, irrespective of sexual orientation.

This study has many noteworthy strengths, including the use of a nationally representative sample of youths with comprehensive measures of the composition of social networks. Indeed, the peer nomination methods that were used in Add Health are considered the gold standard in research on social networks in children and adolescents (Ladd & Kochenderfer-Ladd, 2002). Moreover, these methods enable researchers to link information from the peer nominations to various behaviors of the peers, rather than relying on the respondents' reports of their peers' behaviors, which are subject to reporting biases (Prinstein & Wang, 2005).

The study also has important limitations. First, these data are cross-sectional, and therefore causal relationships between social networks and substance use cannot be inferred. In particular, we cannot rule out the possibility that an unobservable factor may be responsible for these associations, such as exposure to common environmental factors that influence substance use (Cohen-Cole & Fletcher, 2008), or that the observed associations are due to selection (i.e., friendship selection based on substance use behavior). Previous studies have shown that both social influence and social selection processes contribute to peer substance use (Valente et al., 2004).

Second, the only measures of sexual orientation that are available in Wave 1 are those that assess romantic attraction (and relationships); sexual identity (i.e., self-identification as lesbian, gay, or bisexual) was not assessed until Wave 3. Although correlated with other dimensions of sexual orientation, including sexual behavior and sexual identity (Laumann et al., 1994), the prevalence of same-sex attraction is higher than that of same-sex behaviors (Sell et al., 1995) and nonheterosexual sexual identity (Bostwick et al., 2010). Thus, the operationalization of sexual orientation can lead to different population groups (Sell, 2007). As such, it is unclear whether our results are fully generalizable to youths who identify as lesbian, gay, and bisexual.

Third, the social network variables were constructed using nominations in which both the respondent and receiver of the friendship nomination were uniquely identifiable students who completed the in-school questionnaire. Although only 15% of youths nominated friends outside of their school, the sexual minority youths were more likely than opposite-sex–attracted youths to nominate out-of-school friends. However, we are unable to determine whether these out-of-school friends' substance use differs from use of friends who attended their school because the former were not included in the assessments.

Last, as social environments become more accepting and opportunities for social interactions have expanded, the social networks of sexual minority youths are likely to reflect these changes. Hence, the social networks of youths today may differ in important ways from networks seen when the first wave of Add Health data collection was completed in the mid-1990s. At the same time, peer networks within schools remain a crucial social context for adolescents; thus, the results of the current study still provide important

information about the role of school peer networks as a potential risk factor for substance use among sexual minority youths. Nevertheless, studies that examine cohort effects of social networks among sexual minority youths are needed. These studies should focus specifically on how social media and other online media influence the characteristics of social networks among sexual minority youths and whether (and how) these newer networks may affect sexual orientation disparities in health.

Our results raise several questions for future inquiry. In particular, the focus of this study was on examining a measure of the intensity of substance use in the social network (i.e., a frequency/quantity measure) rather than the percentage of friends who merely use substances. Future studies should examine whether our results are generalizable across different measures of substance use networks (e.g., any use vs. intensity of use).

In addition, our measure of social networks relates only to direct ties to ego. Although this type of measure is frequently used in social networks research, studies are increasingly using an expanded definition of social networks that includes individuals at farther degrees (e.g., friends of friends). Because prior studies had not documented whether direct ties to ego were related to substance use in sexual minority youths, we chose to begin with this more basic definition of social network relationships. The next generation of this research should address how other definitions of social networks are related to substance use outcomes among sexual minority individuals.

Research is also needed to address the mechanisms underlying these results. As previous studies have shown, sexual minority youths are more isolated from and less connected to central peer networks in schools than are non–sexual minorities (Hatzenbuehler et al., 2012), which is likely a result of stigma and peer rejection that are common experiences for sexual minority youths (Garofalo et al., 1999; Russell et al., 2001). In turn, this isolation may leave sexual minority adolescents with fewer options for healthy peer networks and therefore place them in other marginalized networks that are more likely to use substances.

In support of this hypothesis (data not shown but available on request), social isolation was correlated with a greater number of tobacco-using peers, suggesting that the experience of social isolation may increase the likelihood that sexual minority youths join peer networks that are more likely to engage in some forms of substance use. However, it also is possible that sexual minority youths actively sort into other "deviant" peer groups, which may be more accepting of their differences. This may lead sexual minority youths to experience greater support within these social networks, but at the same time place them at increased risk for substance use.

With cross-sectional data, we are unable to determine which psychosocial pathways are more likely to influence the development of substance-using networks among sexual minority youths. Identifying these pathways has important implications for interventions that seek to reduce the high rates of substance use and associated problems among this population (Marshal et al., 2008). If social isolation is a primary mechanism, then school-based interventions that focus on reducing stigma and discrimination of LGB youths (e.g., through implementing Gay–Straight Alliances; Russell et al., 2009) may open up greater opportunities for healthier social networks for this group. Thus, greater attention to the social context of substance use among LGB youths may hold promise not only for creating more comprehensive etiologic models of risk but also for aiding in the development of effective public health interventions.

References

Ali, M. M., & Dwyer, D. S. (2010). Social network effects in alcohol consumption among adolescents. *Addictive Behaviors, 35,* 337–342.

Austin, S. B., Ziyadeh, N., Fisher, L. B., Kahn, J. A., Colditz, G. A., & Frazier, A. L. (2004). Sexual orientation and tobacco use in a cohort study of US adolescent girls and boys. *Archives of Pediatrics & Adolescent Medicine, 158,* 317–322.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52,* 1–26.

Bearman, P.S., Jones, L., & Udry, J.R. (1995). The National Longitudinal Study of Adolescent Health: Research Design. Available at: http://www.cpc.unc.edu/projects/addhealth/design

Bearman, P. S., & Moody, J. (2004). Suicide and friendships among American adolescents. *American Journal of Public Health, 94,* 89–95.

Bostwick, W. B., Boyd, C. J., Hughes, T. L., & McCabe, S. E. (2010). Dimensions of sexual orientation and the prevalence of mood and anxiety disorders in the United States. *American Journal of Public Health, 100,* 468–475.

Buhrmester, D., & Furman, W. (1987). The development of companionship and intimacy. *Child Development, 58,* 1101–1113.

Carolina Population Center. (2001). *National Longitudinal Study of Adolescent Health: Network variables codebook.* Chapel Hill, NC: University of North Carolina at Chapel Hill.

Christakis, N. A., & Fowler, J. H. (2007). The spread of obesity in a large social network over 32 years. *The New England Journal of Medicine, 357,* 370–379.

Cohen-Cole, E., & Fletcher, J. M. (2008). Is obesity contagious? Social networks vs. environmental factors in the obesity epidemic. *Journal of Health Economics, 27,* 1382–1387.

Daw, J., Shanahan, M., Harris, K. M., Smolen, A., Haberstick, B., & Boardman, J. D. (2013). Genetic sensitivity to peer behaviors: 5HTTLPR, smoking, and alcohol consumption. *Journal of Health and Social Behavior, 54,* 92–108.

Eccles, J. S. (1999). The development of children ages 6 to 14. *The Future of Children, 9,* 30–44.

Eisenberg, M. E., & Resnick, M. D. (2006). Suicidality among gay, lesbian and bisexual youth: The role of protective factors. *Journal of Adolescent Health, 39,* 662–668.

Fergusson, D. M., Swain-Campbell, N. R., & Horwood, L. J. (2002). Deviant peer affiliations, crime and substance use: A fixed effects regression analysis. *Journal of Abnormal Child Psychology, 30,* 419–430.

Gardner, M., & Steinberg, L. (2005). Peer influence on risk taking, risk preference, and risky decision making in adolescence and adulthood: An experimental study. *Developmental Psychology, 41,* 625–635.

Garofalo, R., Wolf, R. C., Wissow, L. S., Woods, E. R., & Goodman, E. (1999). Sexual orientation and risk of suicide attempts among a representative sample of youth. *Archives of Pediatrics & Adolescent Medicine, 153,* 487–493.

Hatzenbuehler, M. L., Corbin, W. R., & Fromme, K. (2008). Trajectories and determinants of alcohol use among LGB young adults and their heterosexual peers: Results from a prospective study. *Developmental Psychology, 44,* 81–90.

Hatzenbuehler, M. L., Corbin, W. R., & Fromme, K. (2011). Discrimination and alcohol-related problems among college students: A prospective examination of mediating effects. *Drug and Alcohol Dependence, 115,* 213–220.

Hatzenbuehler, M. L., McLaughlin, K. A., & Xuan, Z. (2012). Social networks and risk for depressive symptoms in a national sample of sexual minority youth. *Social Science & Medicine, 75,* 1184–1191.

Institute of Medicine of the National Academy of Sciences. (2011). *The health of lesbian, gay, bisexual and transgender people: Building a foundation for better understanding.* Washington, DC: The National Academies Press.

Ladd, G. W., & Kochenderfer-Ladd, B. (2002). Identifying victims of peer aggression from early to middle childhood: Analysis of cross-informant data for concordance, estimation of relational adjustment, prevalence of victimization, and characteristics of identified victims. *Psychological Assessment, 14,* 74–96.

Larson, R., & Richards, M. H. (1991). Daily companionship in late childhood and early adolescence: Changing developmental contexts. *Child Development, 62,* 284–300.

Laumann, E. O., Gagnon, J. H., Michael, R. T., & Michaels, S. (1994). *The social organization of sexuality: Sexual practices in the United States.* Chicago, IL: University of Chicago Press.

MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods, 7,* 83–104.

Marshal, M. P., Friedman, M. S., Stall, R., King, K. M., Miles, J., Gold, M. A., . . . Morse, J. Q. (2008). Sexual orientation and adolescent substance use: A meta-analysis and methodological review. *Addiction, 103,* 546–556.

McCreary, D. R., & Sadava, S. W. (1998). Stress, drinking, and the adverse consequences of drinking in two samples of young adults. *Psychology of Addictive Behaviors, 12,* 247–261.

McCreary, D. R., & Sadava, S. W. (2000). Stress, alcohol use and alcohol-related problems: The influence of negative and positive affect in two cohorts of young adults. *Journal of Studies on Alcohol, 61,* 466–474.

Millett, G. A., Flores, S. A., Peterson, J. L., & Bakeman, R. (2007). Explaining disparities in HIV infection among black and white men who have sex with men: A meta-analysis of HIV risk behaviors. *AIDS, 21,* 2083–2091.

Moffitt, T. E. (1993). Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy. *Psychological Review, 100,* 674–701.

Monahan, K. C., Steinberg, L., & Cauffman, E. (2009). Affiliation with antisocial peers, susceptibility to peer influence, and antisocial behavior during the transition to adulthood. *Developmental Psychology, 45,* 1520–1530.

Pepler, D. J., Jiang, D., Craig, W. M., & Connolly, J. (2010). Developmental trajectories of girls' and boys' delinquency and associated problems. *Journal of Abnormal Child Psychology, 38,* 1033–1044.

Pollard, M. S., Tucker, J. S., Green, H. D., Kennedy, D., & Go, M.-H. (2010). Friendship networks and trajectories of adolescent tobacco use. *Addictive Behaviors, 35,* 678–685.

Pollard, M. S., Tucker, J. S., Green, H. D., Kennedy, D. P., & Go, M.-H. (2011). Romantic attraction and adolescent smoking trajectories. *Addictive Behaviors, 36,* 1275–1281.

Prinstein, M. J., & Wang, S. S. (2005). False consensus and adolescent peer contagion: Examining discrepancies between perceptions and actual reported levels of friends' deviant and health risk behaviors. *Journal of Abnormal Child Psychology, 33,* 293–306.

Russell, S. T., Driscoll, A. K., & Truong, N. (2002). Adolescent same-sex romantic attractions and relationships: Implications for substance use and abuse. *American Journal of Public Health, 92,* 198–202.

Russell, S. T., Franz, B. T., & Driscoll, A. K. (2001). Same-sex romantic attraction and experiences of violence in adolescence. *American Journal of Public Health, 91,* 903–906.

Russell, S. T., Muraco, A., Subramanian, A., & Laub, C. (2009). Youth empowerment and high school gay-straight alliances. *Journal of Youth and Adolescence, 38,* 891–903.

Safren, S. A., & Heimberg, R. G. (1999). Depression, hopelessness, suicidality, and related factors in sexual minority and heterosexual adolescents. *Journal of Consulting and Clinical Psychology, 67,* 859–866.

Sell, R. L. (2007). Defining and measuring sexual orientation. In I. H. Meyer & M. E. Northridge (Eds.), *The health of sexual minorities: Public health perspectives on gay, lesbian, bisexual and transgender populations* (pp. 355–374). New York, NY: Springer.

Sell, R. L., Wells, J. A., & Wypij, D. (1995). The prevalence of homosexual behavior and attraction in the United States, the United Kingdom and France: Results of national population-based samples. *Archives of Sexual Behavior, 24,* 235–248.

Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. In S. Lienhart (Ed.), *Sociological methodology* (pp. 290–312). San Francisco, CA: Jossey-Bass.

Software for Survey Data Analysis. (2008). SUDAAN, Version 10.0. Research Triangle Park, NC: Research Triangle Institute.

Steinberg, L. (1988). Reciprocal relation between parent-child distance and pubertal maturation. *Developmental Psychology, 24,* 122–128.

Sussman, S., Pokhrel, P., Ashmore, R. D., & Brown, B. B. (2007). Adolescent peer group identification and characteristics: A review of the literature. *Addictive Behaviors, 32,* 1602–1627.

Sutherland, E. H., & Cressey, D. R. (1974). *Criminology* (9th ed.). Philadelphia, PA: Lippincott.

Turner, C. F., Ku, L., Rogers, S. M., Lindberg, L. D., Pleck, J. H., & Sonenstein, F. L. (1998). Adolescent sexual behavior, drug use, and violence: Increased reporting with computer survey technology. *Science, 280,* 867–873.

Ueno, K. (2005). Sexual orientation and psychological distress in adolescence: Examining interpersonal stressors and social support processes. *Social Psychology Quarterly, 68,* 258–277.

Valente, T. W., Gallaher, P., & Mouttapa, M. (2004). Using social networks to understand and prevent substance use: A transdisciplinary perspective. *Substance Use & Misuse, 39,* 1685–1712.

Ziyadeh, N. J., Prokop, L. A., Fisher, L. B., Rosario, M., Field, A. E., Camargo, C. A., Jr., & Austin, S. B. (2007). Sexual orientation, gender, and alcohol use in a cohort study of U.S. adolescent girls and boys. *Drug and Alcohol Dependence, 87,* 119–130.