Published in final edited form as:

Drug Alcohol Depend. 2017 June 01; 175: 246–253. doi:10.1016/j.drugalcdep.2017.02.012.

How many or how much? Testing the relative influence of the number of social network risks versus the amount of time exposed to social network risks on post-treatment substance use

David Eddie* and John F. Kelly

Recovery Research Institute, Massachusetts General Hospital, Harvard Medical School, Boston, MA 02114, United States

Abstract

Background—Having high-risk, substance-using friends is associated with young adult substance use disorder (SUD) relapse. It is unclear, however, whether it is the total *number* of high-risk friends, or the amount of *time* spent with high-risk friends that leads to relapse. Unclear also, is to what extent low-risk friends buffer risk. This study examined the influence of number of high-risk and low-risk friends, and the amount time spent with these friends on post-treatment percent days abstinent (PDA).

Method—Young adult inpatients ($N = 302$) were assessed at intake, and 3, 6, and 12 months on social network measures and PDA. Mixed models tested for effects of number of high- and low-risk friends, and time spent with these friends on PDA, and for net-risk friend effects to test whether low-risk friends offset risk.

Results—Within and across assessments, number of, and time spent with high-risk friends was negatively associated with PDA, while the inverse was true for low-risk friends. Early post-treatment, time spent with friends more strongly predicted PDA than number of friends. Participants were more deleteriously affected by time with high-risk friends the longer they were out of treatment, while contemporaneously protection conferred by low-risk friends increased. This interaction effect, however, was not observed with number of high- or low-risk friends, or number of friends net-risk.

Conclusions—Young adult SUD patients struggling to break ties with high-risk friends should be encouraged to minimize time with them. Clinicians should also encourage patients to grow their social network of low-risk friends.

Keywords

Substance use; Addiction; Recovery; Emerging adults; Social network risk; Treatment outcomes

*Corresponding author at: 151 Merrimac St., 6th Floor, Boston, MA 02114, United States.

Contributors: Both authors materially participated in the research and article preparation. David Eddie conducted the analyses for the present investigation, and was the primary author of the manuscript. John Kelly was co-author of the manuscript, and was the principal investigator of the parent study.

Conflict of interest: The authors have no conflicts of interest to declare.

1. Introduction

Clinicians working across treatment modalities often advise individuals undergoing substance use disorder (SUD) treatment to reduce or eliminate contact with high-risk others who are still engaged in substance use, and increase interactions with non-substance using/recovering others. Social-cognitive learning theory (Bandura, 1986; Maisto et al., 1999), posits that changing social networks from pro-substance use to pro-abstinence and recovery serves important functions implicit in recovery from SUD (Longabaugh et al., 1998; Longabaugh et al., 2010; Zywiak et al., 2002). These include reducing individuals' exposure to substances and related conditioned cues, facilitating the acquisition of recovery coping skills and learning of new non-substance use related recreational activities, and strengthening of abstinence self-efficacy. Thus, adaptive changes in social network composition can help mitigate both cue- and stress-related relapse risks (Brown et al., 1995; Moos, 2007, 2008; Richter et al., 1991). Research supports this clinical lore and theory. Individuals with SUD are exposed to social forces that can strongly influence recovery outcomes (Moos, 2003), particularly as individuals leave inpatient or intensive outpatient care (Broome et al., 2002; Buckman et al., 2008). Although individuals typically self-select social network members, exposure to such social network members is thought to play a key causal role in the resolution of SUD (Brown et al., 1989; Kelly et al., 2011; Marlatt and Gordon, 1985; Stout et al., 2012).

The influence of social networks on health risks and outcomes is also known to vary across the life course. During young adulthood, peers have a particularly strong influence on substance use behaviors, and long-term treatment outcomes (Dobkin et al., 2002; Granfield and Cloud, 2001). This is in part because substance use serves a particularly strong social facilitation function for young adults, especially for those with a history of heavy involvement with alcohol and other drugs (Chung, 2013). As such, helping young adults change their social network from pro-substance use, to pro-recovery and pro-abstinence, is an especially important clinical goal for providers who treat young people with SUD. This is typically achieved by encouraging young adults to reduce or eliminate ties to friends that are still engaging in substance use, and increase or bolster ties with individuals who are not. Young adults' ability to make these changes is ultimately predictive of their long-term SUD recovery outcomes (Kelly et al., 2014, 2013).

It is well understood that high-risk friends confer relapse risk, but it is not clear whether it is the total *number* of high-risk friends, versus the actual amount of *time* spent with high-risk friends that ultimately increases relapse risk. After all, the *number* of high-risk social network members is only a marker for risk. From a social-cognitive learning theory standpoint, the probable causal mechanism that confers risk is more likely to be the actual *amount of exposure* to, or engagement with, social network risks, since it is through actual contact that the purported effects are conferred (i.e., through modeling, offers to use substances, reinforcement of substance use). Such a distinction has theoretical and practical importance since time engaged with high- or low-risk friends may be a more sensitive indicator and potent predictor of substance use behavior than a mere sum of high-risk friends, because the focal individual will have varying degrees of interaction with these high-risk friends ranging from none to a lot in any given period. It is also not clear what role

low-risk friends may play in buffering relapse risk, or whether the quantity of low-risk friends or the amount of time spent with low-risk friends differentially affects substance use outcomes. Moreover, it is unknown to what extent low-risk friends might buffer the risk conferred by high-risk friends.

To date, social network analyses have typically examined only the presence or absence of high- or low-risk individuals in the network (e.g., Stout et al., 2012; Kelly et al., 2011) and not the amount of actual exposure to them. Should it be the case that the amount of time spent with high-risk or low-risk peers is also a predictor of SUD recovery outcomes, then clinical assessment and advice could be tailored more specifically to address this specific exposure intensity risk. Furthermore, young adults often perceive their friends to be caring and supportive of their recovery, and thus are often reluctant to change their high-risk friends. In these cases, negotiating less frequent engagement with these high-risk individuals could offer a way to reduce potential substance-related harm without a wholesale network change.

In the present investigation, we examined the relative influence of the number of high- and low-risk friends, and the amount of time spent with these friends on abstinence in the year following discharge from residential treatment. Additionally, to test to what extent low-risk friends might buffer risk conferred by high-risk friends, we investigated the net effect of number of high- and low-risk friends, and net effect of time spent with high- and low-risk friends, on abstinence (i.e., by subtracting the number of, and time spent with low-risk friends from the number of, and time spent with high-risk friends, respectively). Based on existing literature, we hypothesized that greater numbers of high-risk friends would predict lower PDA, while greater numbers of low-risk friends, would predict greater PDA. We also hypothesized that greater time spent with high-risk friends would predict lower PDA, while more time spent with low-risk friends, would predict greater PDA, and that the magnitude of the relationship between friend risk type and PDA would be stronger for *time* than *number* of friends. Additionally, we hypothesized that a greater net loading toward number of, and time spent with high-risk friends would predict less PDA, while greater net loading toward number of, and time spent with low-risk friends would predict greater PDA.

2. Methods

Data acquisition methods were originally described in Kelly et al. (2010b), and Kelly et al. (2013) and are summarized here.

2.1. Procedure

The present investigation was conducted at a residential treatment facility emphasizing twelve-step facilitation, and motivational, cognitive-behavioral, and family therapy approaches. A total of 607 young adults were admitted to the residential treatment facility during the recruitment period (October 2006–March 2008). Of those approached ($n = 384$), 64 declined or withdrew participation. Following enrollment, an additional 17 participants withdrew prior to baseline assessment, and the consent for one participant was misplaced. The final sample of 302 represents 78.6% of those approached for participation details (see Kelly et al., 2013 for more details).

Research staff conducted assessments at baseline, 1, 3, 6, and 12 months post-discharge. Each assessment included an interview portion, completed either in person or by telephone, and self-administered surveys. Participants were reimbursed \$30 for the baseline assessment, and \$20, \$30, \$40, and \$50 for the post-treatment assessments at 1, 3, 6 and 12 months, respectively. Post-discharge, study retention rates were 84.5% ($n = 256$) at 1-month follow-up, 81.8% ($n = 248$) at 3-month follow-up, 74.3% ($n = 225$) at 6-month follow-up, and 71.3% ($n = 216$) at 12-month follow-up. Assessment completers were compared to non-completers on demographic, clinical, and substance use variables. Relative to those with post-secondary education, those with a high school education or less were more likely to be missed at all time-points.

2.2. Measures

2.2.1. Form-90—The Form-90 (Miller and Del Boca, 1994) interview captures percentage of days abstinent (PDA) from all substances (except caffeine and nicotine) and has demonstrated good test-retest reliability and validity (Slesnick and Tonigan, 2004; Tonigan et al., 1997).

2.2.2. Leeds dependence questionnaire (LDQ)—The LDQ (Raistrick et al., 1994) is a brief measure of general substance addiction severity that is not specific to particular substances. The 10 items address frequency of symptom experience, rated from never (0) to nearly always (3) (range 0–30). The measure has high internal consistency ($\alpha = 0.93$) and good construct validity in the present sample (Kelly et al., 2010b).

2.2.3. Social support questionnaire (SSQ)—The SSQ (Sarason et al., 1983), modified to include items assessing the alcohol and drug use patterns of key significant others (Richter et al., 1991), was used to assess the network risk structure and perceived recovery support. This interview identifies up to five key social network members (i.e., close friends), as well as each member's substance use status rated as one of the following: “currently abstaining (i.e., in recovery)”, “does not use”, “infrequently uses”, “regularly uses”, “possibly abuses”, or “abuses”. Participants also rate how many days contact they had with each individual on average per month during the past follow-up time period.

2.3. Social support measurements

For purposes of data analysis, we classified peers as high-risk or low-risk based on their use of alcohol and other drugs. Those who the participant reported to be engaging in “regular use”, “possible abuse”, or “abuse” of alcohol and/or other drugs were classified as high-risk, while those who the participant reported to be engaging in “infrequent use”, who “do not use”, or were “currently abstaining (i.e., in recovery)” were classified as low-risk.

The number of high-risk friends, and number of low-risk friends was calculated for each participant at each assessment point. Additionally, a net-risk of number of friends index was calculated by subtracting number of low-risk friends from number of high-risk friends. This was done to provide a single measure of risk that captured both the positive and negative elements of the network, and facilitate exploration of the potential buffering effects of low-risk friends.

Time spent with high-risk friends, and time spent with low-risk friends was also calculated for each participant at each assessment point. To calculate these indices, first, time spent with each friend was derived from participants' self-report of the average number of days per month contact they had with each friend over the previous follow-up period. Then, separate indices of time with high-risk friends, and time with low-risk friends were calculated by summing the time spent with friends falling into these respective categories. Because individuals may be exposed to one or more individuals at any given time in any given follow-up period, these sums represent an index of risk exposure. Consequently, this variable could have a potential range of 0–150. A net-risk of time spent with friends index was calculated by subtracting time spent with low-risk friends from time spent with high-risk friends.

2.4. Participants

Participants were 302 young adults undergoing residential treatment enrolled in an observational study of treatment processes and outcomes. At intake, participants were on average 20.4 years old ($SD = 1.6$; range 18–24). Most were European American (94.7%) 1.7% identified as American Indian, 1.3% identified as African American, and 1.0% as Asian (1.4% reported “other” or missing). The sample was predominantly male (73.8%), and all were single; 24.2% were employed full- or part-time, 31.8% were students; 43% of the sample obtained a high school diploma and 39.7% had some college education. The most commonly reported primary substances used were alcohol (28.1%) and marijuana (28.1%), followed by heroin or other opiates (22.2%), cocaine or crack (12.3%), and amphetamines (6.0%). Small proportions reported benzodiazepines (2.0%), hallucinogens (1.0%), or ecstasy (1.0%) as their primary substance. Five participants reported more than one substance, such that these proportions do not sum to 100%.

In terms of addiction severity, the average Leeds Dependence Questionnaire (LDQ) score (see measures section) at baseline was in the severe range at 18.7 ($SD = 8.7$), which is similar to the mean of 19.7 previously reported in a larger clinical sample of older adults with alcohol/opiate dependence (Heather et al., 2001). Similar to other prevalence estimates (Kelly et al., 2010a; Langenbach et al., 2010; Schroder et al., 2008) the prevalence of concurrent (past year) co-occurring Axis I disorders (other than SUD) was 51.2%.

Length of stay in the residential program was a mean of 25.3 days ($SD = 6.2$), and the majority of patients were discharged with staff approval (82%).

Regarding the representativeness of our clinical sample, we compared our private treatment sample with available public residential programs in this age-range using the Treatment Episode Data Set [TEDS], and across a sample of private adult outpatient and residential programs (Roman and Johnson, 2004). We found that compared to same-age, public sector, residential patients our participants are comparable in terms of gender (33% vs. 34% female), marital status (95% vs 92% never married), education (51% vs 53% did not complete high school), unemployment (30% vs 32%), and not being in labor force (e.g., student; 53% vs 54%), but we have a higher European American majority (95% vs 76%). Primary substance at treatment entry was similar with the highest for alcohol (28% vs 21%) marijuana (27% vs 31%), cocaine (12% vs 14%) and opiates (21% vs 18%). Compared to all

adults across all types of programs treated in private programs our sample was similar across these indices except for a greater European American majority (95% vs. 71%), which is a limitation. We anticipate however, that results here will be broadly generalizable to youth treated for SUD.

2.5. Analyses

A large proportion of study participants were engaged in some kind of step-down residential care at the 1-month follow-up assessment. Because such residential settings can substantially influence outcomes, 1-month assessment data is reported in the descriptive statistics, but was not included in the inferential tests. Hence, we report here on the past 60 days at the 3-month follow-up, and the past 90 days at the 6-month and 12-month follow-ups.

2.5.1. Preliminary analyses—Data variable distributions were explored using descriptive statistics. Analyses indicated that number of high-risk and number of low-risk friends, and time with high-risk and time with low-risk friends measures were positively skewed at each assessment time-point (e.g., 6-month time spent with high-risk friends: skew = 2.18, kurtosis = 5.00). These measures were therefore logarithmically transformed to normalize their distribution (e.g., log 6-month time spent with high-risk friends: skew = 0.34, kurtosis = -1.45). Net-risk of number of friends, and net-risk of time with friends measures were normally distributed at each assessment point, and were therefore not transformed.

Substance use outcomes were measured as percent of days abstinent (PDA) from alcohol and other drugs since prior follow-up. In preliminary analyses, PDA was negatively skewed (e.g., 6-month PDA skew = -2.26, kurtosis = 3.97), and was arcsine transformed to normalize (e.g., arcsine 6-month PDA: skew = -1.90, kurtosis = 2.83).

2.5.2. Analysis plan—To examine relationships among study variables over follow-up, zero-order correlations were computed using Spearman's rank order procedure. Differences in correlation magnitude between *number* and *time* risk measures on PDA were computed using Steiger's test of difference between dependent correlations (Steiger, 1980). Next, absolute change in participant PDA, and social risk exposure across assessment time-points were tested using repeated measures mixed models. Repeated-measures mixed models were run to test for effects of number of high-risk friends, number of low-risk friends, net-risk of number of friends, and corresponding time with friends measures, across 3-, 6-, and 12-month assessment points. Because the influence of social supports on SUD treatment outcomes may vary by sex and age (Davis and Jason, 2005; Falkin and Strauss, 2003; Walitzer and Dearing, 2006), these were used as model covariates. Significant assessment number $\times$ risk type interaction effects were followed up with additional post hoc tests to test for associations between risk type and PDA within assessment time-points.

3. Results

3.1. Zero-order correlations among social risk variables and percent days abstinent

Spearman's rho correlation coefficients between *number* and *time* measures of social risk ranged from 0.84 to 0.93 (all $p < 0.01$)

Zero-order correlations between social risk and PDA are presented in Table 1.

At all assessment time-points, significant associations were observed between social risk and PDA in the expected directions. Specifically, greater number of high-risk friends was associated with lower PDA, while greater number of low-risk friends, and lower net-risk of number of friends was associated with higher PDA (Table 1). Additionally, these measures predicted PDA at subsequent time-points.

Similarly, at each assessment, greater time with high-risk friends was associated with lower PDA, while more time with low-risk friends, and lower net-risk time was associated with higher PDA (Table 1). These measures also predicted PDA at subsequent time-points.

Correlation coefficients at 3-month assessment indicated that time with high-risk friends was more strongly correlated with 3-month PDA than number of high-risk friends using Steiger's test of dependent correlation differences ($Z = -3.45$, $p < 0.01$), with 14.4% of the variance in PDA accounted for by high-risk *time*, and 6.7% by high-risk *number*. Similarly, net-risk of time with friends was a stronger predictor of 3-month PDA than net-risk of number of friends using the Steiger test ($Z = -2.86$, $p < 0.01$), with 14.4% of the variance in PDA accounted for by *time* net-risk, and 8.4% by *number* net-risk. Correlations between time with low-risk friends and number of low-risk friends, and 3-month PDA were not significantly different, nor were there differences between correlation coefficients at 6-, and 12-month assessments (all $p > 0.05$).

3.2. Participant risk exposure across assessments

Descriptive statistics for social risk change at each assessment time-point are presented in Table 2 and Fig. 1.

Mixed models were used to assess absolute change in PDA and risk-type across assessment time-points (i.e., baseline, 3-, 6-, and 12-month assessments). PDA significantly increased across assessments, $F(3, 301) = 428.54$, $p < 0.01$, as did number of low-risk friends, $F(3, 301) = 38.35$, $p < 0.01$, while number of high-risk friends decreased, $F(3, 301) = 52.74$, $p < 0.01$. Additionally, the net-risk of number of friends shifted toward lower social-substance use risk, $F(3, 301) = 68.11$, $p < 0.01$.

Similarly, time spent with high-risk friends decreased across followups, $F(3, 301) = 52.08$, $p < 0.01$, and time spent low-risk friends increased, $F(3, 301) = 42.35$, $p < 0.01$. Net-risk of time with friends shifted toward greater time spent with low-risk friends, $F(3, 301) = 67.57$, $p < 0.01$.

3.3. Effects of number of high-risk friends, low-risk friends, and net-risk of number of friends on percent days abstinent

Mixed model analyses for effects of number of high-risk friends, and number of low-risk friends, and their net-risk on PDA are presented in detail in Table 2. As predicted, main effects were observed for risk type, and assessment number on PDA for number of high- and low-risk friend models. The same main effects were observed for the net-risk of number of friends model.

Interaction effects of risk type $\times$ assessment number on PDA were not significant for number of high-, and low-risk friends, or the net-risk of number of friends. Baseline PDA, sex, and age were included in these models as covariates but were not significant predictors of PDA.

3.4. Effects of time with high-risk friends, low-risk friends, and net-risk of time with friends on percent days abstinent

Mixed model analyses for effects of time with high-risk friends and low-risk friends, and their net-risk on PDA are detailed in Table 2. As hypothesized, main effects were observed for risk type, and assessment number on PDA for time with high-risk friends, and low-risk friends, and net-risk time. In addition, significant risk type $\times$ assessment number interactions were observed for all time based measures, suggesting the relationship between the time exposed risk type and PDA varied across the year post-treatment. Sex, and age were included in these models as covariates, but were not associated with PDA.

3.5. Time risk type $\times$ assessment number interaction post hoc tests

Given the significant interaction observed between time spent with friends (high-risk, low-risk, and net-risk) and PDA across the follow-up period, post hoc tests were conducted to help determine the nature of this significant variability across time. These are reported in Table 3.

More time with high-risk friends at 3 months was associated with lower PDA at 3-, 6-, and 12-months (Table 3). Similarly, more time spent with high-risk friends at 6 months was associated with lower PDA at 6-, and 12-months, and more time spent with high-risk friends at 12 months was associated with lower PDA at 12-months. Inspection of the beta coefficients showed that for every additional day of contact per month participants had with high-risk friends in the period leading up to 3-month assessment, participants had a 2.3% lowered PDA.

More time spent with low-risk friends at 3 months was associated with greater PDA at 3-, 6-, and 12-months (Table 3), while, more time spent with low-risk friends at 6 months was associated with more PDA at 6-, and 12-months, and more time spent with low-risk friends at 12 months was associated with more PDA at 12-months. Beta coefficients indicated that every additional average number of days contact per month participants had with low-risk friends in the period leading up to 3-month assessment was associated with a 1.3% increase in PDA in this period.

Additionally, post hoc tests showed that net-risk of time with friends at 3 months was negatively associated with PDA at 3-, 6-, and 12-month assessment. Similarly, net-risk of

time with friends at 6 months was negatively associated with PDA at 6-, and 12-month assessment, and net-risk of time with friends at 12 months was negatively associated with PDA at 12-month assessment. These results indicate that across assessment time-points, greater loading of time spent with high-risk, versus low-risk friends predicted lower PDA.

Slope inspection for post hoc results for net-risk of time spent with friends (Fig. 2), in addition to zero-order correlations presented in Table 1, revealed that the risk conferred by time spent with high-risk friends increased across assessment time-points. At the same time, the protective benefits of time spent with low-risk friends also increased across assessments. Though post hoc tests were not performed for number of high-, low-, and net-risk models due to non-significant risk type $\times$ assessment number interactions, these figures are presented in Fig. 2 for illustrative purposes.

4. Discussion

The goal of the present investigation was to examine the relative influence of number of high-risk and low-risk friends, and the amount time spent with these friends, on substance use outcomes measured by percent days abstinent (PDA). We also explored the net-risk of number of friends, expressed as number of high-risk friends minus number low-risk friends, and net amount of time spent with high-, versus low-risk friends.

As predicted, when averaged over time, a greater number of, and more time spent with high-risk friends was associated with poorer substance use outcomes, while greater number of, and more time spent with low-risk friends were associated with better outcomes. The net-risk of high- and low-risk friends was also a significant predictor of substance use, such that greater number of, and time spent with low-risk friends in relation to high-risk friends was associated with less substance use. Taken together, these findings suggest that individuals' number of friends, as well as the total time spent with these friends, and the attendant risk or protection conferred, are associated with substance use outcomes.

The hypothesis that the magnitude of the relationship between friend risk type and PDA would be stronger for *time* than *number* of friends was partially supported. Time with high-risk friends, and net-risk of time with friends was a substantially stronger predictor of PDA at 3-month assessment than number of high-risk friends, or net-risk of number of friends, but this difference was not apparent at 6-, or 12-month assessment. Additionally, a significant interaction of risk type $\times$ assessment number on PDA was observed for *time* spent with high-, low-, and net-risk models, but not *number* of high-, low-, and netrisk models. Post hoc testing indicated a pattern of increasing risk of time spent with high-risk friends across assessment time-points, while at the same time the protection conferred by low-risk friends appeared to increase.

These findings suggest that assessing the amount of time spent with, compared to the number of, high- or low-risk friends may yield more clinically useful information. Young adults receiving SUD treatment would benefit from being counseled not only to consider the total number of high-risk friends they may have, but also how much contact they have with these friends. Similarly, patients could be encouraged to increase their total number of low-

risk friends, while patients reporting few low-risk friends (which is common in early recovery) might be encouraged to maximize time spent with available low-risk friends.

That said, it is noteworthy that the risk type $\times$ assessment number interaction tests on PDA revealed that the relationship between risk type varied significantly across follow-up and post hoc tests indicated that the magnitude of effect of time spent with friends on PDA differed across assessment time-points. Specifically, the negative deleterious effect of each day spent with high-risk friends on PDA was almost twice the magnitude (i.e., 2.3%) as the positive beneficial effect of spending time with low-risk friends on PDA (1.3%) at 3-month assessment. Thus, similar to prior findings (Hoeppner et al., 2014), it appears relatively more advantageous for young adults to reduce exposure to high-risk friends than to increase exposure to low-risk friends after treatment.

Risk type $\times$ assessment number interactions, and subsequent post hoc tests also indicated *time* spent with high-, low-, and net-risk indicators had a significantly varying influence on substance use across the year following treatment, while the effects of *number* of high-, low-, and net-risk friends was less variable across assessment time-points (see Fig. 2). The change in strength of associations between PDA and risk type was indicative of an increasing vulnerability to substance use associated with time spent with high-risk friends over the first year of SUD recovery (Fig. 2). This may reflect a gradual decay of protective factors conferred by inpatient treatment—in this instance high quality residential care with a strong emphasis on relapse prevention—such that the longer one is out of treatment, the more vulnerable one is to the detrimental effects of exposure to high-risk friends. It is possible that individuals coming out of inpatient treatment programs with less rigorous relapse prevention training may be more vulnerable to the deleterious effects of time spent with high-risk friends sooner after leaving care.

Notably however, the buffering effects of time spent with low-risk friends on substance use appear to strengthen through the first year of SUD recovery (Fig. 2). This may reflect a dynamic and growing positive influence of support, growing trust, and honing of sobriety skills imparted by these low-risk friends. Conversely, risk type $\times$ assessment interactions in *number* of friends models were not significant, suggesting the risk or protection conferred by number of high- or low-risk friends was more consistent across the year following residential treatment. Said another way, having the exact same number of high-or low-risk friends over time confers similar risk and benefits, but having the exact same amount of exposure time to high or low-risk friends over time exerts a dynamically increasingly deleterious, or beneficial effect on PDA.

4.1. Limitations

Several important limitations should be considered when drawing conclusions from this study. By necessity this kind of research on social network influences has to be conducted using naturalistic designs as people cannot be randomly assigned experimentally to their social networks. Consequently, although rigorous analyses support a causal connection between social network risks and substance use behavior (e.g., Stout et al., 2012), we cannot rule out competing hypotheses that some other variable(s) could be influencing or accounting for observed relationships. Also, social network influence itself is complex and

multifaceted. Although, we examined multiple social network variables over time in this study, these are likely to be only a partial representation of the dynamic and complex effects attributable to social network influence.

4.2. Summary and conclusion

The present findings are consistent with prior research and support clinical lore that recommends individuals in early SUD recovery reduce contact with high-risk others, and increase contact with those who pose low-risk for substance use. Moreover, findings highlight the importance of not only addressing individuals' number of high-risk friends and low-risk friends, but also attending to the amount of time spent with these friends. Consequently, patients who insist on keeping certain friends who still engaged in problematic substance use, might be advised to at least reduce their engagement with such high-risk friends, as this could yield recovery benefit. Additionally, young adults in the first year of recovery appear to be at greater risk from exposure to high-risk friends the longer they are out of treatment, and would benefit from knowing this information. Engaging young adults with recovery supportive social networks such as Alcoholics Anonymous and Narcotics Anonymous has been shown to help individuals reduce the number of heavy substance using friends in their social network, and thereby improve the chances of recovery (Hoepfner et al., 2014). Consequently, young adults could be directed to these, and possibly other groups that help facilitate salutary social network changes such as Alternative Peer Groups (Collier et al., 2014; Nash et al., 2015).

Acknowledgments

This study was supported by funding from the National Institute of Alcohol and Alcohol Abuse (NIAAA; grant numbers: R21 AA018185; K24 AA022136; and F32 AA025251-01; the Recovery Research Institute at the Massachusetts General Hospital and through an anonymous donation to the Hazelden Betty Ford Foundation.

Role of funding source: Nothing declared.

References

- Bandura, A. Social Foundations of Thought and Action: A Social Cognitive Theory. Prentice-Hall, Inc; Englewood Cliffs, NJ: 1986.
- Broome KM, Simpson DD, Joe GW. The role of social support following short-term inpatient treatment. *Am J Addict.* 2002; 11:57–65. <http://dx.doi.org/10.1080/10550490252801648>. [PubMed: 11876584]
- Brown SA, Vik PW, Creamer VA. Characteristics of relapse following adolescent substance abuse treatment. *Addict Behav.* 1989; 14:291–300. [http://dx.doi.org/10.1016/0306-4603\(89\)90060-9](http://dx.doi.org/10.1016/0306-4603(89)90060-9). [PubMed: 2787585]
- Brown SA, Vik PW, Patterson TL, Grant I, Schuckit MA. Stress, vulnerability and adult alcohol relapse. *J Stud Alcohol.* 1995; 56:538–545. <http://dx.doi.org/10.15288/jsa.1995.56.538>. [PubMed: 7475034]
- Buckman JF, Bates ME, Morgenstern J. Social support and cognitive impairment in clients receiving treatment for alcohol- and drug-use disorders: a replication study. *J Stud Alcohol Drugs.* 2008; 69:738–746. <http://dx.doi.org/10.15288/jsad.2008.69.738>. [PubMed: 18781249]
- Chung, T. Adolescent substance use: symptoms and course. In: Miller, PM., editor. *Principles of Addiction: Comprehensive Addictive Behavior and Disorders*. Vol. 1. Academic Press; San Diego, CA: 2013. p. 97-106.

- Collier C, Hilliker R, Onwuegbuzie A. Alternative peer group: a model for youth recovery. *J Groups Addict Recov.* 2014; 9:40–53. <http://dx.doi.org/10.1080/1556035X.2013.836899>.
- Davis MI, Jason LA. Sex differences in social support and self-efficacy within a recovery community. *Am J Comm Psych.* 2005; 36:259–274. <http://dx.doi.org/10.1007/s10464-005-8625-z>.
- Dobkin PL, Civita MD, Paraherakis A, Gill K. The role of functional social support in treatment retention and outcomes among outpatient adult substance abusers. *Addiction.* 2002; 97:347–356. <http://dx.doi.org/10.1046/j.1360-0443.2002.00083.x>. [PubMed: 11964111]
- Falkin GP, Strauss SM. Social supporters and drug use enablers: a dilemma for women in recovery. *Addict Behav.* 2003; 28:141–155. [http://dx.doi.org/10.1016/S0306-4603\(01\)00219-2](http://dx.doi.org/10.1016/S0306-4603(01)00219-2). [PubMed: 12507533]
- Granfield R, Cloud W. Social context and natural recovery: the role of social capital in the resolution of drug-associated problems. *Subst Use Misuse.* 2001; 36:1543–1570. <http://dx.doi.org/10.1081/JA-100106963>. [PubMed: 11693955]
- Heather N, Raistrick D, Tober G, Godfrey C, Parrott S. Leeds dependence questionnaire: new data from a large sample of clinic attenders. *Addict Res Theory.* 2001; 9:253–269. <http://dx.doi.org/10.3109/16066350109141753>.
- Hoepfner BB, Hoepfner SS, Kelly JF. Do young people benefit from AA as much, and in the same ways, as adult aged 30+? A moderated multiple mediation analysis. *Drug Alcohol Depend.* 2014; 143:181–188. <http://dx.doi.org/10.1111/acer.12249>. [PubMed: 25150401]
- Kelly JF, Dow SJ, Yeterian JD, Kahler CW. Can 12-step group participation strengthen and extend the benefits of adolescent addiction treatment? A prospective analysis. *Drug Alcohol Depend.* 2010a; 110:117–125. <http://dx.doi.org/10.1016/j.drugalcdep.2010.02.019>. [PubMed: 20338698]
- Kelly JF, Magill M, Slaymaker V, Kahler C. Psychometric validation of the Leeds Dependence Questionnaire (LDQ) in a young adult clinical sample. *Addict Behav.* 2010b; 35:331–336. <http://dx.doi.org/10.1016/j.addbeh.2009.11.005>. [PubMed: 20004062]
- Kelly JF, Stout RL, Magill M, Tonigan JS. The role of alcoholics anonymous in mobilizing adaptive social network changes: a prospective lagged mediational analysis. *Drug Alcohol Depend.* 2011; 114:119–126. <http://dx.doi.org/10.1016/j.drugalcdep.2010.09.009>. [PubMed: 21035276]
- Kelly JF, Stout RL, Slaymaker V. Emerging adults' treatment outcomes in relation to 12-step mutual-help attendance and active involvement. *Drug Alcohol Depend.* 2013; 129:151–157. <http://dx.doi.org/10.1016/j.drugalcdep.2012.10.005>. [PubMed: 23122600]
- Kelly JF, Stout RL, Greene MC, Slaymaker V. Young adults, social networks, and addiction recovery: post treatment changes in social ties and their role as a mediator of 12-step participation. *PLoS One.* 2014; 9:e100121. <http://dx.doi.org/10.1371/journal.pone.0100121>. [PubMed: 24945357]
- Langenbach T, Spönlein A, Overfeld E, Wiltfang G, Quecke N, Scherbaum N, Melchers P, Hebebrand J. Axis I comorbidity in adolescent inpatients referred for treatment of substance use disorders. *Child Adolesc Psychiatr Ment Health.* 2010; 4:25. <http://dx.doi.org/10.1186/1753-2000-4-25>.
- Longabaugh R, Wirtz PW, Zweben A, Stout RL. Network support for drinking, Alcoholics Anonymous and long term matching effects. *Addiction.* 1998; 93:1313–1333. <http://dx.doi.org/10.1046/j.1360-0443.1998.93913133.x>. [PubMed: 9926538]
- Longabaugh R, Wirtz PW, Zywiak WH, O'malley SS. Network support as a prognostic indicator of drinking outcomes: the COMBINE study. *J Stud Alcohol Drugs.* 2010; 71:837–846. <http://dx.doi.org/10.15288/jsad.2010.71.837>. [PubMed: 20946740]
- Maisto, SA., Carey, KB., Bradizza, CM. Social learning theory. In: Leonard, KE., Blane, HT., editors. *Psychological Theories Of Drinking And Alcoholism*. Guilford Press; New York, NY: 1999. p. 106-163.
- Marlatt, GA., Gordon, JR. *Relapse Prevention: Maintenance Strategies In Addictive Behavior Change*. Guilford; New York: 1985.
- Miller WR, Del Boca FK. Measurement of drinking behavior using the Form 90 family of instruments. *J Stud Alcohol Suppl.* 1994; s12:112–118. <http://dx.doi.org/10.15288/jsas.1994.s12.112>.
- Moos RH. Social contexts: transcending their power and their fragility. *Am J Comm Psych.* 2003; 31:1–13.

- Moos RH. Theory-based active ingredients of effective treatments for substance use disorders. *Drug Alcohol Depend.* 2007; 88:109–121. <http://dx.doi.org/10.1016/j.drugalcdep.2006.10.010>. [PubMed: 17129682]
- Moos RH. Active ingredients of substance use-focused self-help groups. *Addiction.* 2008; 103:387–396. <http://dx.doi.org/10.1111/j.1360-0443.2007.02111.x>. [PubMed: 18269361]
- Nash A, Marcus M, Engebretson J, Bukstein O. Recovery from adolescent substance use disorder: young people in recovery describe the process and keys to success in an alternative peer group. *J Groups Addict Recov.* 2015; 10:290–312. <http://dx.doi.org/10.1080/1556035X.2015.1089805>.
- Raistrick DJB, Tober G, Weiner J, Aallison J, Healey C. Development of the Leeds Dependence Questionnaire (LDQ): a questionnaire to measure alcohol and opiate dependence in the context of a treatment evaluation package. *Addiction.* 1994; 89:563–572. [PubMed: 8044122]
- Richter SS, Brown SA, Mott MA. The impact of social support and self-esteem on adolescent substance abuse treatment outcome. *J Subst Abuse.* 1991; 3:371–385. [http://dx.doi.org/10.1016/S0899-3289\(10\)80019-7](http://dx.doi.org/10.1016/S0899-3289(10)80019-7). [PubMed: 1668229]
- Roman PM, Johnson JA. National Treatment Center Study Summary Report: Private Treatment Centers. 2004 Retrieved from Athens, GA.
- Sarason IG, Levine HM, Basham RB, Sarason BR. Assessing social support: the social support questionnaire. *J Pers Soc Psych.* 1983; 44:127–139. <http://dx.doi.org/10.1037/0022-3514.44.1.127>.
- Schroder R, Sellman D, Frampton C, Deering D. Profile of young people attending alcohol and other drug treatment services in Aotearoa, New Zealand: clinical file search. *Aust N Z J Psychiatr.* 2008; 42:963–968. <http://dx.doi.org/10.1080/00048670802415368>.
- Slesnick N, Tonigan JS. Assessment of alcohol and other drug use by runaway youths: a test-retest study of the form 90. *Alcohol Treat Q.* 2004; 22:21–34. http://dx.doi.org/10.1300/J020v22n02_03. [PubMed: 18563208]
- Steiger JH. Tests for comparing elements of a correlation matrix. *Psychol Bull.* 1980; 87:245–251. <http://dx.doi.org/10.1037/0033-2909.87.2.245>.
- Stout RL, Kelly JF, Magill M, Pagano ME. Association between social influences and drinking outcomes across three years. *J Stud Alcohol Drugs.* 2012; 73:489–497. <http://dx.doi.org/10.15288/jsad.2012.73.489>. [PubMed: 22456254]
- Tonigan JS, Miller WR, Brown JM. The reliability of Form 90: An instrument for assessing alcohol treatment outcome. *J Stud Alcohol.* 1997; 58:358–364. <http://dx.doi.org/10.15288/jsa.1997.58.358>. [PubMed: 9203116]
- Walitzer KS, Dearing RL. Gender differences in alcohol and substance use relapse. *Clin Psychol Rev.* 2006; 26:128–148. <http://dx.doi.org/10.1016/j.cpr.2005.11.003>. [PubMed: 16412541]
- Zywiak WH, Longabaugh R, Wirtz PW. Decomposing the relationships between pretreatment social network characteristics and alcohol treatment outcome. *J Stud Alcohol.* 2002; 63:114–121. [PubMed: 11925053]

Fig. 1.

(a) Graph displaying participants' number of high-risk friends, low-risk friends, and percent days abstinent (PDA) at baseline, 3-month, 6-month, and 12-month assessments. (b) Graph displaying participants' average time spent with high-risk friends, low-risk friends, expressed as cumulative days contact, and percent days abstinent (PDA) at baseline, 3-month, 6-month, and 12-month assessments.

Fig. 2. Graphs plotting participants' percent days abstinent (PDA) and net-risk of number of friends, and net-risk of time spent with friends at 3-month, 6-month, and 12-month assessments, showing least-squares mean slopes.

Table 1

tions (r_s) between risk indices and percent days abstinent (PDA).

3-Month Assessment				6-Month Assessment				12-Month Assessment			
Number high-risk friends	Number low-risk friends	Number net-risk		Number high-risk friends	Number low-risk friends	Number net-risk		Number high-risk friends	Number low-risk friends	Number net-risk	
-0.26**	0.21**	-0.29**									
-0.24**	0.20**	-0.27**		-0.33**	0.37**	-0.42**					
-0.27**	0.21**	-0.29**		-0.32**	0.36**	-0.42**		-0.44**	0.32**	-0.44**	
Time high-risk friends	Time low-risk friends	Time net-risk		Time high-risk friends	Time low-risk friends	Time net-risk		Time high-risk friends	Time low-risk friends	Time net-risk	
-0.38**	0.23**	-0.38**									
-0.36**	0.23**	-0.37**		-0.31**	0.40**	-0.44**					
-0.37**	0.20**	-0.33**		-0.34**	0.38**	-0.46**		-0.47**	0.35**	-0.49**	

abstinent; 3-month $n = 245$; 6-month $n = 218$; 12-month $n = 203$;

Table 2

Mean scores for percent days abstinent (PDA), and risk indices at baseline, 3-month, 6-month, and 12-month follow-up, as well as main and interaction effects for mixed model omnibus tests.

Mean (SD)		F							
Baseline	3-Month Follow-up	6-Month Follow-up	12-Month Follow-up	Baseline PDA	Sex	Age	Risk Type	Assessment Number	Risk Type × Assessment Number
Percent Days Abstinent (dependent variable)									
24.0 (29.0)	93.0 (17.2)	87.3 (26.0)	82.2 (30.0)						
Number High-Risk Friends									
2.3 (1.7)	1.1 (1.3)	1.1 (1.4)	1.0 (1.2)	0.91	1.81	0.61	50.53**	6.86**	2.73
Number Low-Risk Friends									
0.9 (1.2)	1.9 (1.6)	1.9 (1.7)	2.0 (1.6)	0.87	2.26	0.97	22.10**	12.29**	2.65
Number Net-Risk									
1.4 (2.4)	-0.7 (2.1)	-0.5 (2.2)	-0.7 (2.0)	0.51	2.16	0.79	50.77**	20.90**	1.69
Time High-Risk Friends [^]									
36.1 (34.7)	11.1 (19.1)	15.1 (24.0)	15.6 (21.6)	1.05	2.10	0.40	60.17**	6.78**	4.06*
Time Low-Risk Friends [^]									
12.9 (22.0)	35.5 (36.4)	34.9 (37.6)	36.5 (35.5)	0.98	2.08	1.00	17.74**	12.21**	3.29*
Time Net-Risk [^]									
23.2 (44.9)	-24.3 (44.8)	-19.8 (50.6)	-20.9 (47.2)	0.64	2.04	0.82	58.79**	19.45**	3.28*

Notes: Mean values are displayed with untransformed data.

[^] Total, average number days contact per month over the follow-up period (i.e., average number days contact per month over the follow-up period with friend number 1 + average number days contact per month over the follow-up period with friend number 2, etc.);

* $p < 0.05$,

** $p < 0.01$.

Table 3

Post hoc mixed model analysis of the effect of risk type on percent days abstinent (PDA; arcsine transformed) at 3, 6, and 12-month follow-up.

	<i>df</i>	<i>F</i>	β
Time with High-Risk Friends			
3-Month Assessment			
PDA at 3-Month Follow-up	1, 240	58.39 ^{**}	-0.37
PDA at 6-Month Follow-up	1, 202	28.83 ^{**}	-0.40
PDA at 12-Month Follow-up	1, 189	30.15 ^{**}	-0.48
6-Month Assessment			
PDA at 6-Month Follow-up	1, 213	18.31 ^{**}	-0.30
PDA at 12-Month Follow-up	1, 186	18.88 ^{**}	-0.36
12-Month Assessment			
PDA at 12-Month Follow-up	1, 198	38.90 ^{**}	-0.46
Time with Low-Risk Friends			
3-Month Assessment			
PDA at 3-Month Follow-up	1, 240	5.53 [*]	0.11
PDA at 6-Month Follow-up	1, 202	7.25 ^{**}	0.19
PDA at 12-Month Follow-up	1, 189	5.07 [*]	0.19
6-Month Assessment			
PDA at 6-Month Follow-up	1, 213	37.43 ^{**}	0.39
PDA at 12-Month Follow-up	1, 186	23.29 ^{**}	0.37
12-Month Assessment			
PDA at 12-Month Follow-up	1, 198	13.34 ^{**}	0.29
Net-Risk of Time with Friends			
3-Month Assessment			
PDA at 3-Month Follow-up	1, 240	35.62 ^{**}	-0.004
PDA at 6-Month Follow-up	1, 202	19.14 ^{**}	-0.005
PDA at 12-Month Follow-up	1, 189	19.29 ^{**}	-0.006
6-Month Assessment			
PDA at 6-Month Follow-up	1, 213	36.18 ^{**}	-0.006
PDA at 12-Month Follow-up	1, 186	41.73 ^{**}	-0.007
12-Month Assessment			
PDA at 12-Month Follow-up	1, 198	50.15 ^{**}	-0.008

Notes: β represents unstandardized parameter estimates of arcsine transformed PDA data;

* $p < 0.05$,

** $p < 0.01$.