Published in final edited form as:

Health Educ Behav. 2016 April ; 43(2): 208–216. doi:10.1177/1090198115599397.

Increases in New Social Network Ties are Associated with Increased Cohesion among Intervention Participants

Sabina B. Gesell, PhD^a, Shari L. Barkin, MD, MSHS^b, Evan C. Sommer, BS, BA^{b,d}, Jessica R. Thompson, MEd^b, and Thomas W. Valente, PhD^c

^aDepartment of Social Sciences and Health Policy, Division of Public Health Sciences, and Maya Angelou Center for Health Equity Wake Forest School of Medicine Winston-Salem, NC, USA

^bDivision of General Pediatrics, Department of Pediatrics School of Medicine, Vanderbilt University Nashville, TN, USA

^cInstitute for Prevention Research, Department of Preventive Medicine Keck School of Medicine, University of Southern California Los Angeles, CA, USA

^dDepartment of Psychology and Human Development, Vanderbilt University, Nashville, TN, USA

Abstract

Objective—Many behavior change programs are delivered in group settings to manage implementation costs and to foster support and interactions among group members to facilitate behavior change. Understanding the group dynamics that evolve in group settings (e.g., weight management, Alcoholics Anonymous) is important, yet rarely measured. This paper examined the relationship between social network ties and group cohesion in a group-based intervention to prevent obesity in children.

Method—The data reported are process measures from an ongoing community-based randomized controlled trial. 305 parents with a child (3–6 years) at risk of developing obesity were assigned to an intervention that taught parents healthy lifestyles. Parents met weekly for 12 weeks in small consistent groups. Two measures were collected at weeks 3 and 6: a social network survey (people in the group with whom one discusses healthy lifestyles); and the validated Perceived Cohesion Scale (Bollen & Hoyle, 1990). We used lagged random and fixed effects regression models to analyze the data.

Results—Cohesion increased from 6.51 to 6.71 ($t=4.4$, $p<0.01$). Network nominations tended to increase over the 3-week period in each network. In the combined discussion and advice network, the number of nominations increased from 1.76 to 1.95 ($z=2.59$, $p<0.01$). Cohesion at week 3 was the strongest predictor of cohesion at week 6 ($b=0.55$, $p<0.01$). Number of new network

Corresponding Author: Medical Center Boulevard \ Winston-Salem, NC 27157, p 336.713.8738 \ f 336.716.7554,

sgesell@wakehealth.edu.

shari.barkin@vanderbilt.edu

jessica.r.thompson@vanderbilt.edu

tvalente@usc.edu

evan.c.sommer@vanderbilt.edu

Competing Interest

The authors declare that they have no competing interests.

nominations at week 6 was positively related to cohesion at week 6 ($b=0.06$, $p<.01$). In sum, being able to name new network contacts was associated with feelings of cohesion.

Conclusion—This is the first study to demonstrate how network changes affect perceived group cohesion within a behavioral intervention. Given that many behavioral interventions occur in group settings, intentionally building new social networks could be promising to augment desired outcomes.

Keywords

Obesity; Child Health; Process Evaluation; Latino; Network Analysis

Introduction

The purpose of this paper is to leverage data collected as part of an ongoing group intervention to answer some basic social network questions. Specifically: What is the association between the sociometric choices people make within a group setting and the feelings of group cohesion measured with a psychometric scale? What process information do these different forms of measurement provide? Answers to these questions are important because many behavioral interventions rely on creating group cohesion in order to be effective.

Sociometric choices and group cohesion have been linked, theoretically and empirically, since the early days of social psychology (Figure 1; Festinger, 1950; Festinger, Schachter, & Back, 1950). Meta-analytic examinations have shown a significant positive correlations between cohesion and behavior, (Beal, Cohen, Burke, & McLendon, 2003), especially in smaller groups (Mullen & Copper, 1994). Cohesion is generally conceptualized as task commitment and attraction to group membership, and generally considered to be a group level property.

Sociometric nominations allow for the mapping of social networks, illustrating the pattern of formal and informal ties between individuals. Current research points to social networks as crucial mediators in the onset, development, and maintenance of health behaviors (Badaly, 2013; Flodgren et al., 2011; Hammond, 2009; Kelly et al., 1991; Shoham et al., 2012; Valente et al., 2007; Valente, Fujimoto, Chou, & Spruijt-Metz, 2009; Valente, Watkins, Jato, van der Straten, & Tsitsol, 1997). Therefore, an ongoing community-based trial (Po'e, Heerman, Mistry, & Barkin, 2013) is exploring the potential to intentionally create new social networks that can influence health behaviors (physical activity, nutrition), making sociometric choices and perceived cohesion important process variables to monitor.

Previous research shows that people who are integrated into their social network tend to adopt behaviors earlier than those who are less integrated (Coleman, Katz, & Menzel, 1966; Rogers & Kincaid, 1981; Valente, 2010). They tend to be more sensitive to social norms and behave accordingly (Valente, 2010). In the GROW trial, we are creating new social groups, new norms for healthy lifestyle behaviors, and hypothesizing that participants who are well integrated into these new social groups will be more likely to exhibit desired behavior changes. Ultimately, we will examine how social networks mediate health behaviors. At this

time, we are able to examine how sociometric nominations are related to perceptions of cohesion at the individual-level within the context of a health behavior intervention.

In the past, researchers have typically used a psychometric scale or sociometric nominations to measure cohesion, but not both. We are aware of only one study that has examined this question that was conducted within a military setting. Salo (Salo, 2006) administered questionnaires and a sociometric survey near the end of a 6 to 12 month Finnish conscript training to sample of 537 predominately white males mostly between the ages of 19-20. He found that, at the individual level, sociometric nominations (e.g., “in a combat situation, which six persons would you choose to be in your squad”) and group cohesion, measured as a scale comprised of 8 5-point Likert scale items (e.g., I feel appreciated in my squad), were moderately correlated, $r = 0.31$, $p < 0.001$. Salo concluded that sociometric choices were not directly and cleanly related to cohesion and behavior in that setting; and recommended that future research examine the relations between group structure and cohesion, before examining their relation to primary outcomes, such as attendance, satisfaction, and behavior. Many behavior change programs are delivered in group settings to manage implementation costs and to foster support and interactions among group members to facilitate behavior change. Understanding the group dynamics that evolve in group settings (e.g., for weight management, diabetes management, Alcoholics Anonymous, smoking cessation support) is important, yet rarely explicitly measured.

In the early stage of this intervention we expect participants to consult interventionists for expert advice but be able to build trust in their networks. Later, as trust and cohesion deepen, participants will eventually be able to rely on these new networks for advice. Thus, we hypothesized that individuals, who nominate more discussion and/or advice partners as measured by a social network name generator, will also report feeling greater group cohesion, as measured by a psychometric scale. We also hypothesized that the association would be stronger for discussion nominations than for advice ones because discussion (conversation) is associated with trust and comfort in contrast to advice (guidance) nominations which are instrumental (Saint-Charles & Mongeau, 2009).

Methods

Description of the Intervention

This study describes process data collected in the first 6 weeks of an ongoing lifestyle intervention delivered weekly by a trained bilingual educator at a community center operated by the Department of Parks and Recreation.

GROW is an ongoing group-level behavioral intervention to prevent childhood obesity. It occurs at public community recreation centers for high-risk parent-preschool child (ages 3-6 years) dyads. GROW is based on a conceptual model that childhood growth patterns are affected over time at sensitive windows of development by both micro- and macro-level systems (Glass, McAtee, & Matthew, 2006; Huang, Drewnoski, Kumanyika, & Glass, 2009). The micro-level system includes personal characteristics ranging from genetic profiles to individual attitudes and behaviors; whereas, the macro-level system ranges from social networks to public policies. The GROW intervention focuses on the family, recruiting

an index parent-child dyad, and connecting that dyad to the larger built environment. This built environment serves as a community-centered location to build healthy lifestyle skills (both routine physical activity and nutritional habits). During the first (intensive) phase of the intervention, families attended skills-building sessions together in small groups for 12 weeks. Parents met in consistent groups of approximately 8-10 parents for 2 hours each week for group sessions. Transportation and childcare for siblings was offered to all study participants to overcome the most frequently cited barriers to study participation (Eakin et al., 2007). Participants did not receive remuneration for attending sessions. All sessions for each group were conducted in English or Spanish by the same group leader, who was trained to facilitate group discussion rather than lecture. All sessions involved a parent-only skills building component and a parent-child applied learning component to build healthy lifestyle skills (nutrition, physical activity). Integrated within the intervention was the intentional building of new social networks described in detail elsewhere (Gesell, Barkin, & Valente, 2013). By design, participants who could not attend group sessions were given the opportunity to receive the intervention via phone call coaching depending on their weekly circumstances.

The study was approved by the Institutional Review Board. Written consent was obtained in the language of preference (Spanish or English).

Sample

Six hundred and eleven adult-child pairs were enrolled in the GROW trial. Of those, 305 pairs were assigned to the intervention designed to teach healthy lifestyles in a group format. Social network data were collected from 304 intervention group adults (in 30 groups) and included in the analysis.

Eligibility criteria for study participation included: (1) Parent or legal guardian 18 years; (2) with a 3-6 year old child; (3) Child's BMI percentile 50 and < 95; (4) English or Spanish-speaking; (5) Parental commitment to participate in a 3-year study; (6) Consistent phone access; (7) Recruitment from Nashville zip code regions characterized by largely underserved populations; and (8) Child completion of baseline data collection including objectively measured height and weight.

Data Collection

Surveys were administered at weeks 3 and 6 to measure social networks and cohesion. Week 3 was chosen as the baseline because no new members were allowed to join the group after this time, and it allowed for some time (3 weeks) for participants to get to know one another. Week 6 was chosen as the follow-up as it allowed time for the interventionists to use the week 6 social network diagnostics to tailor the remaining weeks of the intervention (Gesell et al., 2013).

Surveys were administered at the community recreation center to the intervention group participants in attendance using a paper photo-sheet format with questions read aloud. Survey administration took 10-15 minutes with a facilitator guiding respondents step-by-step and then following up one-on-one.

The responses were immediately entered by trained study personnel and stored in an online database via REDCap (Research Electronic Data Capture) (Harris et al., 2009). A second trained study person reviewed all of the survey data to ensure its quality and accuracy. Study participants who were not in attendance on data collection days were allowed a second opportunity to complete the surveys in-person at the subsequent sessions (week 4 and week 7, respectively).

Measures

Social Network—A social network survey was developed to assess change in social relationships (specifically, advice networks and discussion networks) over the course of the three weeks by capturing the presence and absence of ties at various stages of the intervention. The items were (1) advice nominations: “In your GROW group, who would you go to outside of sessions for advice on making your family healthier (like being more active, eating healthier, and getting more sleep)?” and (2) discussion nominations: “In your GROW group, with whom do you discuss these issues (being more active, eating healthier, and getting more sleep) outside of sessions?” The advice and discussion networks were examined separately and combined. A person could have been nominated in either the discussion or advice network to be included in the combined network. We measured both advice and discussion networks in order to capture two components of interpersonal influence thought to be important, expertise and trust (Saint-Charles & Mongeau, 2009). We measured relationships outside of sessions in order to capture stronger personal ties, rather than the weaker associations artificially created in a structured classroom setting, where all participants are required to interact with each other.

To ease respondent burden and to reduce measurement error, participants had a sheet of photos and names of other group members. Data were collected at the beginning of the group sessions in week 3 and 6. The intervention assistant read the name generator questions out loud. Participants placed stickers on the sheet of photos to indicate ties to other group members. This aided recall was necessary to reduce two sources of measurement error: low literacy and similar names (e.g., in a single group, three participants had the same first name, and two of these also had the same last initial). In this way we could ensure that we were reliably distinguishing individuals with the same name.

Perceived Cohesion—We also administered Bollen and Hoyle’s previously validated cohesion scale to determine if participants increased their perception of cohesion relative to the group (Bollen & Hoyle, 1990; Chin, Salisbury, Perason, & Stollak, 1999). Originally developed for the community level (Bollen & Hoyle, 1990), this scale has been adapted and validated for the small group context (Chin et al., 1999). Cohesion was first conceptualized as unidimensional, but there has been a shift to a multidimensional view of cohesion. This six-item measure reflects two underlying dimensions of cohesion: sense of belonging and feelings of morale. Items are: (1) I feel a sense of belonging to my GROW group, (2) I feel that I am a member of my GROW group, (3) I see myself as part of my GROW group, (4) I am enthusiastic about GROW, (5) I am happy to be in GROW, and (6) GROW is one of the best health programs anywhere. Items 1-3 reflect Sense of Belonging; items 4-6 reflect Feelings of Morale. Responses are recorded on a 7-point Likert scale with the following

anchors: Strongly Disagree, Disagree, Slightly Disagree, Neither Agree nor Disagree, Slightly Agree, Agree, Strongly Agree. The intervention assistant read the items out loud, and respondents followed along and circled their responses.

Analysis

Because network nominations are counts, and thus may follow a Poisson or a Negative Binomial distribution, it would not be appropriate to use a matched-pairs t-test, which assumes normality, to analyze differences in degree scores at week 3 and week 6. Therefore, we ran nonparametric Wilcoxon matched-pairs signed-ranks tests to determine if degree scores increased from week 3 to week 6.

We then ran a series of lagged random effects and fixed effects regression models that included number of new ties, network size, and parental characteristics (such as parent's age, parent's language preference, parent's BMI, child's age, child's gender, child's BMI) as predictors of cohesion. Group (and thus clustering of participants within group) was controlled for through the random effects term. We created a dummy variable to control for interventionist because the person conducting the intervention may have some effect on cohesion. We examined the advice network, the discussion network, and the combined network each separately.

Participants who did not complete the cohesion scale at both time points were dropped from the analysis. Participants who did not provide network data (i.e., nominate others) but did complete the cohesion scale items were included in the analysis; although they did not nominate people with whom they had a relationship and they could have been nominated by other group participants.

Results

Table 1 reports demographic and study characteristics of the sample, and compares participants with and without missing data. Just over half (55.26%) of the participants received the intervention from interventionist 1, a third (33.2%) received it from interventionist 2, with the rest (11.51%) receiving it from three other interventionists. The majority used Spanish as their primary language (>90%). Parent participants were 32.5 years old on average and had a BMI of 29.8. Their children were evenly split between boys (49.3%) and girls (50.7%), their average age was 4.3 years, and their BMI was 16.7.

In Table 1 we report comparisons on the study and demographic characteristics by whether they are missing cohesion data. Survey completion rate was approximately 70% at each wave; but only 55% of participants completed both surveys, given that participants were given the opportunity to receive the intervention via phone call coaching depending on their weekly circumstance. Results show that missing-ness varied by interventionist such that those receiving the intervention from interventionists "2" and "other" (which consisted of three different interventionists) were more likely to be missing data on cohesion. In addition, missing was also greater among those participants who spoke English.

Factor analysis of the cohesion scale at baseline and follow-up showed that the items loaded on one factor with eigenvalues of 3.73 (N=212) and 4.60 (N=204), respectively. Cronbach's alpha for the two sub-scales was 0.89 and 0.95, respectively. There were missing data: 166 of the 305 participants responded to the cohesion questions at both waves. Overall, across all participants, the average perceived cohesion increased from 6.49 to 6.63 (unpaired t-test, $t=2.09$, $p<0.05$); and for those who completed the scale at both time points it increased from 6.51 to 6.71 (paired t-test, $t=4.4$, $p<0.01$). Table 2 reports these average scores.

Discussion network nominations increased from 0.57 to 0.67 over the 3-week period, however this increase was not statistically significant (Wilcoxon matched-pairs signed-ranks test, $z=1.38$, $p=0.17$); advice nominations increased from 1.44 to 1.62 (Wilcoxon matched-pairs signed-ranks test, $z=2.31$, $p<0.05$); and the total increased from 1.76 to 1.95 (Wilcoxon matched-pairs signed-ranks test, $z=2.59$, $p<0.01$). This represents a 10.8% increase in network nominations over the 3-week period $((1.95-1.76)/1.76)$.

Table 3 reports random effects lagged regression on follow-up cohesion of baseline cohesion, baseline outdegree, interventionist, demographic characteristics, and number of new nominations made in each network. Results show, as expected, that baseline cohesion is strongly associated with cohesion 3 weeks later. Group size and baseline outdegree were not associated with cohesion change, but having interventionist 2 was associated with decreased perceived cohesion, although this effect was only suggestive (Figure 3). There was a tendency for a greater number of new discussion ties at follow-up to be associated with an increase in perceived cohesion. For the combined discussion and advice network, greater number of new ties was associated with increased cohesion. We ran the same series of analyses again (1) without baseline outdegree scores, and (2) with sustained ties and dropped ties; however, results did not change. In sum, being able to name new network contacts was associated with feelings of cohesion in this group-based health promotion intervention.

All three models included English language use, adult BMI, adult age, child gender, child age, and child BMI, which were all non-significantly associated with cohesion change. The random effects term (group, which controlled for clustering of participants within group), contributed little to the explained variance of the models. The overall explained variance was due in large part to the strong association between baseline and follow-up feelings of cohesion.

Figure 4 provides two illustrations of change over time in small groups high and low in cohesion.

Discussion

This is the first study to demonstrate how social network changes affect perceived group cohesion within a behavior change intervention. After a 3-week period (week 3 to week 6 of a 3 year intervention), participants in a healthy lifestyle intervention could list new study participants with whom they discussed healthy lifestyles (being more active, eating healthier, and getting more sleep) outside of intervention sessions.

Association between the sociometric choices people make within a group setting and the feelings of group cohesion measured with a psychometric scale

People who could name more discussion partners were more likely to report a greater sense of group belongingness. Both of these mechanisms (perceived cohesion and social network ties) are important levers we hope to increase during the intervention with the expectation that these increased mediators will be associated with behavioral outcomes. We hypothesized that the association would be stronger for discussion nominations than for advice ones because discussion (conversation) is associated with trust and comfort in contrast to advice (guidance) nominations which are instrumental. Our analytic approach to examining new ties that formed over time removed the collinearity between week 3 and week 6 nominations, and revealed that discussion ties, rather than advice ties, seem to play a greater role in developing a sense of group cohesion.

While creating relationships between participants is often cited as a goal of group interventions because it is theorized as the underlying mechanism of behavior change, there are still very few studies that explicitly measure: the extent to which relationships form or dissolve during groups sessions, the extent to which relationships continue outside of sessions, and the extent to which these relationships facilitate or constrain intervention effects. Those studies that do examine change in social network structure in group interventions suggest that significant interaction effects exist and that more research in this area is needed to fully understand how to leverage network effects to accelerate complex health behavior change (Gesell, Bess, & Barkin, 2012; Shin et al., 2014; Valente et al., 2007). This study reveals that new, and potentially strong, social ties can develop within the first months of a group level health intervention; the ties that developed extended beyond the intervention context, and the type of communication ties that developed indicated that trust was developing between intervention participants. We created a pragmatic trial that allowed our participants to either attend in-person sessions with their consistent group as their schedule allowed or receive the curricular materials delivered in a phone coaching session. The majority of participants did flow organically in and out of the group sessions (real-world context) and, despite that, feelings of cohesion increased within the brief time period studied.

Process information provided by different forms of measurement (sociometric choices vs cohesion scale

Unlike the cohesion scale, the network data give us actionable information about informal communication structures that scales cannot. This information can be used for reorganizing groups to support communication and social influence (Valente, 2012). Also, it can be used during the intervention to further increase group cohesiveness and interaction (Gesell, Barkin, & Valente, 2013).

We expected that in the early stage of this intervention, participants would consult interventionists for expert advice while building trust in their networks. Later, as trust and cohesion deepened, participants would rely on their new networks for advice. The different networks suggest a progression of behaviors that participants go through as they reach more

sustainable levels of behavior change. Just measuring cohesion does not assess any progression in information- or skill-building behaviors.

Interventionist mattered

On average, participants with interventionist 2 increased their perceived cohesion the least. Although this difference was not significantly different from the cohesion change for interventionist 1 who worked with the majority of participants (15 groups for interventionist 1 and 11 for interventionist 2), the effect for interventionist 2 was marginally significant in all regression equations. Participants who had interventionist 2 also reported fewer increased nominations. In addition to marginally higher perceived cohesion with interventionist 1, there were also fewer missing data (as a percentage of the total number of participants in those groups). This could indicate that differences in interventionist styles matter for creating social networks and increased perceived cohesion. The current standard is to develop facilitator guides for group-based behavioral trials that lead the interventionist through process and content. Perhaps the personality traits of the facilitator need to be better codified and applied for future considerations of intervention dissemination. It is clear from the literature on support groups, group therapy, and peer-led groups that personal qualities (e.g., warm, empathetic), not just skills (e.g., use of facilitation techniques) affect group leader effectiveness ("6 Group Leadership, Concepts, and Techniques," 2005). For example, peer-led groups, participants have reported greater positive regard for more highly individuated and less shy peer educators, and participants' positive regard for peer educators in turn was associated with the desired health behavior change (Ozer, Weinstein, Maslach, & Siegel, 1997). Other studies have shown race concordance between interventionist and participants to be associated with slightly greater change in the desirable health outcome in participants (Batch et al., 2013). Our results extend this body of literature by suggesting two things: (1) differences in interventionist styles and personal qualities matter for creating social networks that extend outside the group sessions and (2) people may feel more connected to a group when they feel they can communicate with them outside of group sessions.

Limitations

There were limitations that deserve to be mentioned. In this behavioral trial, each week participants were given a choice of either attending a group session or receiving the information on the phone through phone call coaching if needed to accommodate their schedule. While this resulted in high dose delivery, it also resulted in intermittent group attendance. Given the pragmatic design of this trial, the majority of participants did flow organically in and out of the group sessions (real-world context) but even with that cohesion increased.

Four groups had increased missing data on the perceived cohesion scale. These groups had lower than average attendance across all sessions, and as these network surveys were only completed if a participant attended in-person, a larger amount of missing data are present. Additionally, several of these groups experienced administration challenges; for example, if the personnel assigned to review and enter the surveys on-site was delayed in this process due to other pressing needs, such as childcare or transportation issues that may arise in this

type of intervention, he or she may not have had an opportunity to ensure data completeness before the participants had left for the evening.

Wording of the Cohesion scale may have elicited socially desirable responses and thus high agreement, whereas there was no value judgment in the name generator questions. Parents may feel group cohesion, but still not communicate with other group members outside of session due to logistical constraints on their busy lives (time, transportation, and cell phone minute constraints) not because they don't feel close. Tie strength maybe a better predictor of perceived cohesion, rather than the presence/absence of a tie.

Conclusion

Increase in new discussion partners outside of intervention sessions is associated with increased reporting of cohesion in a group-level health intervention. Given that many behavioral interventions occur in group settings, intentionally building new social networks could be promising to augment desired outcomes.

References

- 6 Group Leadership, Concepts, and Techniques. Center for Substance Abuse Treatment. Substance Abuse and Mental Health Services Administration (US); Rockville, MD: 2005.
- Badaly D. Peer similarity and influence for weight-related outcomes in adolescence: a meta-analytic review. *Clin Psychol Rev.* 2013; 33(8):1218–1236. [PubMed: 24252520]
- Batch BC, Ard JD, Vollmer WM, Funk K, Appel LJ, Stevens VJ, Svetkey LP. Impact of participant and interventionist race concordance on weight loss outcomes. *Obesity (Silver Spring, Md.).* 2013; 21(4):712–717.
- Beal DJ, Cohen RR, Burke MJ, McLendon CL. Cohesion and performance in groups: a meta-analytic clarification of construct relations. *J Appl Psychol.* 2003; 88(6):989–1004. [PubMed: 14640811]
- Bollen KA, Hoyle RH. Perceived cohesion - a conceptual and empirical-examination. *Social Forces.* 1990; 69(2):479–504.
- Chin WW, Salisbury DW, Perason AW, Stollak MJ. Perceived cohesion in small groups adapting and testing the perceived cohesion scale in a small-group setting. *Small Group Research.* 1999; 30(6): 751–766.
- Coleman, JS.; Katz, E.; Menzel, H. *Medical Innovation: a diffusion study.* Bobs Merrill; New York, NY: 1966.
- Eakin EG, Bull SS, Riley K, Reeves MM, Gutierrez S, McLaughlin P. Recruitment and retention of Latinos in a primary care-based physical activity and diet trial: The Resources for Health study. *Health Educ Res.* 2007; 22(3):361–371. [PubMed: 16963726]
- Festinger L. Informal social communication. *Psychol Rev.* 1950; 57(5):271–282. [PubMed: 14776174]
- Festinger, L.; Schachter, S.; Back, K. The Spatial Ecology of Group Formation. In: Festinger, L.; Schachter, S.; Back, K., editors. *Social Pressure in Informal Groups.* 1950. (Chapter 4)
- Flodgren G, Parmelli E, Doumit G, Gattellari M, O'Brien MA, Grimshaw J, Eccles MP. Local opinion leaders: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev.* 2011; (8) CD000125.
- Gesell SB, Barkin SL, Valente TW. Social network diagnostics: a tool for monitoring group interventions. *Implement Sci.* 2013; 8(1):116. [PubMed: 24083343]
- Gesell SB, Bess KD, Barkin SL. Understanding the social networks that form within the context of an obesity prevention intervention. *J Obes.* 2012; 2012:749832. [PubMed: 22655175]
- Glass TA, McAtee Matthew J. Behavioral science at the crossroads in public health: extending horizons, envisioning the future. *Soc Sci Med.* 2006; 62:1650–1671. [PubMed: 16198467]
- Hammond RA. Complex systems modeling for obesity research. *Prev Chronic Dis.* 2009; 6(3):A97. [PubMed: 19527598]

- Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)--A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009; 42(2):377–381. [PubMed: 18929686]
- Huang TT, Drewnoski A, Kumanyika S, Glass TA. A systems-oriented multilevel framework for addressing obesity in the 21st century. *Prev Chronic Dis.* 2009; 6(3):A82. [PubMed: 19527584]
- Kelly JA, St Lawrence JS, Diaz YE, Stevenson LY, Hauth AC, Brasfield TL, Andrew ME. HIV risk behavior reduction following intervention with key opinion leaders of population: an experimental analysis. *Am J Public Health.* 1991; 81(2):168–171. [PubMed: 1990853]
- Mullen B, Copper C. The relation between group cohesiveness and performance: an integration. *Psychological Bulletin.* 1994; 115(2):210–227.
- Ozer EJ, Weinstein RS, Maslach C, Siegel D. Adolescent AIDS prevention in context: the impact of peer educator qualities and classroom environments on intervention efficacy. *American Journal of Community Psychology.* 1997; 25(3):289–323. [PubMed: 9332965]
- Po'e EK, Heerman WJ, Mistry RS, Barkin SL. Growing Right Onto Wellness (GROW): a family-centered, community-based obesity prevention randomized controlled trial for preschool child-parent pairs. *Contemp Clin Trials.* 2013; 36(2):436–449. [PubMed: 24012890]
- Rogers, EM.; Kincaid, DL. *Communication networks: toward a new paradigm for research.* Free Press; New York, NY: 1981.
- Saint-Charles J, Mongeau P. Different relationships for coping with ambiguity and uncertainty in organizations. *Soc Networks.* 2009; 31(1):33–39.
- Salo, M. Technical Report 1193. United States Army Research Institute for the Behavioral and Social Sciences; 2006. *The Relation Between Sociometric Choices and Group Cohesion.*
- Shin HS, Valente TW, Riggs NR, Huh J, Spruijt-Metz D, Chou CP, Ann Pentz M. The interaction of social networks and child obesity prevention program effects: the pathways trial. *Obesity.* 2014; 22(6):1520–1526. [PubMed: 24616241]
- Shoham DA, Tong L, Lamberson PJ, Auchincloss AH, Zhang J, Dugas L, Luke A. An actor-based model of social network influence on adolescent body size, screen time, and playing sports. *PloS One.* 2012; 7(6):e39795. [PubMed: 22768124]
- Valente, TW. *Social Networks and Health: Models, Methods, and Applications.* Oxford University Press; New York, NY: 2010.
- Valente TW. Network interventions. *Science.* 2012; 337(6090):49–53. [PubMed: 22767921]
- Valente TW, Fujimoto K, Chou C-P, Spruijt-Metz D. Adolescent affiliations and adiposity: a social network analysis of friendships and obesity. *J Adolesc Health.* 2009; 45(2):202–204. [PubMed: 19628148]
- Valente TW, Ritt-Olson A, Stacy A, Unger JB, Okamoto J, Sussman S. Peer acceleration: effects of a social network tailored substance abuse prevention program among high-risk adolescents. *Addiction.* 2007; 102(11):1804–1815. [PubMed: 17784893]
- Valente TW, Watkins SC, Jato MN, van der Straten A, Tsitsol LP. Social network associations with contraceptive use among Cameroonian women in voluntary associations. *Soc Sci Med.* 1997; 45(5):677–687. [PubMed: 9226791]

Figure 1.
Conceptual model linking social network and perceived cohesion measures within the context of a group-based intervention intended to change health behavior

Figure 2.
Distribution of ties present in the combined Discussion + Advice network at week 3 and week 6

Figure 3.
Change in density by change in cohesion labeled by interventionist

Figure 4.

a. Baseline and follow-up networks for one group with high cohesion (0.54) and network out-degree changes (1.87).

b. Baseline and follow-up networks for one group with negative cohesion (−0.08) and network out-degree changes (−0.67).

Table 1

Demographic characteristics of the study sample.

	Overall (N=304)	Non-Missing (N=166)	Missing (N=138)	P-value
Interventionist 1	55.26%	59.5%	33.9%	0.001
Interventionist 2	33.20%	27.10%	40.60%	0.013
Interventionist Other	11.51%	6.02%	18.11%	0.001
English Language Use	8.60%	5.40%	12.30%	0.03
Adult Age	32.5 (6.18)	32.9 (6.06)	31.9 (6.30)	0.157
Adult BMI	29.8 (6.25)	30.1 (6.53)	29.5 (5.90)	0.407
Child Male	49.30%	50.60%	47.80%	0.631
Child Age	4.3 (0.91)	4.29 (0.90)	4.32 (0.94)	0.809
Child BMI	16.7 (0.79)	16.65 (0.81)	16.72 (0.76)	0.453

Table 2

Cohesion and out-degree (nominations made) at baseline and follow-up.

	Week 3 Mean (SD)	Week 6 Mean (SD)	Statistical Significance
Cohesion	6.51 (0.70) Range: 1-7 Mode: 7 Median: 6.5	6.71 (0.45) Range: 4-7 Mode: 7 Median: 6.83	t=4.40, p<0.01
Discussion Nominations	0.57 (1.12) Range: 0-7 Mode: 0	0.67 (1.25) Range: 0-7 Mode: 0	z=1.38, p=0.17
Advice Nominations	1.44 (1.70) Range: 0-7 Mode: 0	1.62 (1.58) Range: 0-7 Mode: 1	z=2.31, p<0.05
Discussion + Advice	1.76 (1.89) Range: 0-7 Mode: 1	1.95 (1.74) Range: 0-7 Mode: 1	z=2.59, p<0.01

Table 3

Random effects coefficients (and standard errors) for cohesion at Week 6 on baseline cohesion, group characteristics, and network nominations (N=165).

	Cohesion Week 6		
	Discussion Network	Advice Network	Discussion + Advice Network
Cohesion Week 3	0.548 (0.046) **	0.564 (0.046) **	0.558 (0.046) **
Group Size	0.001 (0.009)	0.007 (0.009)	0.007 (0.009)
Outdegree Week 3	−0.002 (0.023)	−0.021 (0.017)	−0.014 (0.015)
New Ties Week 6	0.071 (0.035) *	0.033 (0.27)	0.064 (0.025) **
Interventionist 2	−0.127 (0.069) †	−0.114 (0.062) †	−0.093 (0.058) †
R ²	0.530	0.529	0.542
Rho	0.059	0.018	0.000

† p<0.10;

* p<0.05;

** p<0.01

NB: Equations also included English language use, adult BMI, adult age, child gender, child age, and child BMI which were all non-significantly associated with cohesion change.

NB2: Bivariate analyses revealed one case in which all six cohesion scale items were scored as one at baseline and 7 at follow-up. This case was removed. Its inclusion causes English to be statistically significantly associated with cohesion change.