Health and the Structure of Adolescent Social Networks

Steven A. Haas¹, David R. Schaefer¹, and Olga Kornienko¹

Abstract

Much research has explored the role of social networks in promoting health through the provision of social support. However, little work has examined how social networks themselves may be structured by health. This article investigates the link between individuals' health and the characteristics of their social network positions. We first develop theoretical predictions for how health may influence the structure of adolescent networks. We then test these predictions using longitudinal analysis of the National Longitudinal Study of Adolescent Health (Add Health). We find important relationships between the health status of adolescents and the characteristics of the social network positions within which they are embedded. Overall we find that adolescents in poor health form smaller local networks and occupy less central global positions than their healthy peers. These results also have implications for social network research, expanding the scope of factors responsible for the network positions individuals occupy.

Keywords

Add Health, adolescence, self-rated health, social networks, structure

Researchers from various disciplines have spent the past three decades connecting the health of individuals to the properties of their social relationships. There is compelling evidence that those with meaningful and reciprocal relations with family and friends live longer, healthier lives than their less socially connected peers (Berkman and Glass 2000). Much of that work has examined the impact of social support that individuals derive from their social networks (Pescosolido 2001). Others have investigated the role of networks in spreading deleterious health outcomes such as sexually transmitted disease (Bearman, Moody, and Stovel 2004) and obesity (Christakis and Fowler 2007).

An important limitation of this work is that most studies presuppose the existence, composition, and structure of social networks without examining the ways in which health may actively influence their creation and maintenance. For example, work that examines the social influence of peers on adolescent smoking largely ignores the fact that adolescents actively choose their friends, and that smoking may influence one’s relative attractiveness to peers with differential predispositions to smoke. Therefore, patterns of smoking within a network develop both from social influence and peer selection processes. Despite calls for greater attention to the determinants of network structure and social support, especially regarding the exogenous effects of health (House, Umberston, and Landis 1988), little research has addressed these issues. While previous studies have investigated peer relationships among ill adolescents, only a minority have explicitly examined the structural aspects of their social networks. The few studies that have taken a network approach have done so within the narrow bounds of specific conditions including distress (Hansell 1985),

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By failing to examine exogenous health effects, our estimates of the effects of networks on health. The reciprocal effect of network structure on health in addition, while the focus on specific diseases can help elucidate particular mechanisms, it can also limit the generalization of processes that may be consistent across a broad array of health conditions. The current study develops and tests theoretical predictions about why individuals in poor health may be embedded in different social network positions than their healthy counterparts. Specifically, we investigate the longitudinal impact of poor health on change in individual local networks (e.g., the number of close friends and their interconnectedness) and global networks (which reflect position within the broader network).

We investigate this question within the context of school-based networks of U.S. adolescents. Though social ties develop in other institutional contexts, for adolescents, school forms the primary hub of their social relationships. Thus, we believe that understanding this particular social space provides a window into a broad swath of adolescent networks and processes that likely generalize to other social contexts. Much of what we describe can also inform the larger issue of health and social networks outside of adolescence. The processes through which health affects social networks may also operate in arenas such as workplaces, families, neighborhoods, churches, and other voluntary organizations.

Understanding adolescent school-based networks themselves is important for several reasons. To begin, adolescence is a time when children begin spending more time with peers and less time with parents (Larson and Verma 1999), making peers an increasingly important source of influence. Research has found that characteristics of adolescent social networks affect numerous important social outcomes including academic achievement (Alexander and Campbell 1964), depression (Prinstein 2007), substance use (Ennett et al. 2009a), and deviance (Case and Katz 1991).

Furthermore, it is important to consider effects of health on network structure to avoid biasing our estimates of the effects of networks on health. By failing to examine exogenous health effects, previous research may overestimate the influence of networks on health, as part of the association likely results from reciprocal feedback processes (House, Landis, and Umberson 1988). A unidirectional view of networks and health obscures the fact that networks are inherently dynamic phenomena. Our goal is not to refute prior understandings of the link between social networks and health. Rather we aim to augment it with a greater appreciation of networks as emergent phenomena. It is only through a more complex understanding of the bidirectional pathways connecting health and social networks that we can fully understand what has become a foundational concept within medical sociology.

**BACKGROUND**

Understanding the impact of health on social ties requires analysis of both local (egocentric) networks and the global network within which local structures are nested. Characteristics of positions at these two levels correspond with different opportunities and constraints vis-à-vis the types of resources networks provide (Schaefer 2009). Local network characteristics, such as how large or dense the network is, determine access to resources such as social support that are acquired directly from one’s social contacts. In contrast, global network positions—which reflect whether an individual is included in multiple social circles versus enmeshed in an exclusive group or isolated from much of the network—affect the receipt of information, exposure to new behaviors or diseases, and access to other resources that can diffuse through a network. For instance, the risk of contacting a sexually transmitted disease is less a function of local position (number of partners) than global position, which captures indirect connections to the partners of one’s partners (Bearman et al. 2004). We first examine the impact of health on egocentric networks before describing how these local processes ripple through the global network.

We presuppose that friendship formation and maintenance among adolescents in poor health must be understood within the normative constraints of their social environment. Fine (1980) identified three interrelated factors that affect the process of friendship formation and persistence: (1) structural opportunities for contact, (2) mutually appealing individual characteristics, and (3) satisfying interactions. Each of these factors must be present for relationships to develop, and changes in any one of them threatens to weaken or break existing relationships. Integrating...
health into this framework reveals interrelated and cumulative effects on the size and structure of adolescent social networks.

Opportunities for Contact

Propinquity is the first prerequisite of friendship formation. Relationships are structured around foci that bring people into regular contact with one another (Feld 1981). For adolescents, the school forms the primary context for friendship development (Hallinan and Williams 1989; Cairns and Cairns 1994). Poor health can impose systematic constraints on opportunities for contact with peers. Health-related restrictions on physical activity can make it difficult to participate in activities that serve as sites of friendship formation. For example, substantial physical handicaps are associated with social isolation among children (Cadman et al. 1987). Additionally, poor health may interrupt daily activities and increase school absence, thus diminishing opportunities for social interaction (La Greca 1990). For example, adolescent cancer patients miss four times as many school days as their peers (Noll et al. 1991).

Individual Characteristics

Relationship formation also requires that individuals find something attractive in one another to motivate further interaction (Fine 1980). Similarity is one basis for attraction, leading to widespread homophily in relationships (McPherson, Smith-Lovin, and Cook 2001). Gender is a primary dimension of homophily from the age of three up through middle to late adolescence (Shrum, Cheek, and Hunter 1988) and across the life course. Other salient dimensions of homophily include sociodemographic characteristics, school-related attitudes, achievement, aspirations, and risk behavior profiles (Kandel 1978; Billy, Rodgers, and Udry 1984; Tolson and Urberg, 1993; McPherson et al. 2001; Moody 2001). Such similarities help ensure common experiences and interests that facilitate the communication, support, and overall benefit that relationships provide (McPherson et al. 2001).

The effects of health on this process can be separated into ego effects (e.g., consequences for one’s own behavior) and alter effects (e.g., how one’s health affects the behavior of peers). Beginning with alter effects, poor health may affect peers’ willingness to enter a friendship if it is accompanied by changes in physical appearance (La Greca 1990). Representing what Goffman (1963) described as an “abomination of the body,” poor health is more likely to result in stigma if it is readily apparent to others, perceived to be the bearer’s responsibility, unalterable or degenerative, or if perceived to be contagious or otherwise dangerous (Crandall and Moriarty 1995). With respect to health-induced alterations of physical appearance, it has been observed that children with a visible physical disability experience fewer reciprocated best-friendship nominations compared to able-bodied peers (Kleck and DeJong 1983).

As stigma is not confined to the afflicted individual and can easily spread to their nonafflicted associates, adolescents may attempt to avoid this halo effect by not associating with stigmatized persons. Moreover, balance theory, which posits that individuals tend to avoid dissonance in their social relations, would suggest that individuals avoid others whom their friends avoid (Cartwright and Harary 1956). Thus, adolescents may avoid unhealthy individuals in order to maintain harmony with existing friends who see an ill peer as stigmatized. The consequence of this for adolescents experiencing poor health is a restricted pool of potential friends who are open to forming a relationship, leading to smaller networks.

Poor health may also influence ego’s preferences and behavior when seeking friends if it produces relationship needs or constraints that differ from those of otherwise healthy adolescents. For instance, maintenance of social relationships requires energy and resources. Too many friends can induce stress (Segerstrom 2008) and, when one is unable to reciprocate friendships, create role strain that leads to increased depressive symptoms (Falci and McNeely 2009). Poor health creates additional stressors and reduces the energy that can be devoted to social relationships, making it potentially even more difficult to sustain relationships. Further, individuals suffering from health problems that carry stigma often withdraw from social interactions and relationships that are not believed to offer compassion (Link et al. 1989). Accordingly, we hypothesize that adolescents respond to poor health by maintaining fewer relationships. Although smaller in number, we expect relationships among adolescents in poor health to be just as strong as those among adolescents in better health. Stronger relationships are more likely to survive the strain that accompanies health problems (Cornwell 2009a). Thus, we postulate that adolescents will maintain their close friendships at the expense of more casual acquaintances, yielding smaller networks.
Beyond network size, poor health has implications for other structural properties of social networks. Network density captures the interconnectedness among one's friends. Though empirical support is mixed, it has been argued that denser networks produce higher levels of social support by increasing communication and coordination (Stokes 1983). Walker, Wasserman, and Wellman (1993) suggest that intensive support (such as chronic health care) is better provided by dense networks, while less intensive support (such as companionship) is facilitated by low density networks.

We hypothesize that adolescents in poor health will have denser networks as a consequence of maintaining smaller networks concentrated on close friendships. Networks among close friends are more likely to exhibit transitivity, where one's friends are also friends with one another (Granovetter 1973). The networks of healthy adolescents may contain both close friends and more casual acquaintances. By narrowing the size of their social circles, adolescents in poor health are inadvertently increasing their network density. This is similar to the phenomenon among older adults, who have fewer disconnected ties as the care required to manage health problems dissolves weaker, nonkin ties (Cornwell 2009a). Thus, we hypothesize that adolescents with poor health will be, ceteris paribus, embedded within higher density networks.

**Interaction Outcomes**

The final step in the development of friendships is interactions that produce positive experiences for the individuals involved, including the exchange of mutually beneficial rewards and the avoidance of costly externalities (Fine 1980). Poor health can affect the consistency of interaction in the same ways that it decreases the opportunities for relationships to develop. When adolescents are routinely absent from school, existing relationships are placed in jeopardy. Without regular interaction, the friends of an unhealthy adolescent may seek out others who can provide them with more consistent friendship (Molm, Schaefer, and Collett 2007). Accordingly, youths who missed school due to periodic hospitalizations are less preferred as playmates by their peers (Graetz and Shute 1995).

Adolescents with health problems also often face recurrent modifications in lifestyle aimed at the alleviation of symptoms and prevention of acute crises (La Greca 1990; La Greca, Bearman, and Moore 2002). These changes to daily life may include dietary restrictions, complicated medication regimens, and disease management tasks. For instance, dietary restrictions are important for management of diabetes, and activity restrictions to prevent exposure to irritants and allergens are common in asthma management (La Greca 1990). Such aspects of treatment are not only disruptive to normative peer activities but may contribute to self- and peer-perceptions of being “different.” In addition, the presence of microstresors, or small daily hassles, can detract psychological and physical energy from youth, lessening their capacity for meaningful engagement with peers (Varni et al. 1989).

Poor health may also lead to asymmetrical resource exchange and imbalance within friendships. As in any form of social exchange, norms of reciprocity require that both members of a friendship derive value from the relationship (Molm et al. 2007). While the members of a dyad may derive different forms of value (i.e., one emotional and the other instrumental), if the exchange of support is perceived to be too one-sided, the relationship may become strained. Health problems may create imbalance either by increasing demands for social support from one’s peers or by constraining one’s ability to reciprocate in ways required to maintain the friendship.

**Health and Global Network Position**

To this point, we have considered how poor health affects the structure of adolescents’ local networks, composed of one’s friends and the relationships among them. These network features are readily perceptible to adolescents—students know who their friends are, and, among them, who is friends with whom—and are often utilized in studies of “ego networks” (e.g., Lin, Ye, and Ensel 1999). In contrast, students also occupy a position in the broader school network. Beyond their direct connections to friends, students have many more indirect connections to other students in the school through friends of their friends. However, the nature of the indirect connections to others in the global network can differ greatly. For example, student A may have five densely connected friends but be part of a rather isolated clique, with only one member regularly interacting with students outside the clique. Student B may also have five densely connected friends, but the friends mingle in somewhat different social circles. Students A and B have the same local network structure but
their global positions differ widely. Consequently, student B is likely to be better informed about other students and events within the school than student A. Student B likely has greater exposure to ideas and behaviors that diffuse through the school network; whereas student A’s access to information is restricted to the single friend with ties outside the clique.

The effects of poor health on global position are based on local friendship processes (described above) whose effects ripple through the network. We propose that poor health impacts global network position through two processes related to participation in formal and informal groups. Groups create the possibility for direct ties to co-participants in addition to indirect ties to co-participants’ friends outside the group (Moody 2001). The risk of network marginalization is expected to increase to the extent that poor health prevents adolescents from participating in group activities. Since groups draw their members from distinct niches or network regions (McPherson 1983), reductions in group involvement will diminish the likelihood of forming ties to others in different niches (reducing one’s global centrality). Less healthy adolescents may form just as many relationships within the groups they join, but their global centrality will be lower.

Even if health does not affect adolescents’ rates of group affiliation, global centrality will still be lower for adolescents in poor health if their groups are lower in status. For instance, poor health may lead adolescents away from sports, the activity most populated by popular students (Brown 2004), and toward activities associated with less popular crowds. Because activities serve as a locus for friendship, poor health adolescents are left with lower status friendship groups. Alternatively, health may affect centrality through its role as a status characteristic that affects others’ perceptions of one’s friendship potential. Gould (2002) proposed that “individuals face a trade-off between attaching themselves to desirable alters and attaching themselves to available alters” (p. 1150). Following this logic, low status adolescents who are less able to form friendships with high status peers turn to lower status peers for friendship. Because youth suffering from illness are perceived to be less desirable as friends (Richardson 1983), they are effectively lower in status and, hence, more likely to be friends with other lower status adolescents, including others in poor health. Indeed, research suggests that a similar stigmatization process leads to homophily on body size among adolescents (Crosnoe, Frank, and Strassmann 2008). If poor health adolescents are in status-homophilous relationships, then the groups they participate in will also tend to be lower in status. In either case, when adolescents affiliate with lower status groups, they occupy more marginalized positions that offer lower direct and indirect access to others in the wider network.

Hypotheses

We propose four hypotheses about the effects of poor health on the social networks of adolescents.

**Hypothesis 1:** Poor health will be negatively associated with network size: Adolescents with poor health will have fewer network ties than their healthier peers.

**Hypothesis 2:** Poor health will be positively associated with the probability of being a social isolate.

**Hypothesis 3:** Poor health will be positively associated with friendship network density.

**Hypothesis 4:** Poor health will be negatively associated with adolescents’ position within the global friendship network.

**METHODS**

**Data**

This study uses data from waves 1–2 of the National Longitudinal Study of Adolescent Health (Add Health), which investigates the health, social contexts, and relationships of adolescents in the United States. Add Health provides a unique opportunity for investigating the associations between health and social networks in a nationally representative sample of adolescents. Add Health uses a multistage, clustered sampling design, in which a nationally representative sample of 132 middle and high schools was selected (Bearman et al. 2004). During the in-school survey, conducted September 1994 through April 1995, all students in attendance were given self-administered questionnaires. A subsample of participants from the initial school survey was then selected for an in-depth, in-home component, in which both adolescents and their parents completed questionnaires between April and December 1995. Wave 2 in-home surveys were then collected from April through August 1996. Because we are interested in both ego and global networks we limit our analysis to respondents in 16 saturated schools (where all
students were targeted and complete network data are available). Within the 16 saturated schools 4,195 adolescents participated in the in-school data collection. For 127 students, coding errors involving student IDs precluded matching network and survey data, leaving 4,068 students with valid wave 1 data on friendship networks, health, and control variables. Because we are interested in the longitudinal impact of health on network size and structure we further constrain our analysis to the 2,065 respondents also participating in the subsequent in-home survey at wave 2. Last, we omitted an additional five students who were missing proper sampling weights, yielding a final analytic sample of 2,060 adolescents. There were 2,003 students who did not participate in wave 2. Of these, 1,585 were juniors or seniors during in-school wave 1 and would have graduated in the interim between the data collection points; thus, they were ineligible for follow-up. Attrition of the remaining 418 cases was due to unknown reasons.

**Measurement**

**Adolescent friendship networks.** Participants received a roster of all students enrolled in their school and their sister feeder school and were asked to nominate up to five male and five female friends. In some instances, students nominated friends who were not found on the roster. Unless otherwise noted, we excluded such nominations from these analyses, as no data were available on the outgoing ties—and hence network position—of out-of-school friends. The networks formed by these nominations were used to construct the measures of local and global network position. We constructed network indices for two time points: baseline (wave 1 in-school) and subsequent in-home (wave 2).

Out-degree and in-degree are used to describe the size of local networks. **Out-degree** is the number of friendship nominations that a focal adolescent makes. Given the network data collection strategy, each adolescent was able to nominate up to 10 friends. It should be noted that we calculated this index based on the complete set of nominated friends—identifiable and unidentifiable—since information about friends’ ties is not required. **In-degree** is the number of friendship nominations that a focal adolescent receives. Given that any number of students could potentially nominate a focal adolescent, this index can range between zero and the number of other students attending a school. We also created a dummy variable which indicates whether the adolescent received no in-coming nominations and is thus a **social isolate**. The contrast between the act of nominating and being nominated provides insight into how adolescents view their social ties compared to how they are viewed by peers. Differential impact of poor health on out-degree and in-degree sheds light on whether health-related differences in network size likely derive from ego or alter effects, respectively. If health problems lead adolescents to have smaller networks than what they desire or is normative for their age, they may be less discriminating when completing the Add Health survey, resulting in the inclusion of weaker friendships. This would impact outgoing (made by ego) but not incoming (received by ego) nominations.

Network **density** was calculated by dividing the number of ties between one’s alters (e.g., friends nominating ego and nominated by ego) by the total number of ties possible between alters (calculated as the number of alters, \( n \), times \( n - 1 \)). This results in a proportion representing the level of interconnectedness among each respondent’s friends. The density of isolates’ friendship networks is undefined; therefore isolates were excluded from the density analysis. The distribution of density had a positive skew; to better approximate a normal distribution we transformed it by adding one to the density score and taking the natural logarithm.

We operationalize global network structure with two measures: **influence domain** and **Bonacich centrality**. These measures index the volume of ties emanating from an adolescent (Borgatti and Everett 2006). They differ from degree-based measures in that they consider both direct and indirect connections to others. Influence domain and Bonacich centrality capture different aspects of centrality and the extent to which students are active within the broader school environment, not just with their group of friends. Using outgoing ties, Bonacich centrality weights ego’s centrality by the centrality of his or her alters (Bonacich 1987). This form of centrality is high when students are connected to others who are themselves well-connected and is often used as an indicator of sociometric popularity (Bonacich 2007). For example, a student with three friends who are themselves central in the network is more central than a student with three friends located in more peripheral network positions. This metric is calculated according to the following formula:

\[
\text{Bonacich Centrality of } X (\alpha, \beta) = \alpha \times (I - \beta \times X)^{-1} X, \]

where \( \alpha \) is the complexity parameter, \( \beta \) is the Bonacich parameter, \( X \) is the matrix of nominations, and \( I \) is the identity matrix.
where \( X \) contains all friendship nominations in the form of an adjacency matrix; \( \alpha \) is a scaling factor (determined mathematically to allow the equation to be solved); \( \beta \) is a power weight reflecting the degree of dependence of actor’s prestige on the extent of prestige of the alters to whom the ego is connected (which we set equal to .1); \( I \) is the identity matrix; and \( 1 \) is a vector of 1s.

Again if less healthy adolescents tend to be less discriminating when nominating friends, then measures of centrality based on outgoing ties (such as Bonacich centrality) may be artificially inflated. However, centrality measures based on incoming ties would not be affected. Thus, examining centrality through incoming and outgoing ties separately is important for assessing and overcoming measurement error due to social desirability. Therefore, we also consider influence domain, which is based on the number of incoming ties (i.e., others who nominate ego directly or indirectly). Influence domain measures the number of alters who can reach ego through direct and indirect connections. For example, A can reach B if A has a direct tie to B or if A has a tie to C who has a tie to B. Given that this measure is sensitive to the size of a school (i.e., students in larger schools could have a larger number of direct and indirect incoming nominations), it was standardized by dividing by the size of the network in each school to create a proportion. While we expect health conditions to lead to more marginal positions in both regards, it is possible that the strength of effects varies. Moreover, to the extent that results for the two measures of global position converge, we are confident that response bias is not problematic for our inferences.

Adolescent health. We examine the impact of adolescent’s poor health status using self-rated health status, dichotomized as 0 = excellent/very good; 1 = good/fair/poor. Among adults, self-rated health is a reliable and valid measure of general physical well-being (Idler and Kasl 1991). Recent research has found that among adolescents, self-rated health is moderately stable over repeated observations and that it captures both enduring and transient physical and psychological dimensions of well-being (Boardman 2006; Fosse and Haas 2009). In Add Health, self-rated health was gathered from adolescents at the in-school and in-home surveys. To minimize missing data we used the wave 1 in-home value for those adolescents missing in-school health reports.

Control variables. We included the following control variables in the analyses: age (in years), race (a set of three dummy measures: white [omitted referent], African American, and other, and Hispanic ethnicity [dummy]). In addition, two variables were created to control for respondent socioeconomic background: (1) a dummy variable for family receipt of public assistance, obtained from the parental report, and (2) a series of dummy variables (less than high school, high school [referent], and more than high school) capture the highest level of educational attainment of the highest educated residential parent. Finally, we measured family structure with a series of dummy variables differentiating among adolescents who resided with two biological parents (referent), a single parent, or other type of households. Descriptive statistics for all variables used in the analysis are provided in Table 1. There were some missing data on covariates (particularly for the public assistance variable). Missing data were handled using multiple imputation via the Proc MI procedure in SAS.

Analysis

To examine the effect of poor health on the properties of adolescents’ networks we estimate longitudinal residual-change models. Residual-change models (also known as auto-regressive models) are among the most frequently used techniques to examine change over time. The residual-change approach involves modeling the outcome of interest at time 2 while controlling for the level of that same variable at time 1. This provides more compelling evidence as to whether poor health significantly impacts social network structure and position than traditional cross-sectional regression models, as only predictors of change in the rank order of observations are typically statistically significant. Those variables that predict systematic monotonic change among all observations typically remain insignificant (Meredith and Tisak 1990). We estimated in-degree, out-degree, density, influence domain, and Bonacich centrality using residual-change OLS regression models, and we used logistic regression to estimate social isolate status. In each model, the network variable at wave 2 is regressed on baseline poor self-rated health, the network variable at wave 1, and additional control variables. We also tested models without adjustment for baseline network status and the results are not substantively different. We used sampling weights and survey regression procedures for all analyses. Regression estimates
derived from multiple imputations were combined using the SAS MIANALYZE procedure.

RESULTS

Local Networks

Table 2 presents the results of the regression of local (egocentric) network. The impact of poor health on change in network size varies greatly depending upon whether it is measured on the basis of incoming versus outgoing ties. Using outgoing ties (first set of columns) we find no statistically significant impacts of poor self-rated health on the number of friendship nominations made. However, when considering incoming nominations (second set of columns) we find that adolescents who reported poor self-rated health at baseline received fewer subsequent friendship nominations than their healthier peers. Adolescents with poor self-rated health at baseline had on average .20 fewer incoming nominations compared to their healthy peers, net of prior number of incoming ties. This is equivalent to approximately a 7 percent reduction from the mean number of incoming nominations at wave 2. The effect of health on incoming ties is roughly the same magnitude of the impact of family structure and Hispanic ethnicity. However, it is only one-fifth the size of the impact of race. Similarly, adolescents in poor health were significantly more likely to be a social isolate at wave 2 (third set of columns). Poor health increased the odds of becoming a social isolate by nearly 20 percent (odds ratio = $e^{0.18} = 1.197$). This effect is also similar in magnitude to the effect of being Hispanic. These findings are consistent with hypotheses 1 and 2 which predicted that poor health would be negatively associated with network size and positively associated with odds of being a social isolate. We also find that non-white

| Table 1. Descriptive Statistics (Add Health 1994–1996) |
|------------|-----------|-----------|-----------|
|            | %         | Mean      | SD        | % Missing |
| Good/Fair/Poor SRH | 36.2 | 2.5 |
| Excellent/Very Good SRH | 63.8 |
| Network Variables |
| In-degree wave 1 | 4.30 | 3.6 | .0 |
| In-degree wave 2 | 2.90 | 2.7 | .0 |
| Out-degree wave 1 | 6.80 | 3.4 | .0 |
| Out-degree wave 2 | 5.80 | 2.8 | .0 |
| Isolate wave 1 | 8.5 | .0 |
| Isolate wave 2 | 27.8 | .0 |
| Density wave 1 | .16 | 8.5 |
| Density wave 2 | .17 | 27.8 |
| Bonacich centrality wave 1 | .93 | .7 | .0 |
| Bonacich centrality wave 2 | 1.11 | .9 | .0 |
| Influence domain wave 1 | .53 | .2 | .0 |
| Influence domain wave 2 | .18 | .2 | .0 |
| Control Variables |
| Age | 16.11 | 1.5 | .1 |
| Female | 50.5 | 2.5 |
| Hispanic | 20.1 | .3 |
| White | 60.2 | .3 |
| African American | 16.9 | .3 |
| Other race | 22.9 | .3 |
| Parental education < 12 years | 12.5 | 3.0 |
| Parental education 12 Years | 31.9 | 3.0 |
| Parental education > 12 Years | 55.6 | 3.0 |
| Public assistance | 6.2 | 18.1 |
| Two parent family | 73.8 | .3 |
| Single parent family | 22.2 | .3 |
| Other family | 4.0 | .3 |

Note: SRH = Self-rated health.
adolescents experienced greater declines in incoming and outgoing friendship nominations and were more likely to become social isolates relative to their white peers. Adolescents from single-parent families experienced fewer incoming nominations than those from intact families. Family socioeconomic status was not significantly associated with change in local network parameters over time.

The last set of columns in Table 2 present analysis of network density. Hypothesis 3 predicted that poor health would be associated with higher network density, primarily as a function of maintaining fewer ties. In contrast to the results for network size, we find no support for the hypothesis that poor health increases network density. Baseline poor self-rated health was not associated with subsequent differences in network density. This finding is especially intriguing given the finding that network size declined from baseline. In general, as network size increases, the density of ties decreases because it is difficult to maintain the same level of connectivity within larger groups. The fact that network density did not decline from baseline while size did indicates that adolescents with poor health did not experience the greater density that often accompanies smaller networks. Because density is positively associated with friendship strength (Granovetter 1973), these findings suggest that adolescents in poor health not only have fewer friends but possibly weaker friendships as well. Older adolescents as well as African Americans had lower social network density than their younger and white peers.

### Global Network Position

Hypothesis 4 predicted that adolescents with poor health would occupy less central locations within the global network. Table 3 presents estimates of the impact of health on adolescent’s global network position as measured by influence domain and Bonacich centrality. The left hand columns of Table 3 present results for the analysis of the impact of poor health on influence domain (which represents the proportion of students in the school who could reach ego directly or indirectly). We find a significant negative association between poor self-rated health at baseline and subsequent

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**Table 2. Regression of Adolescents’ Local Friendship Network (Add Health 1994–1996)**

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<th>Density</th>
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<td>.10</td>
<td>–.20**</td>
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<td>Wave 1 Out-degree</td>
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<td>Wave 1 Isolate</td>
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<td>Wave 1 Density</td>
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<td>Other Raceb</td>
<td>–1.02****</td>
<td>.16</td>
<td>–.30</td>
<td>.16</td>
</tr>
<tr>
<td>Single Parentc</td>
<td>–.14</td>
<td>.14</td>
<td>–.14*</td>
<td>.07</td>
</tr>
<tr>
<td>Other Familyc</td>
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<td>.27</td>
<td>–.33</td>
<td>.20</td>
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<tr>
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<td>.24</td>
<td>–.07</td>
<td>.16</td>
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<td>.18</td>
<td>.08</td>
<td>.13</td>
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<tr>
<td>Public Assistance</td>
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<td>.22</td>
<td>–.29</td>
<td>.27</td>
</tr>
<tr>
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<td>2,060</td>
<td>2,060</td>
<td>1,487f</td>
</tr>
</tbody>
</table>

*p < .05; **p < .01; ***p < .001 (two-tailed tests)

Note: SRH = Self-rated health.

Areference category is excellent/very good.

bReference category is white.

cReference category is two parent families.

dReference category is 12 years.

ereference category is 12 years.

eresults of logistic regression.

Density is undefined for social isolates.
### Table 3. Linear Regression of Adolescents' Global Friendship Network (Add Health 1994–1996)

<table>
<thead>
<tr>
<th>Influence Domain</th>
<th>Bonacich Centrality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
</tr>
<tr>
<td>Good/Fair/Poor SRH&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.02&lt;sup&gt;*&lt;/sup&gt;</td>
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<tr>
<td>Wave 1 Influence</td>
<td>.21&lt;sup&gt;****&lt;/sup&gt;</td>
</tr>
<tr>
<td>Wave 1 Centrality</td>
<td>.21&lt;sup&gt;****&lt;/sup&gt;</td>
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<tr>
<td>Age</td>
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<td>-.07&lt;sup&gt;***&lt;/sup&gt;</td>
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<td>Public Assistance</td>
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</table>

<sup>*p < .05;  **p < .01;  ***p < .001</sup> (two-tailed tests)

Note: SRH = Self-rated health.

<sup>a</sup> Reference category is excellent/very good.

<sup>b</sup> Reference category is white.

<sup>c</sup> Reference category is two parent families.

<sup>d</sup> Reference category is 12 years.

The coefficient of −.02 indicates that students in poor health were reachable by 2 percent fewer adolescents net of their prior reachability. Thus, adolescents with poor self-rated health occupied increasingly marginalized positions within their networks over time. We further find that racial-ethnic minorities, those from non-intact families, and those with less educated parents also occupied less central positions within their networks based on influence domain.

The right-hand columns of Table 3 present results for Bonacich centrality. Bonacich centrality affords a more nuanced picture of individual global position because it weights ego’s centrality by the centrality of the friends he or she nominates. Worse self-rated health ($b = −.05$) was significantly and inversely associated with Bonacich centrality at wave 2 net of prior centrality. Adolescents reporting poor self-rated health at baseline nominated friends who themselves tended to nominate fewer friends than adolescents reporting better health. The results for both influence domain and Bonacich centrality provide support for hypothesis 4: Poor health had a negative effect on network centrality. In addition, the finding for Bonacich centrality provides support for the mechanisms behind hypothesis 4. Adolescents in poor health had less central friends, which suggests that they were involved in peer groups that were lower in status. While older teenagers had higher Bonacich centrality, Hispanic adolescents occupied less central network positions.

### DISCUSSION

Understanding social networks and how their structural properties facilitate or inhibit the provision of social support is critical to understanding the social context of health and well-being and has been the subject of substantial social science research over the past three decades. However, little research has investigated, conceptually or empirically, how an individual’s health status may act as an important determinant of the structure of his or her social network. This study fills this gap by developing theoretical predictions about the influence of health on adolescent social networks and testing them with high quality longitudinal data.
We find that adolescent health has significant impacts on both local, egocentric network structure and position within the larger global network. The above analysis provides support for hypotheses 1 and 2, clearly showing that, net of sociodemographic background and baseline network characteristics, adolescents who report poor self-rated health at baseline have fewer subsequent friends in their social networks and are significantly more likely to be social isolates. This is driven entirely by differences in the number of in-degree friendship nominations. As they nominate the same number of friends as their healthier peers, adolescents with worse health do not necessarily perceive themselves as having fewer friends. However, they are less likely than their healthier peers to be nominated by others. This would suggest that alter-related behavior, rather than the preferences and actions of adolescents themselves, may be most responsible for the adverse impact of poor health. This could be an indication of stigmatization associated with health that creates weaker attachments to less healthy adolescents. Alternatively, the strain and stress associated with poor health may drive away friends of less healthy adolescents, which is more evident in friends’ reports of their relationship. Still, we cannot discount the possibility that the differences between in and out degree are a consequence of social desirability.

Contrary to hypothesis 3, we find that initial health status does not appear to impact change in network density. The simultaneous finding of declining network size and stable density of ties suggest that adolescents in poor health may have friendship circles consisting of a small number of relatively weaker ties. This has important implications for the availability of social support, as the presence of weak ties would predict that the marginal (per friend) supply of social support may be less than expected given the size alone. Reductions in network size due to poor health do not translate into denser networks as we expected. We also find support for hypothesis 4, that adolescent health also has significant impacts on adolescent position within the larger global network. Adolescents with poorer health occupy more marginal and less central positions within their larger networks, based on multiple measures of global centrality including influence domain and Bonacich centrality.

The presence of reciprocal feedback effects from health to social network structure suggests that prior estimates of the impact of networks on health may be overestimated. Future analyses of health and social networks should take advantage of new statistical techniques developed to model the co-evolution of individual traits and social networks (Snijders 2005). Such models allow for a clearer understanding of the simultaneous effects of social influence and peer selection processes in determining the distribution of health behaviors and conditions within networks.

The finding that health can shape social networks also has important implications for a variety of social processes and outcomes. For example, a growing body of research has shown that poor health status has a detrimental impact on the educational achievement and attainment of adolescents (Haas and Fosse 2008). Given the important role of relationships in mediating the adverse effects of health insults and the long-observed impact of peer influences on academic achievement (Alexander and Campbell 1964; Duncan, Haller, and Portes 1968), social network processes may be an important mechanism linking health and educational outcomes. For example, their greater social isolation and marginalization may reduce sick adolescent’s attachment to school, negatively impacting achievement. Future research would be wise to examine the potential mediating role of social networks in health-related selection into lower educational strata. In addition, peer relationships may be an important point of intervention to improve the social functioning and academic outcomes of children and adolescents with health problems.

The findings also have important implications for social network researchers. Although the association between health and network position may be apparent to health scholars, social network researchers typically take a more structural approach that treats individuals as homogenous actors. While social network researchers have recognized that individual characteristics matter for some network processes (i.e., homophily), they have only recently begun to explore whether the occupation of network positions is itself a product of individual attributes. Recent suggestions have been made to consider how social development (Schaefer et al. 2010), cognitive processes (Robins and Kashima 2008), and psychological predispositions (Kalish and Robins 2006) affect the types of positions individuals occupy in a network. The current study identified health as a key individual characteristic affecting adolescent social position and provides additional insight to the processes through which individuals sort themselves into network positions.
There is reason to suspect that much of the processes outlined above are strongly structured by gender norms. As such, the social impact of poor health needs to be understood within the gender-specific developmental context. In additional analysis (not shown) we tested for interaction effects between gender and poor self-rated health. The results revealed no significant gender differences in the effect of poor self-rated health on social networks structure or position. This may be due to true gender invariance in the impact of health on networks. Alternatively, boys and girls may be equally affected by health problems, though the effects may operate through different mechanisms. For example, it has been shown that treatments for health problems that limit physical growth and strength have greater social consequences for boys, whereas those reducing physical attractiveness are more distressful for girls (Hurtig and White 1986; Wasserman et al., 1987; La Greca 1990). Similarly, La Greca (1990) has noted that health-related restrictions on physical activity might be differentially consequential for boys’ and girls’ peer relations. Unfortunately, the limited information on specific health conditions and their low prevalence in the Add Health sample prohibit such analysis. Further research is needed to explore gender differences in the mechanisms linking health to networks.

The chief limitations of this study derive from constraints of the data. We have detailed three broad classes of mechanisms by which poor health may impact adolescent networks. First, the condition may inhibit participation in normative activities where social ties are constructed and maintained. Second, the condition may alter ego’s preferences for peers or be a source of stigma reducing ego’s social desirability. Third, the condition may impact interactional outcomes by creating asymmetrical resource exchange either through placing a heavy support burden on peers or by inhibiting ego’s ability to reciprocate. While self-rated health has been shown to be a reliable measure of overall health it does not allow us to elucidate these specific pathways. The use of specific disease categories would provide greater purchase on the underlying social processes than would general measures of health (Timmermans and Haas 2008). Some conditions are likely to act exclusively through one mechanism or another. For example, asthma may prevent adolescents from engaging in certain types of activities, such as athletics, which are important centers of friendship formation, but it may not otherwise make one undesirable to others, or create much support burden on peers. Similarly, the skin condition psoriasis is not likely to limit one’s activities, nor is it likely to create undue stress on one’s relationship with peers. However, it can be highly stigmatizing, reducing one’s desirability as a potential friend. Conversely, depression may influence all these mechanisms. Depression creates asymmetrical resource exchange by placing a heavy support burden on peers while also limiting ego’s ability and desire to reciprocate. Often accompanied by anhedonia, depression can make individuals undesirable to be around and, to the extent that it is known to others, may be highly stigmatized. Depression also inhibits one’s ability to cope with stress (or proxies for it), thereby preventing the occupation of more stressful network positions such as bridges across structural holes (Cornwell 2009b). Though Add Health includes some information on specific chronic conditions, unfortunately their prevalence in the data is inadequate to support further in-depth analysis. In addition, due to the survey design, information on most specific health conditions is only available for respondents who first reported problems with limb function. More research with better data is needed to further unravel the relative importance of these and other mechanisms. Investigating such processes within an aging population with higher prevalence of chronic health problems is likely to be most fruitful.

A second limitation is that we are only capturing the school-related dimension of adolescent social experience, due to the artificial network boundary imposed by the study design (Marsden 2005). While the school is a primary hub of adolescent social relationships, other institutions and environments in which they are embedded clearly matter. This may be particularly important for the social adaptation of chronically ill youth who may feel constrained and isolated within the normative context of the school and seek out alternative sites of friendship formation and social support. This may include joining formal or informal groups associated with their condition, where shared health experiences facilitate social relationships. Thus, social deficits experienced in school may be offset by nonschool peer relationships. However, in additional analysis (not shown) we find adolescents in poor health are no more likely to have nominated friends outside of the school than their healthier peers. We also estimated models with and without controls for the number of nonschool friendship nominations. This did not meaningfully change the results. Thus, we find no evidence that restricting the social network to within the school significantly affects our results.

This study has focused on friendship formation and maintenance of adolescents. Though many of the
specifics of this discussion are unique to that population, we believe that much of the underlying process and mechanisms described above are generalizable to adults. That is, adults with health problems face many of the same constraints in regard to limitations on opportunities for social interaction, stigmatization, and adverse interaction outcomes (see Cornwell 2009b). At the same time, the impact of poor health on social network structure may be more pronounced in adolescence given the more tenuous and fluid nature of friendships. Adults, on the other hand, may benefit from the greater probability of having long-standing relationships and the prior winnowing of the weaker, less secure, and thus less supportive ties in their friendship networks. Older adults in particular may have different experiences as chronic health problems become common and normative among peers. More research is needed to elaborate the common and unique dimensions to these processes at later points in the life course.

The results of this study highlight the need for a more complex and dynamic understanding of social networks and health. Such an understanding should not only illuminate the ways in which various network structures facilitate or inhibit the provision of social support; it should also recognize that social networks are themselves emergent, a product of health conditions and other factors. It is only through such a dynamic reciprocal approach that researchers can begin to fully appreciate the rich and complex processes linking health and human social relationships.

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FUNDING

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NOTES

1. Network data were collected as part of the first in-home survey; however, many students were only allowed to nominate one male and one female friend, for a maximum of two alters. To maintain consistency with the school survey and provide a better representation of friendship networks, we use the more complete data available at school and the second home survey.

2. Eighty-five students had exclusively, nonuniquely identifiable alters. These cases are not included in the analysis of density, Bonacich centrality, or influence domain, all of which require indentifying unique alters.

3. For all models estimated using OLS we conducted sensitivity analyses to test the robustness of results to different distributional models, including Poisson and negative binomial specifications. The direction, substantive magnitude, and level of statistical significance of parameter coefficients did not change appreciably across different model specifications of the outcome variables.

REFERENCES


**Bios**

**Steven A. Haas** is an assistant professor of Population Dynamics at Arizona State University. His research examines the social and economic causes and consequences of poor health over the life course. His recent work has appeared in *Demography, Social Forces, Journal of Health and Social Behavior, and Social Science & Medicine.*

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**Olga Kornienko** is a doctoral candidate at the School of Social and Family Dynamics at Arizona State University. Her research interests include examining the depression contagion between close friends and understanding how selection and social influence processes in friendship networks are related to mental health outcomes among U.S. adolescents.