
Use of social network analysis to map the social relationships of staff and teachers at school

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Abstract

Understanding the pre-existing social relationships in a setting is vital in health promotion, not only for understanding important people to get 'on side' with an intervention but also for appreciating how the intervention itself might change social structures. Social network analysis is a method for capturing the complexity of social relationships that has not been used widely in health promotion research. We present the results of an application in a high school. We characterize the school in terms of the density of relationships and the centrality of particular staff and teachers. We illustrate how simply being well-known or being nominated by lots of others as a person to turn to (a concept reflected in a person's degree centrality score) is not always the best guide for whom to select as an intervention champion. Indeed, for many interventions, a person's strategic connection to the most marginal people in a community, school or workplace could be the most important criteria (a concept better reflected by a person's betweenness centrality score). Given the ease of survey administration and the high yield in terms of analytic insight, we recommend that social network analysis be used more routinely in health promotion intervention design and evaluation.

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Introduction

Social relationships, the ties people have with others, can enhance or hamper quality of life, coherence, sense of personal worth, health and educational and economic opportunity [1]. Social relationships affect the subjective domain of people's experience (how people feel) and also the instrumental aspects of human experience (what information or resources people can access). Some health promotion interventions target social relationships specifically, such as intervention aimed to build social support and befriending among particular groups [2]. In other interventions, the primary focus might be elsewhere, but an understanding of social relationships that exist within a setting is still considered vital for the intervention's success or sustainability. Practitioners are encouraged, for example, to identify and build the capacity of those people who might be potential programme champions if they want an intervention to be sustained [3].

In schools, it is unusual for researchers to measure social relationships specifically as part of the intervention. Instead, social relationships are usually seen as one part of the broader, umbrella concept of the school's 'social environment'. Rating scales or check-lists completed by students, staff and teachers have been devised to tap opinions about a variety of aspects of the social environment, drawing indirectly on social relationships such as how close students feel to people at the school, help and interest shown by teachers, feelings of safety, belonging, fairness in relation to rule enforcement, mutual respect and participation in decision making. Indeed a myriad of constructs are thought to be contained

within the phrase social environment at school and a recent article has begun to disentangle the overlap and differences among rating scales which purport to measure school attachment, school bonding, school climate, school context and so on [4]. Other ways to characterize the social environment of the school and the experience of it draw on qualitative methods, for example, the use focus groups to interpret student, parent and teacher perceptions [5].

In this paper, we present a method for assessing the social relationships directly in a school by focusing on multidimensional social interaction structures or networks among the teachers and staff. In the theoretical tradition of this way of thinking, interpersonal exchanges among people in a particular place create a web of relationships that are integral to understanding system-level phenomena, such as how quickly information gets around or how easy it is to rally resources. So rather than asking individual people what they feel or think about a setting using methods derived principally from education or psychology, and aggregating up to draw inferences about the most common or least common perspectives, researchers use social network analysis methods to capture the ‘social positions’ occupied by people in those settings in order to understand social experience differently.

Social network analysis involves mapping relationships or ties among people or organizations. In social network analysis, people and their actions are viewed as interdependent and lasting patterns of relations over time among people come to constitute the social structure [6]. Researchers use network analysis to gain unique insights into wide aspects of social phenomena, such as the social inclusiveness of the setting, the processes which underlie hierarchy and stratification, the formation of ‘in’ and ‘out’ groups and so on. Such analyses are central to structuration theory in sociology [7]. They also compliment activity-settings theory in community psychology. According to this theory, the nature of a setting and the patterns of interaction that occur regularly are thought to provide a better basis for predicting behaviour in a setting than one could infer from just assessing the attributes of people within it [8].

Network analysis has been used in infectious disease epidemiology [9] in studies of inter-organizational collaboration [10, 11] and in research into social capital [12, 13]. In health promotion research, Wickizer *et al.* [14] demonstrated how to use network analysis to assess the activation level of agencies involved in community projects in tobacco control and adolescent pregnancy prevention. A history of the method is provided by Wellman [15] and an introduction and glossary for social network analysis in health research are provided by Hawe *et al.* [16].

In this study, we set out to see how network analysis could allow us to capture the social structure of the high school staff and teachers at the start of a whole-school health promotion intervention. We wanted to identify key players or gatekeepers who might be crucial to getting the intervention off the ground. Identifying gatekeepers or natural helpers is not a new notion in health promotion interventions. We refer here to landmark contributions by Israel [17] and Eng *et al.* [18]. But mapping networks systematically at the start of an intervention, and analysing them mathematically, is rare.

Methods

Our study is in a town in the province of Alberta and the town’s only high school, with Grades 10–12. The total student population is 556. The school was established in 1966. We are engaged in a whole-school mental health promotion intervention modelled on the experience of the successful Gatehouse project in Australia [19, 20]. Staff and teachers were our focus for the first stage of the intervention.

We started by conducting in-depth, face-to-face interviews with all staff and teachers as a way of engaging with the school and learning how they described the ‘feel’ or social climate of the school. This is the topic of a separate paper. We then introduced social network analysis as a means to obtain a profile of relationships in the school.

We set out to map five relations across a ‘complete network’, that is, among all teachers and staff in

the school. Following an initial consultation and pilot, the chief relationships we set out to map were whether staff and teachers (i) knew a person by name, (ii) knew a person more personally (defined by knowing personal information such as the name of a member of a person's family), (iii) engaged in regularly occurring conversations with a person (defined as more than just saying 'hi'), (iv) sought advice from a person in relation to a school matter and (v) socialized with that person outside of school hours. In social network research, questions focused on usual transactions and routine relationships have been found to be more reliable than questions asking about specific events in specific time frames (e.g. 'in the last week have you spoken with ...') [21].

A self-completed questionnaire was administered to staff and teachers attending a regularly scheduled professional development activity. It took 15 min to complete. Participants were asked to identify their relationships as they stood 1 year ago (i.e. at the end of the previous school year, prior to engagement with the project team). Ten people had joined the school at the start of the school year, 9 months prior, and were included in the study. This was because our interest was in reflecting the real-world state of familiarity among staff and teachers. Six of the 10 newcomers to the school were teachers and four support staff. Ethics permission for the study was provided by the Conjoint Health Research Ethics Board at the University of Calgary.

Analysis was conducted using UCINET 6 [22]. We did not expect all relationships to be reciprocal or two-way. For example, Teacher 1 could know Teacher 2 by name but the reverse may not be the true. On the other hand, there were two relationships which we did expect to be reciprocal. These were 'regular conversations' and 'socialize with'. In this case, to be conservative, we followed the recommendation of Wasserman and Faust [6] and counted the relationship as being present only if both people said the tie was present. The technical term for this is symmetrizing the data by the minimum value.

Each relationship, such as advice-seeking or knowing-by-name, constitutes a separate network. So we had five networks to analyse in this study and

in reporting the results we use the custom of referring to each of them by the relationship they tap (e.g. the advice-seeking network).

For each network of relationships, we calculated the density of ties and the network centralization scores. Density is the amount of ties that are present as a proportion of the total possible ties. So if everyone knows each other, the density score is 100%. Network centralization calculates the extent to which a network is centralized or dominated by a few people [23]. Network centralization is based on individual centrality scores for each individual in the network. We calculated two types of centrality scores for all the members of the networks, and therefore two network centralization scores for each complete network.

The network degree centralization score is calculated based on the degree centrality for each individual in the network. Degree centrality simply counts the direct ties 'coming in' and 'coming out' from people in the network. Those with the most ties have the highest centrality scores. The network betweenness centralization score is calculated based on the betweenness centrality for each individual in the network. Betweenness centrality examines the number of times one person lies on the shortest path between two others [23]. In common language, betweenness centrality is thought of in terms of whom a person has to get through to get to someone else. It is thought of as a measure of gatekeeping. Betweenness centrality is therefore considered by network analysts to be a measure of strategic advantage and information control.

Both of the network centralization scores examine the disparity between individuals in terms of their individual centrality scores. A highly centralized network has a great degree of inequality between individual centrality scores, while an uncentralized network has no inequality between individual centrality scores. In this paper, we report Freeman centralization scores [23]. These are scores presented as a percentage of the maximum scores for networks of this size based on a star graph as the most unequal network.

We computed the two-step reach for all five relationships we investigated. More popularly known as

‘six degrees of separation’ (which is six-step reach) as a result of the famous play and film [24], two-step reach tells the analyst what proportion of the total number of people in the network can be reached by any particular person within one ‘link’ or step of the people who comprise his/her immediate ties. It is therefore a good measure of the extent to which any person could mobilize resources or convey information by reaching out to others. Box 1 gives a summary of the main terms used and analyses conducted. Note that some terms are about network characteristics. Others are measures about an individual person’s position in the network.

To draw inferences about patterns of relationships among particular types of people, we classified people according to whether they were (i) teachers; (ii) support staff, e.g. library assistants,

secretaries, janitors and (iii) administration, i.e. Principal or Vice Principal. We also conducted an additional analysis by gender.

Results

Of the 53 teachers and staff at the school, 50 were present on the day of the survey and provided complete data (response rate of 94%). The respondents comprised 28 women and 22 men. Eighteen of the respondents were support staff and 32 were teachers, including both the Principal and Vice Principal.

The density of ties for each of the five relationships and the centralization scores appear in Table I.

The density for knowing a person by name was 66%. This was the highest score, contrasted with socializing which was just 6%. The centralization

Box I. Key terms

Network density	The number of ties or links among people in the network expressed as a percentage of all possible ties. If every person is tied directly with every other person the density is 100%.
Network degree centralization	The most centralized network would be a star shape, where all the people at the perimeter are directly tied to one person at the centre, but not to each other. Network degree centralization compares the observed centralization in a network (how focused it is around particular people) with this perfect star-shaped scenario (i.e. with the maximum amount it possibly could be) for a network of the same size and expresses this as a percentage.
Degree centrality	Refers to a particular person and the number of direct ties or links they have to the other people in the network. In a star-shape network, as mentioned above, the person in the middle has the highest degree centrality. All the other people would have the same degree centrality.
Betweenness centrality	The extent to which a particular person lies on the shortest path between one person and another. Betweenness centrality is used as a measure of ‘gatekeeping’.
Geodesic	Technical term for the shortest path between one person and another.
Network betweenness centralization	Freeman’s network betweenness centralization score compares the observed disparity in betweenness centrality in a network (the inequality of betweenness centrality scores among individuals) with the most unequal network of the same size (which, like for degree centralization, is also a star graph) and expresses this as a percentage. In the star graph, the person in the middle holds the highest betweenness centrality because they lie on every geodesic while all the other individuals have betweenness centrality of 0 as they lie on no geodesics. Thus, the star graph is highly unequal or highly centralized.
Ego network size	A term used in relation to a particular person (called ‘the ego’), it refers to the number of people with direct ties to him/her.
Two-step reach	How many people in the network a person could get to within two links of him/herself, expressed as a percentage of the total number of people in the network.

scores indicate how centred the network is around a few dominant people. The advice-seeking network is the most highly centralized, on both degree centralization and betweenness centralization.

The advice-seeking network is illustrated in Fig. 1, which represents the network structure using multidimensional scaling techniques. The most

central people here are the Principal and Vice Principal, shown in grey. They appear to have the most lines coming in and going out from each of them and calculations of the size of their ego network illustrate this precisely. Teachers (clear) are more central in the network than the support staff (black). Person ID 340 is the school secretary. She is the support staff member (black) with the strongest role in this network. It can be seen that some ties between people are reciprocal, that is people seek advice from each other. Overall, however, the proportion of reciprocated ties in the advice-seeking network was 29%. This means that most relationships are ‘one-way’. Seven people in the advice-seeking network are isolates. That is, they do not seek advice within this network.

The Principal has 37 direct ties and the Vice Principal has 35 direct ties in the advice-seeking network. Using a Freeman’s degree centrality measure, which focuses on the direct ties coming in and out for each person, both the Principal and the Vice

Table I. Basic characteristics of the five networks (n = 50)

Relationship	Density score (%)	Degree centralization score (%)	Betweenness centralization score (%)
Socialize with outside of school	5.9	19.4	14.4
Seek advice	15.2	54.0	23.4
Engage in conversations regularly	25.5	39.3	4.8
Know personally	29.0	38.9	4.63
Recognize by name	65.9	27.4	1.47

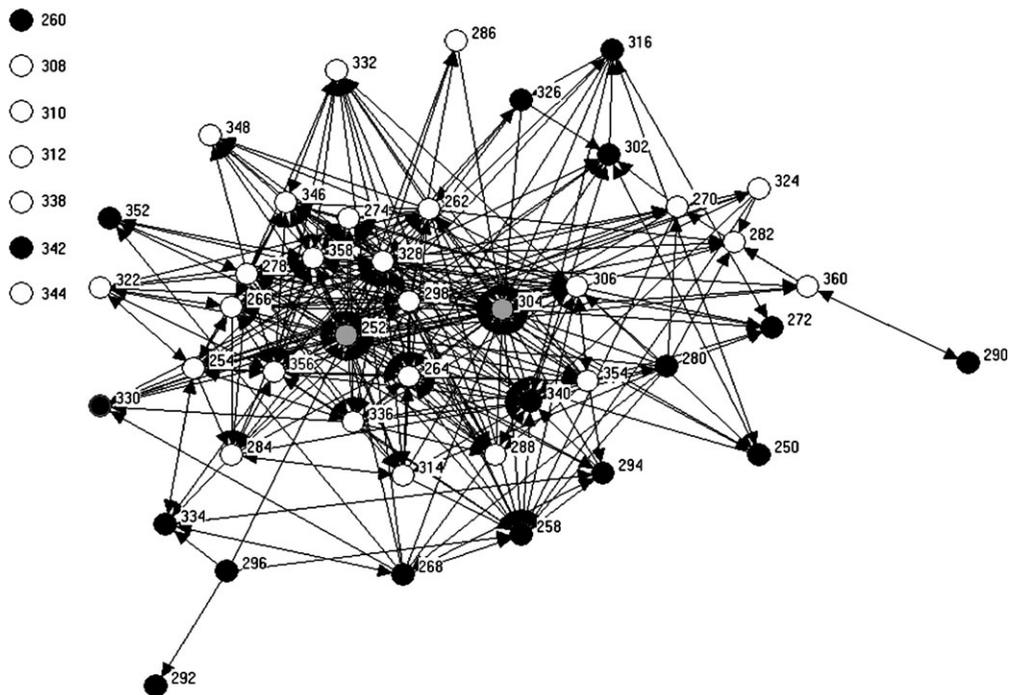


Fig. 1. Advice-seeking network. Grey = Principal and Vice Principal. Clear = teachers. Black = support staff.

Principal score similarly. The centrality scores of each person are 76 and 71%, respectively. By contrast, the other centrality measure, betweenness centrality, examines the strategic position of each person in the network in terms of the others they are linked to and stand ‘in between’ on the path connecting one person to another. The Principal has four times the score of Vice Principal for betweenness centrality because the Principal is connected to some people who otherwise seek advice from no one. This increases his power and potentially makes him more important or crucial.

The ego network size and two-step reach for the Vice Principal and Principal for all five relationships appears in Table II. The Principal socializes with two people at the school and the Vice Principal socializes with ten people. From the two-step reach for socializing, we can see that 27% of the network is within two links of the Principal but 47% of the network is within two links of the Vice Principal. For other relationships, advice-seeking, regular conversations knowing personally and recognizing by name, their two-step reach is much the same. Note that because each person is connected differently to people who in turn may be connected differently, it is possible to have the same two-step reach from

a different number of links within the ego network. Note also that even though the Principal and the Vice Principal had very different betweenness centrality in the advice-seeking network, their two-step reach in the advice-seeking network is much the same because two-step reach only counts up the number of people who can be reached within two steps. It does not factor in the fact that the positions of the people reached might be different.

Overall, we found that support staff are more marginal than teachers, in that they appeared more on the periphery of the network than at the centre for all relationships we mapped. An analysis by gender also shows that women, who occupy the bulk of the support staff positions, were more likely to be on the edges of the network.

Discussion

Our questions were simple and, as such, represent a relatively blunt instrument for assessing teacher’s social networks. The advantages of this were that all teachers and support staff present on the day we surveyed were willing to complete the survey, the survey was completed quickly and it was well tolerated. More sophisticated questions, getting at say, frequency or quality of interaction among people may have revealed more subtle social structures. Our concern, however, was to not construct questions that might appear too intrusive, prompting a non-response reaction that might compromise involvement in future projects with the researchers as well. Given these limits, it was encouraging therefore that our methods were still able to depict some distinct patterns in the social structures.

Our findings showed that network density was related to what might thought of as the intensity of the relationship. Hence, network density was higher for more superficial relationships, such as knowing a person by name, and smaller for socializing. The density for knowing-by-name was lower than we had expected at 65%. That is, more people than we expected are in that awkward position of encountering other staff and teachers, but not

Table II. *Ego network size and two-step reach for the Principal and Vice Principal for each relationship*

	Ego network size	Two-step reach (%)
Socialize with outside of school		
Principal	2	27
Vice principal	10	47
Seeking advice		
Principal	37	85
Vice principal	35	83
Regular conversations		
Principal	29	75
Vice principal	27	73
Know personally		
Principal	33	98
Vice principal	35	98
Recognize by name		
Principal	43	100
Vice principal	42	100

being addressed by their name. But were no isolates in the know-by-name network. That is, everyone was linked to someone, including all 10 newcomers.

Seeking advice was centred around the Principal and Vice Principal, with 85 and 83% of teachers and staff within the Principal and Vice Principal's two-step reach. Seven people were unconnected in the advice-seeking network, a phenomenon which could be addressed, if perceived as a problem.

In terms of application then, data such as these can be useful in two ways. The first is in shaping ideas for what would be acceptable or desirable in school network structures. The data might be useful for setting goals about creating more inclusive social networks and for tracking progress towards desired changes in those network structures. That is, specific goals might be set about increasing links between people or about increasing reciprocity (making more links two-way). One might say, for example, that low density in the socializing network is acceptable, but that low density, and in particular the presence of isolated people, in the advice-seeking network is not. Another common type of analysis is to search for cliques or closely connected subgroups [6]. Again, such diagnostics depend on the goals and purpose of the intervention and the reason for the researcher's presence in the school.

The second way in which the data can be useful is in identifying people of strategic influence, so that interventions can be tailored to them. Here, our analysis revealed insights we might otherwise not have had about this school. Investigators using peer or lay models of helping [25, 26] utilize network concepts (if not the methods) when they identify and recruit natural leaders or helpers in communities by asking people who they go to for information or support. They then recruit as intervention agents only those people nominated by many other people. Using the terminology presented in this paper, lay helper models identify nominees within the immediate ego network of the person. However, the additional advantage of the network mapping presented in this paper is that the investigator can better appreciate the structural position 'of those to whom nominees in turn are linked'. Analyses such

as these may lead to more strategic choices for health promotion intervention agents than the traditional methods used up until now.

For example, the Principal and the Vice Principal were about equally central in Freeman's degree centrality on the advice-seeking network. This is the type of centrality that simply looks at the number of direct connections a person has with others. On this basis, one would be pleased to recruit either the Principal or the Vice Principal as a champion for a new intervention in the school. But this measure of centrality ignores the consequences of exactly to whom the Principal and Vice Principal are connected. The alternative measure, betweenness centrality, examines this broader gatekeeping phenomenon by specifically focusing on the extent to which one person lies on the shortest path between others. In our study, the Principal had four times the score of Vice Principal for betweenness centrality because of his unique links. So, on this basis, recruitment of the Principal as opposed to the Vice Principal would be the best choice at the start of an intervention. Of course, most health promotion practitioners would choose to get the Principal onside for an intervention anyway. But our point is the more general observation that being well-known or being nominated by lots of others of itself is not always the best guide for whom to select as an intervention champion. Indeed, for many health promotion interventions, 'connection to the most marginal or isolated people' in a community, school or workplace could be the most important criteria for choosing natural helpers. Social network analysis offers an opportunity to identify these people and therefore could be a useful assessment method at the start of any intervention that places value on the social connections of participants. We acknowledge, of course, that considerations other than strategic position may also come into the decision of whom to recruit at the beginning of an intervention (e.g. consideration of people's workload).

Additional social network analyses with students and/or with parents would start to round out the picture of the school and how interactions among various groups create a social environment which in turn may be linked with student outcomes [27].

Data gathering of this type, along with testing the amenability of these social structures to change, has now become the focus of our enquiry. We are also repeating our surveys and analyses in other schools as a way of understanding how the different contexts in different schools may affect intervention outcomes differently. Given the high yield in terms of analytic insight and the ease of data collection, we encourage other researchers to investigate the utility of social network analysis in intervention settings.

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Conflict of interest statement

None declared.

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