How to do (or not to do) . . . a social network analysis in health systems research

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The main challenges in international health are to scale up effective health interventions in low- and middle-income countries in order to reach a higher proportion of the population. This can be achieved through better insight into how health systems are structured. Social network analysis can provide an appropriate and innovative paradigm for the health systems researcher, allow new analyses of the structure of health systems, and facilitate understanding of the role of stakeholders within a health system. The social network analysis methodology adapted to health systems research and described in detail by the authors comprises three main stages: (i) describing the set of actors and members of the network; (ii) characterizing the relationships between actors; and (iii) analysing the structure of the systems. Evidence generated through social network analysis could help policy makers to understand how health systems react over time and to better adjust health programmes and innovations to the capacities of health systems in low- and middle-income countries to achieve universal coverage.

Keywords Health systems research, health systems, research methods, social networks, social sciences

Introduction

Since the launch of the Millennium Development Goals (MDGs) in 2000 (United Nations 2000), health systems have become a priority focus for researchers, managers and decision makers, and efforts have been increasingly invested to improve the capacity of local health systems with the aim of achieving the MDGs by 2015 (Murray and Frenk 2000; Sachs et al. 2004; Reich et al. 2008). The message from the international experts who came together as part of the 2008 G8 Summit held in Japan was very clear: health system strengthening and disease-specific strategies were no longer seen as competing approaches but were complementary interventions (Fukuda 2008; G8 Health Expert Group 2008).
Social networks in health care

Social network analysis (SNA) is defined as a distinctive set of methods used for mapping, measuring and analysing the social relationships between people, groups and organizations (Scott 1999; Borgatti et al. 2009). Using mathematical algorithms (Marsden 1990) and software (e.g. UCINET) (Borgatti et al. 2002), researchers have analysed how patterns of relationships between actors within a system can facilitate or constrain the individual decisions and actions of actors, as well as system functions and adaptive capacities (Wasserman and Faust 1994). In a graphic representation of social networks (Figure 1), SNA illustrates an actor (e.g. an individual, a family, a community or an organization) by a node and the relationships between actors by ties (Marsden 1990; Degeneve and Forsé 1999; Borgatti and Cross 2003; Batley and Larbi 2004; Islam 2007). Relationships between actors can be as diverse as friendship, trust or knowledge transmission (Folke et al. 2002).

Beyond being a method, SNA is also viewed as a paradigm that has its own international society (the International Network for Social Network Analysis) and its own scientific journal (Social Networks). SNA provides an avenue for analysing and comparing formal and informal information flows in a system. SNA recognizes the complexity and dynamics of networks and their influence on behaviour and decisions (Borgatti et al. 2009). SNA has proved that it can be used to help understand the nature of relations between actors within a system and how these relationships influence the structure of a system (Webb and Bodin 2008; Borgatti et al. 2009). Although SNA and health care have long been interconnected, SNA has not been applied yet to health systems research in LMIC, which remains a nascent field of investigation.

Social network theories have a long history in health care. Social network theories were born in public health in 1934 when, after an epidemic in a New York school, Moreno tried to understand why the epidemic spread so quickly amongst the pupils (Moreno 1934). Moreno (1934) was also the first to represent graphically the relationships between pupils and their social position with each other. In order to model systems, social networks theoreticians applied mathematical and graphical techniques to illustrate and understand the complexity of human and organizational relationships.

The role of networks has become crucial in health care during the 21st century with the emergence of informational and technological innovations, and with the recognition from health managers that hospitals were no longer the unique place where health care was delivered (Greenhalgh 2008). Health care providers have acknowledged the role of other actors—medical and non-medical, private and public—and the positive impact of multi-scale and multi-disciplinary network-based initiatives involving medical staff working in hospitals, health staff posted in primary care health facilities or community-based workers (Atkinson 2002; Bloom and Standing 2008).

Applying SNA in health systems research encounters a number of challenges, such as capturing the dynamics of systems, the limits of a social network and the effects of multi-scale events that affect several spatial scales of the health system (e.g. the increase of the price of oil has an impact on the delivery of health care services at regional, district and community levels). Therefore, innovative approaches were...
introduced combining social network theories and other approaches that could potentially generate new knowledge when applied to health systems (Cumming et al. 2010). At the individual level, social scientists showed that social networks determined the level of co-operation between individuals: individuals tend to collaborate more easily with their direct neighbours. SNA researchers also showed that, although individuals are connected with a limited number of people, people in the world are all indirectly connected by a number of ties that on average does not exceed ‘six degrees’ (Watts and Strogatz 1998). This high degree of connectivity between individuals and organizations has implications for the level of interdependence and embeddedness between networks. Individuals connected through a social network tend to have similar beliefs and values (McGuire 2000; Kiesler and Cummins 2002; Uzzi and Gillespie 2002). Scholars found that there was a relationship between the structure of networks, the type of links between actors (i.e. the existence of a flow of information between two actors). (Source: Karl Blanchet)

Figure 1  Example of social network: the case of the eye care programme in the Brong Ahafo region, January 2010. Each square represents an actor and the arrow a relationship between two actors (i.e. the existence of a flow of information between two actors). (Source: Karl Blanchet)

Literature on social networks is now relatively vast. SNA has had concrete applications in many fields including health behaviour, health prevention, organizational management or group behaviour (Valente 2010). How SNA can serve the interests of health systems researchers by providing concrete measures and tools to define health systems is described in the following sections.

The main characteristics of social networks and health systems

Health systems research aims to understand health governance in a context characterized by a multitude of diverse actors (World Health Organization 2009). Governance is one of the six functions of health systems along with service delivery, financing, human resources, technology and health information systems (World Health Organization 2010b). Lebel et al. (2006) proposed a conceptual framework to describe the six main
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characteristics of the ‘good’ governance of social-ecological systems. Of these six characteristics, three can be applied to the governance of health systems: (i) capacity to engage effectively with and handle multiple- and cross-scale dynamics; (ii) capacity to anticipate and cope with uncertainties and surprises; and finally (iii) capacity to combine and integrate different forms of knowledge. To illustrate the utilization of network tools to health systems, the authors will show how these three system properties can be analysed by using five different network properties: two properties related to the structure of the network and three properties related to the position of actors.

First, in terms of general structure of a network, two properties are particularly used in SNA: cohesion and shape (Borgatti et al., 2009). Cohesion describes the number of connections within a network and includes sub-properties such as density and fragmentation. More dense networks have a higher number of connections between actors. Shape relates to the overall distribution of ties and distinguishes the core actors from the peripheral ones (Borgatti et al., 1990). The core actors are highly connected with each other while the peripheral actors have loose links.

A second application of SNA in health systems research is in the analysis of the role and position of specific actors. Health systems research focuses on the role of actors within a health system (World Health Organization, 2009) and in the diffusion of knowledge and innovations, such as in the management of epidemics (Rogers, 1995; Latkin et al., 2003; Helleringer and Kohler, 2005). However, work in health systems research is still at an early stage and the available tools such as stakeholder analysis (Glassman et al., 1999; Brugha and Varvasovszky, 2000) provide limited analysis of the role of actors in a health system. SNA could be an appropriate analysis tool to generate an actor-level analysis of health systems (Borgatti and Foster, 2003). SNA can also be a valuable tool to uncover the most influential players in a system (Valente and Pumpuang, 2007; Riglan and Supovitz, 2008).

One finding from SNA is that the position of an actor in a network determines their capacity to access and diffuse knowledge and information or, in other words, control the flow of information (Borgatti et al., 2009). SNA provides tools to identify a knowledge broker, i.e. individuals who create links between users and researchers (Thompson et al., 2006).

The brokers in a health system will help co-ordinate actors in times of crises or shocks and build bridges between different groups of the system (Burt, 2003; Newman and Dale, 2005). Other actors essential to the diffusion of innovations, such as opinion leaders, champions or change agents, can be identified through the number of links they have with their peers or non-peer actors at different levels of the health system (Berner et al., 2003). For example, opinion leaders, i.e. people who can influence other people’s views (Rogers and Cartano, 1962), have the highest numbers of ties within a network. Identifying opinion leaders and building a programme through these key people can help to diffuse innovations in a network, e.g. utilization of medical guidelines (Lomas et al., 1991) or HIV risk-reduction practices (Sikkema et al., 2000). Centrality, reachability and betweenness are the most well-known node-related properties (Freeman, 1977). The definitions of these quantitative measures are presented in Table 1.

### How to design a social network analysis

The methodology described below is one approach to SNA, but other study designs could be used and explored by interested researchers. In the following sections, particular attention is paid to adapting SNA design to health and more specifically to health systems research in LMIC. The methodology presented in this paper was elaborated and tested by the authors in a study conducted between 2008 and 2010 in the Brong Ahafo region of Ghana. That study aimed to analyse the influence of district hospital directors’ social networks on their capacity to make management decisions.

The SNA methodology developed by the authors consists of three main stages: (i) describing the set of actors and members of the network; (ii) characterizing the relationships between actors; and (iii) analysing the structure of the systems (see Box 1).

### Describing the list of actors and members of the network

The first stage of SNA consists of describing the actors and members of the network. Actors are defined as persons, informal groups of people or formal organizations who may

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**Table 1 Definition of key network measures**

| Characteristic | Measure |
|----------------|---------|
| Betweenness    | Betweenness is a measure that indicates how much a node is located in the path between other actors or how much a node connects other nodes with each other (Freeman, 1977). |
| Centrality     | The degree of centrality represents the number of ties a node has (Freeman, 1979). If a node has many ties compared with actors, this indicates that this node has a central position in the network. Centrality can also characterize the shape of a whole network. |
| Density        | Density is defined as the number of existing ties divided by the number of possible ties. |
| Distance       | Distance measures the number of ties that separate two actors. If two nodes are directly connected, the distance is one. If these two nodes are separated by one node, the distance is two. |
| Reachability   | Reachability defines the degree by which a node can be reached by other nodes. If a certain number are unreachable by some actors, it means that the network is fragmented. Reachability corresponds to the number of steps maximally needed to reach from one node to any other node in the network. |
influence a project’s outcomes and the system’s resilience both through their interactions, and through individual or collective actions (Freeman 1979; Grimble and Wellard 1997; Brugha and Varvasovszky 2000).

The pluralistic nature of health systems means that the diversity of actors involved in a health system is broad and that the boundaries of the system can remain blurred (Bloom et al. 2007). The actors involved in a system can be identified by combining two different but complementary methods proposed by Grimble and Chan (1995): (i) the list of stakeholders involved in a system can be pre-defined by the researcher based on a detailed review of project proposals and documents; (ii) this list of actors is complemented by information collected through interviews with key respondents.

To increase the validity of findings and reduce the incidence of recall bias (e.g. making sure that any actor part of the system will not be omitted), a third step was added by the authors: every interviewee is asked to identify additional actors on the basis of their answers to the following questions adapted from Salam and Noguchi (2006): (a) who gained or lost during the health intervention? (b) Who is expected to gain or lose as a result of the health intervention’s success? A final set of actors that are involved in the project is established. These actors become the key informants of the study.

Characterizing the relationships between actors
Relationships between actors can be of different kinds. They depend on various social factors such as trust, conflicts or knowledge sharing (Wasserman and Faust 1994; Folke et al. 2005; Manring 2007). However, all these factors rely on a key process: the circulation of information between and within social networks (Bodin et al. 2006; Manring 2007). Studying information flow mechanisms between actors and within networks can help to understand the social processes influencing health system dynamics and reactions.

The second stage of SNA consists of identifying the existence of flows of information between actors or, in other words, the demand (receiving information) and supply (providing information) of information between individuals. This information can be collected through interviews. The people interviewed are the actors identified during the first stage of the process. A robust method for generating self-reported ties is to use recall lists (Marsden 1990): a list of all organizations in the field with adjoining empty columns in which respondents can mark their different relations to others (Diani 2003). An alternative is to use a paper card for every actor. The pieces of paper are displayed in front of each interviewee.

The interviewee is asked about the demands for information: Do you receive information from this actor? If the interviewee answers ‘Yes’, then the investigator can ask additional questions to collect more qualitative information about the type of information received. For example, what kind of information do you receive? What is the frequency of your contacts? How do you receive it: by phone, through visits, letters...?

The same questions are systematically asked about every actor identified. Once this is completed, the investigator starts again at the beginning of the pile of cards (or the table) and asks about the supply of information: do you provide information to this actor? If the answer from the interviewee is ‘Yes’, the investigator can ask more questions about the type of information provided and the way the information is circulated.

Data collected are recorded in the information flow matrix elaborated by Brinkerhoff (2004) (see example in Table 2): one matrix for demand of information and a second one for supply of information. Each respondent thus generates a row of 1’s and 0’s for each of the two network relations (demand and supply of information): ‘1’ symbolizing the existence of demand/supply of information, and ‘0’ signifying no information flow between the two actors.

The third stage in the proposed method consists in analysing the ties between actors and the structure of the network.

Analysing the structure of systems: the use of software packages
The properties of the networks are analysed using the algorithms available through specialized software packages.
such as UCINET 6, designed by academics for research purposes (Borgatti et al. 1999).

Through this method, two matrices are generated: one matrix for demand of information and one matrix for supply of information. The two matrices are then combined to generate a single matrix (Marsden 1990). The final matrix is the result of the addition of the two links. In summary, the new link is \( A + B \), where \( A \) and \( B \) represent the value of the links in the demand and supply matrix, respectively. The new network is transformed into a symmetrical and dichotomized network (i.e., without direction of links and no strength, just zeros and ones). The new matrix of the system is inserted into the software UCINET (Borgatti et al. 2002) that helps analyse the properties of the network.

Calculations are run by the software. The network measure calculated is then analysed to understand how health systems are governed. For example, in order to be able to find multi-scale solutions to multi-scale problems, the actors of a network need to be able to get access to information from various types of actors and not only from their close colleagues and neighbours. This means getting access to stakeholders who have access to different sources of information and different types of power (Oh et al. 2004). Access to various sources of information requires a high level of reachability and short distances between actors. Table 3 describes the links between network measures and the systems’ properties.

As a final result, health systems are then represented by graphs showing the nature of actors involved and the relationships between these actors. The analysis provides valuable information to decision makers and managers on what key influential actors were excluded from the systems and what new relationships should be encouraged to facilitate collaboration between key players. The analysis of the structure of health systems provides information on the properties of the system (e.g., density, centrality). Describing the strength and weaknesses of the structure of health systems can help decision makers predict how an innovation can be diffused within the system and what is the best strategy to adopt to circulate information.

### Conclusion

Health systems are seen as a combination of various systems embedded within each other, such as public and private systems, local, regional and global systems or social and organizational systems (Snijders and Doreian 2010). An event at the level of one sub-system can have an impact on another sub-system and influence the behaviour of network actors. The complexity and embeddedness of health systems create very similar challenges for analysis to the ones generated by social networks (Laumann et al. 1983). Today, the main priorities in international health are to scale up effective health interventions in LMIC in order to reach a higher proportion of the population. The present paper described the origin of SNA, the added value it can represent in health systems research, health
service management and health policy, and how it can be used to analyse the relationships between actors and the social position of actors and their degree of influence. Evidence generated through SNA could help policy makers understand how health systems react over time and how ties between actors can influence the diffusion of innovations. However, additional issues need to be addressed by researchers when studying health systems in LMIC: (i) the dynamics of systems and networks (actors and relationships between actors are in constant evolution); (ii) the factors that determine the structure of health systems and are correlated to contextual factors; (iii) the relationships between the structure of a health system and the structure of other systems, in which the former is embedded. Progress can be made in health systems research with the help of SNA and in-depth insight can be brought to make better sense of how health systems react to shocks.

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**Conflict of interest**

None declared.

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