

**Supplementary Material:** *Health professional networks as a vector for improving health care quality and safety. A systematic review.*  
Cunningham *et al.*

**Table S1.** Social Network Analysis – Definitions, Theories and Propositions

Item	Researcher	Definition, Theories and Propositions
Actors	Newman, Watts & Strogatz [1] Uzzi [2-3] Burt [4]	People who make up a social network.  Actors favour others whom they trust.  Actors favour others with whom they exchange information, or upon whom they depend.
Broker relationships	Provan, Fish & Sydow [5] Burt [4]	'To what extent does an organisation span gaps, or structural holes, in a network, and what are the implications of this for the organisation?'  'Organisations that span 'structural holes' are considered to be brokers, often occupying positions of considerable influence.'
Centrality	Bavelas [6]  Newman, Watts & Strogatz [1] Webster <i>et al.</i> [7: p. 171]	Within the network, the recognised leader will probably have the position of highest centrality. Based on the study of communication and information flow in a network, Bavelas noted that 'in patterns with a high, localised centrality, organisation evolves more quickly, is more stable, and errors in performance are less. At the same time, however, morale drops. It is inconceivable that morale should not, in the long run, affect stability and accuracy negatively.'  The influence of the various 'actors'.  'The most theoretically developed set of network measures for the study of leadership are measures of centrality' (Webster cites: Bavelas [6]; Beauchamp [8]; Bonacich [9]; Freeman [10]; Knoke and Burt [11]; Leavitt [12]; Sabidussi [13]. 'Both individuals and groups can be considered in terms of centrality.'
'Betweenness' centrality	Mendel <i>et al.</i> [14]  Hawe, Webster & Shiell [15]	The extent to which an organisation serves as a link or bridge across different parts of the network that would otherwise not be connected.  'The number of times an actor connects pairs of other actors, who otherwise would not be able to reach one another. It is a measure of the potential for control as an actor who is high in 'betweenness' is able to act as a gatekeeper controlling the flow of resources between the alters that he or she connects.'

Table S1: Continued		
Item	Researcher	Definition, Theories and Propositions
Degree centrality	Freeman [10] Mendel et al. [14] Provan, Fish & Sydow [5]	Degree centrality of a point, which is the sum of all other points directly connected to it, signifies activity level. The sheer number of ties that an organisation has with other organisations in the network. "In-degree" and "out-degree" centrality: Calculation of in-degree and out-degree centrality is also possible and is based on the extent to which assets such as resources, information, and clients are coming <i>into</i> an organisation from others in the network versus those being sent <i>out</i> to other organisations.'
Closeness centrality	Hawe, Webster & Shiell [15]	'Based on the notion of distance. If an actor is close to all others in the network, a distance of no more than one, then she or he is not dependent on any other to reach everyone in the network. Closeness measures independence or efficiency. With disconnected networks, closeness centrality must be calculated for each component.'
Cliques	Provan, Fish & Sydow [5]	'Cliques are clusters of three or more organisations connected to one another. At the ego-centric level, the extent of an organisation's connectedness to a clique may affect organisational outcomes in ways that are different than when the organisation is connected only through a dyad.'
Clustering	Newman, Watts & Strogatz [1] Scott [16]	'Occurs when two "actors" have another mutual acquaintance, or several.'  'The intuitive idea of a cluster corresponds to the idea of an area of relatively high density in a graph.'
Cohesion	Hawe, Webster & Shiell [15]	The interconnectedness of actors in a network. Measures of cohesion include: 'Distance': The distance 'between two actors in a network (or nodes in a graph) is calculated by summing the number of distinct ties (lines) that exist along the shortest route between them.' 'Reachability': 'Measures whether actors within a network are related, either directly or indirectly, to all other actors. Actors who are not connected to any other actors are called <i>isolates</i> . 'Density': (see definition below).
Connection diversity	Strogatz [17]	'The links between nodes can have different weights, directions and signs.'

Table S1: Continued		
Item	Researcher	Definition, Theories and Propositions
Datasets (network):		
Attribute datasets	Hawe, Webster & Shiell [15]	Data on the characteristics of the network members.
Relational datasets	Hawe, Webster & Shiell [15]	Social network analysis is the study of structure and involves 'relational' datasets. The structure is derived from the regularities in the patterning of relationships among social entities, which might be people, groups, or organisations.
Degrees	Newman, Watts & Strogatz [1]	The number of 'ties' that 'actors' have to other 'actors'.
Density	Berkman et al. [18] West and Barron [19]	The extent to which the network members are connected to each other (whether a network is dense or loose). 'Where ties are dense, information and influence can spread rapidly among all those who are in frequent contact. Where ties do not exist, on the other hand, dissemination through informal interaction is impossible.'
Duality	Wasserman and Faust [20: p.295]	'The duality in affiliation networks refers specifically to the alternative, and equally important, perspectives by which actors are linked to one another by their affiliation with events, and at the same time events are linked by the actors who are their members.'
Fragmentation	Provan et al. [21]	Are all or most network members connected, either directly or indirectly (that is, through another actor or organisation), or is the network broken up into fragments of unconnected actors or organisations?
Governance	Provan, Fish & Sydow [5]	'What mechanism is used to govern and/or manage the overall network? Even if networks are considered as a distinct form of governance, the mechanism used can considerably vary and range from self-governance, to hub-form or lead-organisation governed, to a network administrative organisation (NAO) model.'
Homophily	McPherson, Smith-Lovin & Cook [22]	This principle - the homophily principle - structures network ties of every type, including marriage, friendship, work, advice, support, information transfer, exchange, co-membership, and other types of relationship. (These authors note that the classic citation in the sociological literature seems to be Lazarsfeld and Merton's [23] study of friendship process in Hilltown and Crafttown.)

Table S1: Continued		
Item	Researcher	Definition, Theories and Propositions
Lines	Hawe, Webster & Shiell [15]	The relational ties connecting actors.
Multiplexity	Hawe, Webster & Shiell [15] Provan et al. [21]	'Actors can have multiple ties with other actors.'  '[T]he strength of the relationship between individual network partners, based on the number of types of different links (joint programs, referrals, etc.) they maintain.'
Network centralisation	Mendel et al [14]	A measure of the extent to which a network is dominated by one or a few very central hubs (i.e., nodes with high degree and betweenness centrality)
Network structure	Brass [24]; Hawe, Webster & Shiell [15]	The relationships between network structure and position and access to the resources within those networks.
Network subgroup measures	Hawe, Webster & Shiell [15]	A network can be partitioned, as follows: <i>Component</i> : A portion of the network in which all actors are connected, directly or indirectly, by at least one tie. <i>Clique</i> : A subgroup of actors who are all directly connected to one another and no additional network member exists who is also connected to all members of the subgroup.
Prestige	Wasserman and Faust [20: p.174]	'The prestige of an actor increases as the actor becomes the object of more ties but not necessarily when the actor itself initiates the ties. In other words, one must look at ties directed to an actor to study that actor's prestige.'
Relation	Knoke and Yang [25: p. 7]	'A relation is generally defined as a specific kind of contact, connection, or tie between a pair of actors, or dyad. Relations may be either directed, where one actor initiates and the second actor receives (e.g., advising), or nondirected, where mutuality occurs (e.g., conversing).'
Small-world network	Newman, Watts & Strogatz [1] Watts and Strogatz [26]	A network that exhibits a combination of short paths and social structure, the latter being defined in terms of network clustering.  'These systems can be highly clustered, like regular lattices, yet have small characteristic path lengths, like random graphs.'

Table S1: Continued		
Item	Researcher	Definition, Theories and Propositions
Social capital	Coleman [27]  Lin [28-29]  Brass [24]	Coleman identified three forms of social capital: obligations and expectations, information channels and social norms, and described the social structural conditions under which it arises.  'A resource (e.g., access to valuable information, word –of-mouth referrals, and power) available in one's network of relationships.'  'Social capital is often operationalised as "network centrality", or the number of connections between an individual and others in a network, which grants the central actor access to those individuals and their resources.'
Social connectivity	Pappas, Flaherty & Wooldridge [30: p. 16]	'Social networks within organisations have been used ... to determine social connectivity based on friendship, trust, communication, and even intergroup conflict.' (See also: Krackhardt and Hanson [31]; LaBianca and Brass [32])
Social influence	Marsden and Friedkin [33]	Social influence 'links the structure of social relations to attitudes and behaviours of the actors who compose a network.' 'The proximity of two actors in a social network is associated with the occurrence of interpersonal influence between the actors.'
Structural complexity	Strogatz [17]	The [network] wiring diagram can be an intricate tangle.
Structural embeddedness	Granovetter [34: p. 35, 35-36]  Burt [4]  Jones, Hesterly & Borgatti [37]  Granovetter [35]  Uzzi [3]	The extent to which a 'dyad's mutual contacts are connected to one another'. Structural embeddedness is a function of how many participants interact with one another, how likely future interactions are among participants, and how likely participants are to talk about these interactions.  The more structural embeddedness there is in a network, the more information each actor knows about all the other actors and the more constraints there are on each actor's behaviour.  'Since structural embeddedness diffuses information throughout a system, it also facilitates the development of macroculture – the common values, norms, and beliefs shared across firms – because parties share perceptions and understandings.'  Overreliance on strong ties tends to develop tight, relatively isolated cliques that are not well integrated with the rest of the industry.  Over-embeddedness (many strong ties and few weak ties) can lead to feuding, choking off novel information from other parts of the industry, and welfare-like support of weak network members.

Table S1: Continued		
Item	Researcher	Definition, Theories and Propositions
Structural holes	Burt [4]	'Structural holes' are non-redundant relationships where the hole acts as an insulator. It is more beneficial to be the exclusive link between individuals and groups (thus filling a structural hole) who are not themselves tied to each other.
Ties	Wellman[38: p. 86]  Newman, Watts & Strogatz [1]  Granovetter [35]	The essence of community is its social structure, not its spatial structure. By assessing actual ties between network members, one can empirically test whether community exists and whether that community is defined on the basis of neighbourhood, kinship, friendship, institutional affiliation or other characteristics.  'The pattern of interactions between the actors.' The importance of the number of ties that actors have to other actors, their so-called 'degrees'. For example, in many networks, the distribution of actors' degrees is highly skewed, with a small number having an unusually large number of ties. This skewness could have an impact on the way in which communities operate, including the way information travels through the network and the sustainability of networks.  Ties connecting actors can be strong or weak.
Transitivity	Mendel et al. [14]	Transitivity measures how well information flows within a network, based on the proportion of times a connection from one node to two others is accompanied (or 'closed') by a connection between the other two nodes (akin to a 'friend of a friend' scenario). It is a measure of the extent to which a network is dominated by one or a few very central hubs.
Trust	Provan et al. [21: p. 605]	Trust refers to 'the quality of the relationship among partners (that is, based solely on formal agreements, rules, and procedures, or on trust and informal norms of reciprocity)'.

## References – Table S1

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**Table S2:** Search terms

SEARCH TERMS FOR SOCIAL NETWORKS (HEALTH PROFESSIONALS)	
1.	'Social network*' AND
2.	'Health care' OR 'Healthcare'
3.	OR 'Healthcare sector' OR 'Health care sector'
4.	OR 'Health personnel'
5.	OR 'Medical staff'
6.	OR 'Workforce'
7.	OR 'Professional practice'
8.	OR 'Delivery of healthcare' OR 'Delivery of health care'
9.	OR 'Interprofessional relations'
10.	OR 'Interpersonal relations'
11.	OR 'Interdisciplinary communication'
12.	OR 'Organi*ational culture'
13.	OR 'Models, organi*ational'

**Table S3:** Study quality assessment criteria

Study Design	Criteria
All study designs	Presentation of an appropriate research question, clear details of study design and methodology, including dates and sources for data collection, survey techniques, description of analysis, data presentation, discussion of results and study conclusions.
Case studies	Description of case settings and characteristics, adequate sample size and selection, adequate response rates (>60%).
Ethnographic studies	Description of study setting, and methods: observation, interviews, document review. Adequate number of participants observed and adequate observation period.
Cross-sectional study	Description of study setting, and methods used to collect data, adequate size and selection of sample so that participants are likely to be representative of target population, adequate response rates (>60%).
Overall ratings	Criteria
+++	All of the above criteria were fulfilled.
++	Almost all of the above criteria were fulfilled, and those criteria that were not fulfilled were thought unlikely to alter the conclusions of the study.
+	Some of the above criteria were fulfilled, and those criteria that were not fulfilled were thought unlikely to alter the conclusions of the study.
-	Few or no criteria were fulfilled, and it was not clear if the conclusions of the study would alter with their inclusion.

**Box S1: Study inclusion criteria**

- Publication between 1995 to 2009, inclusive, as most articles using network analysis in the health sector have been published since 1995.
- English
- Empirical research
- Editorials, review articles, and discussion pieces were omitted so that only peer reviewed articles were included. The 'grey literature' was not included as it did not meet criteria of being peer reviewed, and being published in scholarly journals.
- Research had to focus on dealing with some depth on one or more aspects of networks of practicing health professionals, or health service agencies with bearing on health practice, particularly in relation to quality of care and sustainability, i.e., mere mention of the term of 'network' was not sufficient.

**Box S2: Review approach**

Two reviewers from the team appraised all included reports. By drawing on published checklists;[39-42] quality was assessed according to the following: whether there was a clear and systematic description of the aim of the study; participants; sampling strategy; data collection and analysis methods; results of the study; relationship between the researchers and the participants; context and setting of the study; strengths and weaknesses; and implications of the study. Studies were excluded only after discussion between at least two reviewers.