PERGAMON

Social Science & Medicine 48 (1999) 633–646

SOCIAL SCIENCE & MEDICINE

Hierarchies and cliques in the social networks of health care professionals: implications for the design of dissemination strategies

Elizabeth West [a,*], David N. Barron [b], Juliet Dowsett [c], John N. Newton [c]

[a] *Royal College of Nursing Institute, Radcliffe Infirmary, Woodstock Rd., Oxford OX1 6HE, UK*
[b] *Said Business School, University of Oxford, Oxford, UK*
[c] *Institute of Health Sciences, University of Oxford, Oxford, UK*

Abstract

Interest in how best to influence the behaviour of clinicians in the interests of both clinical and cost effectiveness has rekindled concern with the social networks of health care professionals. Ever since the seminal work of Coleman et al. [Coleman, J.S., Katz, E., Menzel, H., 1966. Medical Innovation: A Diffusion Study. Bobbs-Merrill, Indianapolis.], networks have been seen as important in the process by which clinicians adopt (or fail to adopt) new innovations in clinical practice. Yet very little is actually known about the social networks of clinicians in modern health care settings. This paper describes the professional social networks of two groups of health care professionals, clinical directors of medicine and directors of nursing, in hospitals in England. We focus on network density, centrality and centralisation because these characteristics have been linked to access to information, social influence and social control processes. The results show that directors of nursing are more central to their networks than clinical directors of medicine and that their networks are more hierarchical. Clinical directors of medicine tend to be embedded in much more densely connected networks which we describe as cliques. The hypotheses that the networks of directors of nursing are better adapted to gathering and disseminating information than clinical directors of medicine, but that the latter could be more potent instruments for changing, or resisting changes, in clinical behaviour, follow from a number of sociological theories. We conclude that professional socialisation and structural location are important determinants of social networks and that these factors could usefully be considered in the design of strategies to inform and influence clinicians.

1. Introduction

Interest in the social networks of clinicians has been given impetus by increasing pressures on health care systems world-wide to contain costs and achieve value for money. Research shows that clinicians' knowledge deteriorates gradually after graduation (Ramsey et al., 1991) and that important research findings are often not translated into practice. Conversely, practices shown to be ineffective, or even harmful, are perpetuated to the detriment of individual patients and the health care system as a whole. It seems clear that if care is to become more clinically and cost effective, better strategies for disseminating information and for using social influence processes to change clinicians' behaviour need to be devised.

Social networks have been shown to be important channels for the diffusion of information and social influence. These informal channels are undoubtedly one way that clinicians hear about innovations and experience pressures to conform to standard practice. However, there are few studies of the social networks of health care professionals in the UK. This makes it difficult to apply what we know (or think we know)

* Corresponding author. E-mail: elizabeth.west@rcn.org.uk.

0277-9536/99/$ - see front matter
PII: S0277-9536(98)00361-X

about social networks and the diffusion of information to influence clinical behaviour constructively.

To begin to address some of these deficiencies we have collected data on the network characteristics of members of two occupational groups, one each from the medical and nursing professions currently employed by the UK National Health Service (NHS). We ask whether individuals in these two groups differ on network dimensions such as density, centrality and centralization, concepts relevant to the dissemination of information and social influence. This study tests the hypothesis that the professional affiliation and occupational status of individuals determine, to a certain extent, the characteristics of their social networks. The theoretical framework explores the links that have been drawn between network characteristics and access to information and influence.

2. Theoretical framework

Patterns of diffusion of ideas, customs and technologies have long been of interest to social scientists. Within this tradition, social networks representing ties between individuals have come to be a potent image. Network analysts examine the pattern of ties, those that exist and those that are absent, to draw inferences about the social structure within which individuals are embedded. A central premise of network analysis (Knoke and Kuklinski, 1992) is that

> The structure of relations among actors and the location of individual actors in the network have important behavioural, perceptual and attitudinal consequences both for the individual units and for the system as a whole.

One of the founding studies in the literature linking social networks with the diffusion of innovations through medical communities was conducted by Coleman et al. (1966). They studied the process by which three groups of physicians (general practitioners, internists and paediatricians) adopted the use of tetracycline in three mid-western cities in the United States. They interviewed all the doctors in these three groups (125 in all) to obtain two types of data. First, they collected conventional information about the personal characteristics of doctors, including age, number of medical journals subscribed to, attachment to medical institutions outside the community and so on. Second, they obtained data about the doctors' social networks by asking about the people they turned to for advice, with whom they discussed their cases and with whom they socialised. Coleman et al. (1966) found that while individual characteristics were important in predicting the length of time taken to prescribe the new drug, network position was even more important. Doctors who were frequently mentioned as someone to whom others turned for advice and information prescribed the new drug before those who were infrequently mentioned. From this, Coleman et al. (1966) deduced that socially integrated and socially isolated doctors differed markedly in their rate of adoption of tetracycline.

One way that the Coleman et al. (1966) study might be interpreted is to suggest that the more ties an individual has, the more likely they are to hear about an innovation and to change their practice accordingly. Burt (1991) would disagree with this interpretation. His theory of 'structural holes' argues that 'bigger is not always better' in network terms. Although relationships with friends, colleagues, kin and contacts can provide useful information and opportunities, relationships are costly to maintain. As de Sola-Pool and Kochen (1978) pointed out, "the day has 24 hours and the memory has limits". We can only maintain relationships with a finite number of people, however much we like them and however valuable they might be to us at a future date.

Burt (1991) argues for these reasons that network structure is more important for ensuring that the individual obtains information than is network size alone. What is important is that each relationship delivers to the individual (ego), new information. In other words, the ties on which ego expends its scarce resources of time and energy should be 'non-redundant'. In dense networks, where each individual is connected to every other, information diffuses rapidly and they all soon share the same knowledge of the world. In sparse networks, where individuals are often connected to each other only indirectly, each relationship puts ego in contact with different social groups. Consequently, Burt (1991) argues that dense networks are less efficient than sparse networks of the same size because they return less diverse information for the same costs. Efficient networks have more 'structural holes' that is, they have more ties that span non-redundant contacts.

These theoretical arguments are related to Granovetter's (1973) statement concerning "the strength of weak ties". He found, in a study of how people find jobs, that most of his respondents got work through information passed to them by people they saw infrequently, rather than through close friends and family. One might assume that because relatives are motivated to help each other and know each other's aptitudes and preferences they would be the most likely source of information about vacancies. However, Granovetter (1973) showed that close or strong ties were involved in the process of finding a job less frequently than were weak ties. Burt's (1991) theory of structural holes builds on this insight. He argues that weak ties are good conduits for infor-

mation not primarily because they are weak, but because they span structural holes.

In addition to the information advantages, Burt (1991) maintains that structural holes have the advantage of allowing ego to mediate and control the flow of information to others. If ego is the only way that information can get from one alter to another, then ego has the chance to broker relationships between them. Several sociologists have examined the connection between brokerage opportunities and power (Cook and Yamagishi, 1992). This connection is of interest in this context because access to information, though a necessary prerequisite, may not be sufficient to change clinical behaviour.

Social influence may be required to stimulate changes in attitudes and behaviour, in addition to exposure to new ideas or information. An individual or group may be influential because they have power over others or because they set a standard against which others judge their own behaviour. The sources of power are diverse. Control over information is one source, but social power may also lie in the capacity to coerce, the ability to reward, incumbency in a position of legitimacy or authority, expertise, or may be based on identification, charisma and esteem (Raven and Raven, 1959). Power is one way that an individual can influence the behaviour of others but there may be other, more subtle mechanisms as well. Social comparison, which is the process by which an individual compares his or her own behaviour with that of a reference group, may be particularly important when situations are ambiguous. When people are unsure about how they should behave, their reference group is an important source of guidance (Erikson, 1988). Although we still have little information about how individuals choose their reference groups Festinger (1954) has hypothesised that individuals are most influenced by others that are similar to themselves.

Network analysts have long been interested in the subject of social influence. Marsden and Friedkin (1994) state that, "the general hypothesis is that the proximity of two actors in social networks is associated with the occurrence of interpersonal influence between the actors", where 'influence' refers not just to deliberate attempts to modify behaviour, by using power or persuasion, but wholly unconscious processes such as imitation, contagion, or comparison. Some network characteristics may, in a parallel way to the argument above about information, be more conducive to the operation of social influence and interpersonal power. For example, once a few members of a densely connected network (where each member is connected to every other) become convinced of the efficacy of a certain procedure, or convinced of the need to change current practice, such a group would be much better at ensuring that all members follow suit. This is a function of the multiple ties which provides them with the opportunities to persuade, cajole and monitor the others. Also, because cohesive groups or cliques are important to their members' own identity and sense of belonging, they are very powerful in terms of social influence and pressures to conform.

This argument depends on understanding why people join groups, why they are willing to contribute to them, despite the often considerable personal expense and why some groups are more solidary than others. Hechter (1987) uses rational choice theory to explain that individuals are motivated to join groups to produce and consume "excludable jointly produced goods". Groups can produce commodities that an individual cannot produce alone and they can often prevent all but members from enjoying them. Social relations, developed as a result of the interaction within the group are an important example. Hechter (1987) describes members' relationships as an "irredeemable investment (or sunk cost) in the group". Hechter's (1987) model, which has two main variables, how dependent on the group each of the members are and how much control the group is able to exert over its members, is designed to explain why some groups are more solidary than other. Groups vary in the extent to which they have a monopoly over the goods that individuals want. Members dependence may be decreased if alternative sources are available and the individual's "cost of exit" (Hirschman, 1970) is low, that is, if they can leave with impunity. One of the factors which explains group solidarity is, then, the extent to which members are dependent on the group for access to certain goods or resources. The other causal variable is the control capacity of the group: the extent to which the group is able to monitor and sanction (or reward) the behaviour of members.

Drawing on the social psychological literature on social influence and on Hechter's (1987) theory of group solidarity we argue that dense networks, where each individual is tied to every other, where each member knows every other, interacts with them frequently and expects to do so in the foreseeable future, are more likely to be able to influence the behaviour of members. The multiplicity of ties gives members the opportunity to persuade, cajole and monitor the performance of others. In addition, dense networks can appear to outsiders as separate sub-cultures with their own norms, values, expectations and orientations, which may run counter to official or formal social structure. For many individuals, membership of a solidary group is central to their identity and sense of belonging. In other words, members are dependent on their membership for many commodities for which there is no obvious alternative source. The opportunities for monitoring and sanctioning members behaviour and the threat of exclusion make solidary groups

very powerful in terms of social influence and pressures to conform to group norms. Thus, the two important components of Hechter's (1987) model, dependence and control, would appear to be a feature of dense rather than sparse networks.

At least three network concepts, density, centrality and centralisation, are therefore relevant to the theoretical arguments outlined above. Density, defined as the proportion of all those links that could possibly exist among persons that do in fact exist, tells how tightly knit a network is and describes the overall level of cohesion. According to Burt (1987), "cohesion is the empirical indicator of redundancy", because in densely connected networks many of the ties are carrying the same information and there are many alternative paths that the information could use to get to ego. Cohesive networks are not efficient in terms of the amount of new information they receive.

We also use density as the empirical indicator of group solidarity. Although cohesive networks may not be efficient in terms of attracting new information, we argue that they are probably much more efficient in setting group norms and influencing the behaviour of individual members. They can do so because each of the members is proximate in terms of the number, length and strength of paths that connect members. If the homophily principle is correct, cohesive networks are likely to comprise individuals who are similar to each other in social characteristics, such as age, education, social class and so on. This means that the network can form an important reference group and source of social comparison. Also, cohesive groups develop and monitor their own norms and because each member has multiple ties to every other one, then there are opportunities to persuade, cajole or even coerce members into conformity. Further, members of tightly knit, cohesive groups often value membership highly because it enhances their identity and sense of belonging. The group has a powerful weapon in the threat of exclusion.

Centralisation, a concept related to density, measures the way that cohesion is organised around particular focal points. Highly centralised networks are like hierarchies, at the extreme there will be one focal actor. In decentralised structures there are no focal points: everyone is connected to everyone else. Centralisation, then, tells us something about the way that information can flow through a network. In a hierarchical structure there are fewer pathways and they lie vertically. Some individuals at the top of the structure will have more opportunity to control the flow of information in such a network structure. There are therefore important implications for power and influence as well as information flow inherent in the degree of network centralisation.

Density and centralisation are network measures. It is also useful to be able to characterise the network position of *individuals* within a network. There are many different ways of measuring network centrality, reflecting the fact that there are many different ways in which an actor can be central to a network. We adopt a definition, known as *actor information centrality*, that is suitable to our concern with information flow through a network. An actor is defined as central if they are on the pathway between many other actors and if there are few other actors functioning as intermediaries in the network. If ego is the only way that information can get from one of the individuals in the network to another, then we might assume that ego is more important or more central to the networks of both of them. In calculating actor centrality, the contribution of a path linking two actors is weighted by the strength of ties, based on the expectation that paths involving actors that are especially close will carry more information than ties between actors who are not close. From the discussion above, the connection between actor information centrality and social power should be clear. Power in turn is an important component of social influence.

To summarize, the literature on structural holes, weak ties, group solidarity and social comparison, influence and power suggests that structural features are related to the informational and influential capacity of networks. Network measures such as density, centrality and centralisation are important ways of measuring the presence of these theoretical concepts. In the empirical part of this paper we ask whether network features are related to structural location in the organisational hierarchy or whether they are simply a function of individual characteristics. If there are clear distinctions between senior nurses and doctors in terms of their social network characteristics then there may be implications for the design of more effective strategies to disseminate information and promote behaviour change throughout the two professions.

3. Research design

We gathered data from a random sample of 50 Clinical Directors of Medicine and 50 Directors of Nursing currently employed by the NHS and working in hospitals in England. We used Binley's Directory of NHS Management to select the sample from the total population. This directory lists the names of the members of the management teams of *all* Trusts in the UK. Treating the two occupational groups separately, we first identified the pages on which either of the two groups could appear, then we computer generated a list of random numbers between the first and last page numbers. We then selected the first Clinical Director of Medicine or Director of Nursing to appear on each page that appeared in the list of random numbers. We

believe that this procedure ensured that each member of these two occupational groups working in England had an equal chance of being included, which is the essential characteristic of a random sample.

We chose to focus on the top of the hospital hierarchy because senior staff are more likely to have well developed networks, are easily located in national lists and because they have control over their own time. We focused on medicine and nursing because they are the two most important groups in health care in terms of numbers and power.

There are a number of interesting differences between the two occupational groups in this study. Although both have clinical training and experience, the work of clinical directors of medicine has both managerial and clinical components, whereas the work of nursing directors is exclusively managerial. There is only one nursing director in each hospital and he or she is usually an executive director of the organisation. Although qualified doctors have high status, those in our sample are in mid-career and are located around the middle of the medical hierarchy. There are several clinical directors in a hospital trust, each of whom is responsible to the medical director. They differ from consultant physicians in that they are released from direct clinical care for one or two sessions a week to devote this time to manage their unit or specialty. In sum, the doctors in this sample are still primarily clinicians and are highly specialised in a clinical area, whereas the nurses are managers and generalists who have authority across the whole hospital.

We build on the classic work of Coleman et al. (1966) described above, where respondents were asked to name only three others (alters) for each of three types of tie (advice, discussion and friendship) from their medical colleagues in the same city. This is tantamount to assuming that doctors' social networks are not extensive either geographically or professionally. Coleman et al. (1966) placed these limitation on their respondents in order to gather data on a 'complete' network.

In recent years, increasing attention has been paid to problems of network analysis using samples of respondents who are expected to be representative of a population. One of the most important stimuli to development in this direction was the decision to include network questions in one year of the US General Social Survey. Burt's (1984) arguments for the validity and usefulness of network data collected from a large sample persuaded us to base our survey instrument on the GSS questions, modified to suit our focus on professional networks. In order to link network characteristics to aspects of clinical and managerial behaviour we rewrote the GSS name generator to focus on work related issues:

> From time to time people discuss important professional matters with other people. In the last twelve months, who are the people with whom you have discussed important professional matters?

We defined important professional matters to include both clinical and managerial issues and explained the definition to each respondent. From the list of individuals elicited by the name generator we asked for detailed information on five alters, the nature of the relationship between ego and each alter and the relationships between each alter pair. We also collected personal details about ego, including age, marital status, education, journals read and memberships of professional and social associations. In this paper we focus on analysing network characteristics derived from questions about the strength of ties between ego and alter and the presence and strength of ties between alters. We analyse egocentric networks, "consisting of each individual node, all others with which it has relations and the relations among these nodes.... Each actor can be described by the number, the magnitude and other characteristics of its linkages with other actors, for example the proportion of reciprocated linkages or the density of ties between actors in ego's first-order zone, i.e. the set of actors directly connected to ego" (Knoke and Kuklinski, 1992). It is on this first-order zone that we focus in this paper.

To summarize, the overall goal of this research is to build on the tradition established by Coleman et al. (1966) of investigating the network causes of clinician behaviour change. We use a modified form of the GSS network questions since this instrument has been extensively tested and has been shown to provide valuable network information relevant to our inquiry (Carroll and Teo, 1996). We gathered data from a random sample of 100 senior nurses and clinical directors of medicine. These two groups provide a number of interesting comparisons in terms of education, professional background, managerial responsibilities and career history and trajectory.

4. Hypotheses

4.1. Structural location and network characteristics

The main hypothesis is that professional socialisation and occupational position both enable and constrain the kind of social networks that an individual can sustain. We think that the formal structure of the hospital organisation is very important and that the great differences in the structure of the two professions will shape the networks of the two groups in distinctive ways.

Hypothesis 1. *The social networks of directors of nur-*

sing and clinical directors of medicine will differ in characteristic ways.

Within the hospital, nursing directors occupy a unique position, whereas a potential peer group exists for clinical directors. The lack of peer discussion partners, combined with their position of responsibility for nursing practice within the hospital, suggests that nurses will more often cite junior staff as the people with whom they discuss important professional matters. The structure of medicine, though hierarchical, is modified by the independent practitioner status of each doctor. We therefore expect that clinical directors of medicine will be more likely to discuss important professional matters with peers who are available within the same organisation, have the necessary expertise to understand their problems and may be in a position to contribute to their solution.

Hypothesis 2. *Directors of nursing are more likely than clinical directors of medicine to name alters who are junior to them.*

Peers, with whom we share our history, experiences and perspectives, are important. For some subjects and some problems they are indispensable. Because their input is so important, individuals in unique structural locations in an organisation might be expected to look to people in similar positions in other organisations for peer group support and advice. Of the two groups in our sample, we expect nurses to be more likely to seek alters outside their own organisation, driven at least in part by the desire to include peers in their networks. As a consequence of including individuals from other organisations, we predict that nurses' alters are less likely to know each other than are doctors' alters. This implies that:

Hypothesis 3. *The networks of directors of nursing will be lower in density than clinical directors of medicine.*

Density is defined as the number of ties that do exist relative to the number of ties that could exist if all alters were connected to each other (see Appendix A for a formal definition).

It follows from the differences in the two professional groups discussed above that the networks of directors of nursing are likely to be more hierarchical and therefore more centralised, than those of clinical directors.

Hypothesis 4. *Networks of directors of nursing will be more centralised (as measured by group degree centralisation) than those of clinical directors.*

Centralisation is a key concept in many studies of networks. In studies of organisational structure, for example, it is common to distinguish between very centralised, hierarchical structures where there is little communication across horizontal levels in an organisational hierarchy and structures which are more decentralised, encouraging communication and coordination at lower levels of the hierarchy. Clearly, differences in group centralisation have important implications for how information and influence are distributed through a network.

A measure of group centralisation should be able to distinguish between these types of network structure. Centralisation is a function of the *heterogeneity in the centralities of the individual actors in the network*. In a hierarchical structure, those actors at the top of the hierarchy are much more central than those at the bottom. In a decentralised structure, there is less difference in the centrality of actors at different levels of the hierarchy. Density by itself, however, does not have this property, it is an average rather than a measure of variability, so it needs to be supplemented to give a more complete picture of the centralisation of a network. One common measure of centralisation is *group degree centralisation* (Freeman, 1979). This is low when there is little difference in the centralities of actors in the network and high when one actor is much more central than the others[1].

The measures we have discussed so far are network measures. It is of course possible to calculate centrality measures for individual actors within a network. There are a wide range of possible measures, each of which captures a different aspect of what it is to be in a central location in a network (Freeman, 1979; Wasserman and Faust, 1994). Given that we are interested in the mediating role of networks in the dissemination of information, we have used a measure that focuses on the information contained in all paths originating with a specific actor: *actor information centrality* (Wasserman and Faust, 1994)[2].

The best way to interpret actor information centrality is as the proportion of all the information flowing through a network that is controlled by an individual actor. An actor gets a high value of this index if he or she is intermediate between many other actors and if there are few such intermediaries in the network. As a simple example, consider the case where a network consists of ego and two alters. If the alters are not directly connected to each other, we have a network of the form A1–E–A2. In this case, the relative actor information centrality of the two alters is 0.286, while that of ego is 0.429. If, on the other hand, the two alters are directly connected, all three members of the network have centralities of 0.333. Unlike most centrality measures, the contribution of a 'path' linking two actors to the index is weighted by the strength of

[1] See Appendix A for a formal definition.

[2] The procedure for calculating actor information centrality is described in the Appendix A.

Table 1
Cross-classification tables of sex, marital status and level of education against occupational group

	Clinical directors	Directors of nursing	Pearson X^2
Male	47	14	
Female	3	36	45.8*
Single	5	38	
Married	16	27	7.62*
Non-graduate	0	22	
Graduate	12	13	14.2*

*$p < 0.05$.

the ties involved. This is important because we expect that paths involving actors who are 'especially close' will carry more information than ties between actors who are not close.

In light of what we have said earlier about the two occupational groups in this study, we would expect directors of nursing to have higher information centrality scores. This follows from the hypothesis that directors of nursing will have less dense networks and that many of the alters they name will be subordinates. Because of this, directors of nursing would be expected to have more control over information flow in their networks than is the case for clinical directors.

Hypothesis 5. *Directors of nursing will have higher actor information centrality scores than clinical directors of medicine*.

5. Results

We begin with a discussion of the individual characteristics of directors of nursing and clinical directors. Cross-classifications of occupational group with sex, marital status and having a degree are shown in Table 1.

From Table 1 we can see that there are marked socio-demographic differences between the two professional groups. Almost all the clinical directors of medicines are male (47 out of 50), while the majority of the directors of nursing are women (36 out of 50). This difference is statistically significant ($X^2 = 45.8$, df = 1, $p \ll 0.01$). More surprisingly, there is also a dissimilarity in marital status. Almost all the doctors are married (38 out of 43), while nurses are split between being single (16 cases) and married (27 cases). Again, this difference is statistically significant ($X^2 = 7.62$, df = 1, $p = 0.003$). Nurses are also evenly split between graduates (13 cases) and non-graduates (12 cases), while all the doctors have degrees since graduation is required for qualification. ($X^2 = 14.2$, df = 1, $p \ll 0.01$).

Table 2 presents the means of several variables across the two occupational groups, along with statistical tests of the hypothesis that these means are not equal.

We can see that the ages of the members of the two groups are quite similar, the mean ages being 49.3 and 46.2 for clinical directors of medicine and directors of nursing respectively. Since the t-statistic for the difference of these two means is only 1.76, we cannot reject the null hypothesis that they are equal. This implies that differences between the two groups in terms of marital status cannot be explained by age.

Table 2
Differences in means of variables across occupational groups

Variable	Occupational group	N	Mean	Standard deviation	t-Statistic
Age	clinical directors	42	49.3	6.93	1.76
	directors of nursing	44	46.2	9.08	
Professional associations	clinical directors	42	4.05	1.56	9.72
	directors of nursing	44	1.45	0.761	
Social associations	clinical directors	42	1.36	1.59	0.18
	directors of nursing	44	1.29	1.64	
Number of journals read	clinical directors	42	1.83	1.83	−0.55
	directors of nursing	43	2.02	1.32	
Network density	clinical directors	50	0.931	0.121	−4.18
	directors of nursing	50	0.809	0.167	
Degree centralisation	clinical directors	50	0.105	0.183	4.32
	directors of nursing	49	0.302	0.262	
Information centrality	clinical directors	50	0.194	0.035	2.76
	directors of nursing	50	0.221	0.059	

Table 3
Cross-classification tables of alter's relative rank and ego-alter tie strength against occupational group

	Clinical directors	Directors of nursing	Pearson X^2
Senior or equal	177	151	
Junior	48	69	5.77*
Know each other	76	34	
Especially close	34	45	1.94

We expected that doctors, in general, would belong to more social and professional associations than nurses due to the fact that they are all graduates and higher education is usually associated with a higher number of organisational affiliations. This is true only for professional associations. Clinical directors of medicine are members of 4.05 professional associations on average, compared to 1.45 memberships for the average nurse in this occupational group. With a *t*-statistic of 9.72, this difference is statistically significant. There is, however, no difference in the affiliation to other types of associations across the two occupational groups. The higher average educational qualification of doctors also made us suspect that clinical directors would subscribe to and read more journals than directors of nursing. Although the average number of journals read by the doctors in our sample is slightly lower than that of the nurses, these averages mask a high degree of variation across individuals in the sample of doctors. Partly as a result of this, the difference between the two groups is not statistically significant (*t*-statistic $= -0.55$).

Considering the structural location of the two groups led to the hypothesis that directors of nursing would be more likely to discuss important professional matters with juniors than would clinical directors of medicine (hypothesis 2). Table 3 shows a cross-classification of the status of the alters named by the respondents, dichotomized into 'junior' and 'equal or senior' categories, against occupational group. This shows that there is a statistically significant difference between the two groups ($X^2 = 5.06$, df $= 1$, $p = 0.024$). Of the alters named by nurses, 34.3% were junior, whereas only 20.6% of the people named by doctors were their junior in rank. On the other hand, the two groups did not differ in the number of ties that they held to be especially close (Table 3).

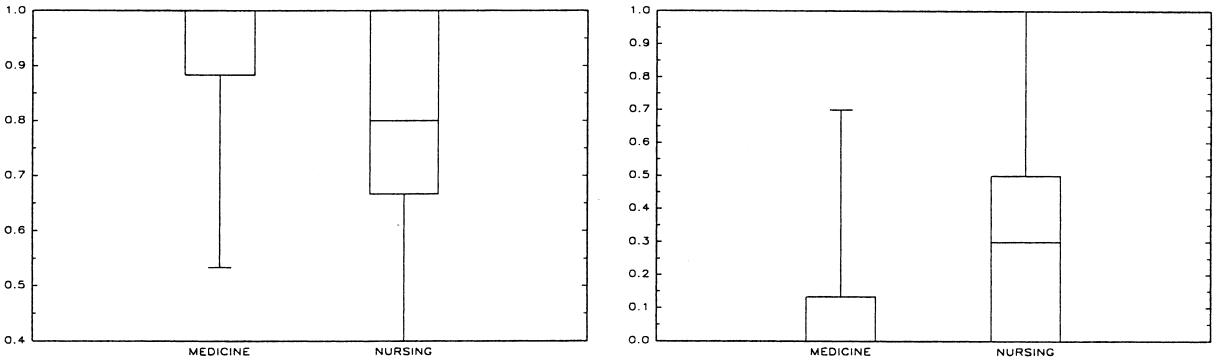
The most striking differences between these two groups of professionals lie in their network characteristics. Consistent with our hypotheses, the networks of the directors of nursing are lower in density that the clinical directors of medicine. Table 2 shows that the difference in the mean densities is statistically significant. These differences can be presented graphically in box plots. Fig. 1 shows box plots for density and group degree centralisation[3]. What does this mean sociologically? Density is a measure of the general level of cohesion in the network. It describes the extent to which actors are tied to each other directly (as is each alter to ego in our sample), or connected through short pathways. Some alters in our study are only connected to each other through ego and, according to ego, "would not recognise each other if they passed each other in the street". Senior nurses' networks are less dense because more of their alters are strangers to each other. As Burt (1991) has shown, there are potential benefits to networks of this sort. Because many of the alters do not know each other, this suggests that they are operating in different social circles and will be party to different kinds of information and will, in turn, be able to spread information more widely.

The networks of the directors of nursing have, on average, higher group degree centralisation scores than do those of the clinical directors of medicine in this study. Fig. 1 also shows box plots and Table 2 shows tests of the hypothesis that the mean value of group centralisation differs across occupational group. These differences are statistically significant. Centralisation and density are related and complementary measures, the latter describes the general level of cohesion in a network whereas the former describes the extent to which this cohesion is organised around particular points (Scott, 1991). In a centralised system, communication tends to flow vertically, between layers of the organisational hierarchy. That nurses' networks are more centralised tends to support the commonly held belief that hierarchical relations are more typical of this profession than medicine where the autonomy and independence of individual practitioners is emphasised. Our data support the conclusion that there is less of a hierarchical dimension to doctors' relations with other doctors, even when they have administrative and managerial components to their role.

The information measure of actor centrality that we describe in Appendix A can also be compared across the two professional groups. Fig. 2 shows box plots of this variable.

Again, we can see that directors of nursing are, on average, more central than clinical directors of medicine. The *t*-test of the equality of the means is again shown in Table 2. In this case, the difference just fails to reach statistical significance at the 0.05 level; for a two-tailed test, the *p*-value is 0.059. People are central to the extent that they are on lots of paths connecting other individuals in the network. In a hierarchy, one

[3] The box plots show the minimum and maximum values (the ends of the 'whiskers'), the upper and lower quartiles (the ends of the boxes) and the median (the line inside the box).



(a) Density (b) Group degree centralization

Fig. 1. Box plots of the densities and group degree centralization indices of the ego-networks of directors of nursing and clinical directors.

of the easiest ways to be central is to be at the top. If there are lots of connections between alters, then ego is less important. The finding that nurses are more central to their network is therefore consistent with our previous results and with information on their position in the hierarchy. Central network positions have been associated by a number of theorists (Burt, 1991; Cook and Yamagishi, 1992) with the ability to control access to network resources, in this case, information. While others are dependent on the central actor for access to information, he or she is less dependent on any of the others in the network. Although Knoke (1994) was writing in the context of inter-organisational networks, his argument, that a major problem for all actors is reduction of resource dependency, holds for individual actors as well: "structural autonomy (low resource dependence) within networks enables an actor to pursue its goals with fewer constraints".

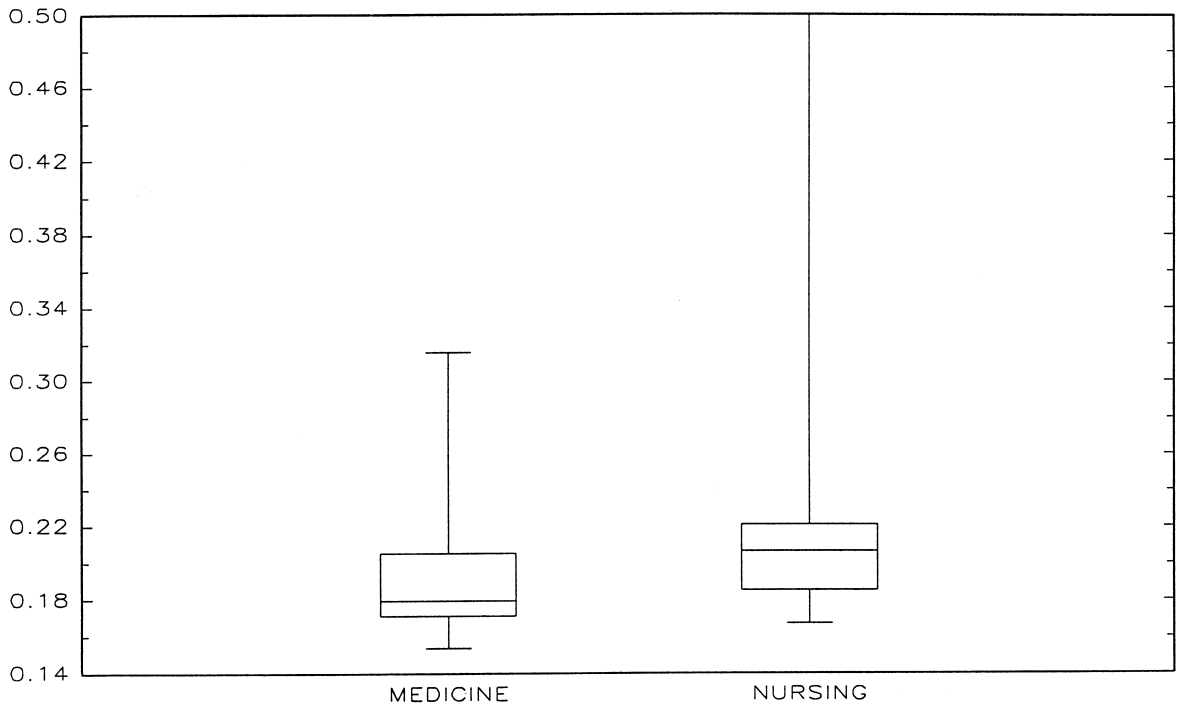


Fig. 2. Box plots of actor information centrality scores of directors of nursing and clinical directors.

6. Summary and conclusions

Theory holds that the social networks within which individuals are embedded have an important impact on their attitudes and behaviour. Networks provide channels for the transmission of information and influence and network characteristics, such as density, centrality and centralisation affect the speed and distance that information travels. Further, because information is an important resource in our society, access to and control over information is related to power and independence.

At the outset of this research we wondered whether busy professionals would be willing and able to answer our network questions. We found that they were and gathered data on the social networks of senior nurses and doctors, 100 in total, currently employed in the NHS (England). We then analysed these data using descriptive statistics and standard network techniques to show that doctors and nurses differ quite markedly on a number of interesting dimensions.

The main socio-demographic differences were that clinical directors of medicine tended to be married men and nursing directors were mostly, but not exclusively, unmarried women. In terms of personal characteristics the two professional groups were similar in age, journal readership and tendency to join social associations, but doctors belonged to about twice as many professional associations as nurses.

Directors of nursing and clinical directors of medicine doctors did not differ in the number of ego/alter relations they described as particularly close, but there were differences in the status characteristics of alters. As we hypothesised, nurses were more likely to discuss important professional matters with juniors than were doctors. This difference is probably largely due to the structural position of the nurses in this sample, who occupy an unique position in hospital organisations. In an extension of this study we intend to ask for more details about the profession, status and institutional affiliation of alters, to try to disentangle the role of choice from opportunity in the selection of partners for discussion networks.

Do differences in network characteristics matter? We draw on the literature on structural holes (Burt, 1991), the strength of weak ties (Granovetter, 1973) and social influence (Marsden and Friedkin, 1994), which suggests that some network features are beneficial in terms of access to information whereas others are more effective in terms of social control. Our empirical measures of the theoretical concepts are density, centrality and centralisation.

The networks of directors of nursing are less dense than clinical directors of medicine (where density is defined as the number of actual ties that exist among the people that the respondent has in their discussion network relative to the number of ties that could exist). The nurses in this sample tend to discuss important professional matters with people who do not know each other, or who know each other, but are not close. Sociologists suggest that such networks have significant advantages in terms of access to information (Granovetter, 1973; Burt, 1991) because each individual brings information from a group which is not connected to the others by any other routes. In dense networks, many ties are redundant. This suggests that the directors of nursing in this sample get a wider spectrum of opinion on their problems than do clinical directors of medicine. In addition, they may be able to send messages more widely throughout the system.

Directors of nursing are more central to their networks than are clinical directors of medicine. An actor is defined as central if they are on the pathway between many other actors and if there are few other actors functioning as intermediaries in the network. In calculating actor centrality, the contribution of a path linking two actors is weighted by the strength of ties, based on the expectation that paths involving actors that are especially close will carry more information than ties between actors who are not close. Directors of nursing then are the go-between for a number of people who would not otherwise be connected. There are good reasons for this in terms of their structural position in the formal organisation. As the average of their centrality scores indicate, nurses in this sample are in a position to mediate and control, not just passively receive, information. The nurses in our sample occupy central positions which means that they play a very important role in the diffusion of information and influence within the wider structure of their profession by sending, receiving and transferring signals from diverse groups.

The networks of directors of nursing are also more centralised overall. This network characteristic, though related to density (the overall cohesion or integration of the graph), adds to it by measuring the extent to which cohesion is organised around particular focal points. The most general way of measuring centralisation is to examine the difference in centrality scores of the most central actor relative to those of all other actors. Highly centralised networks are like hierarchies, there will be one central actor, whereas in decentralised structures there will be many focal points. We found that the directors of nursing had networks that were more centralised than clinical directors reflecting conventional wisdom about the structure of the two professions. Strong and Robinson (1990) describe the elaborate internal hierarchy of the nursing profession which they attribute, not primarily to nursing itself but to "the many powerful forces-medicine, gender and the demands of an extremely labour intensive industry-

which created, shaped and controlled the nursing trade''.

Turning now to doctors' social networks, we found that clinical directors of medicine were embedded in tightly knit groups where each alter was likely to know the others. Such networks have fewer advantages in terms of information acquisition. True, if new information does reach a member of the clique it will circulate very quickly, but, because clique members have fewer ties to diverse social groups, new information is simply less likely to be acquired through informal relations. Dense networks may, however, have some advantages in terms of influencing and controlling members behaviour. It seems intuitively plausible that once a few members of a densely connected network become convinced of the efficacy of a certain procedure, or convinced of the need to change current practice, such a group would be much better at ensuring that all members follow suit. This is a function of the multiple ties which each member has to every other which provides them with the opportunities to persuade, cajole and monitor the others. Also, because cohesive groups or cliques are important to a member's own identity and sense of belonging, they are very powerful in terms of social influence and pressures to conform. As is often the case, this power can be used for different ends. There is no guarantee that the group will use its ability to control members' behaviour to change in the direction suggested by outside agencies. As one of the reviewers of this paper wrote: ''doctors are well placed to resist, harness and co-opt managerial interventions and ideas about clinical evidence''. Once mobilised against change, the medical clique could be extremely resistant to outside persuasion and pressure.

We found that doctors are less central to their own discussion networks than are nurses, who tend to be intermediate between many actors. In a medical network, ties are so dense that even if the respondent were removed, information would still flow relatively well because so many alternative channels to communication exist. This means that our respondents are unlikely to be able to use control over information as a source of power within their own group of discussion partners.

In comparison to nurses' networks, those of doctors are egalitarian and decentralised, which is consistent with conventional wisdom and some empirical evidence about the structure of the two professions in the NHS. Strong and Robinson (1990), for example, describe the way that members of medical profession are ''...bound together by their long initiation, common practice and shared technical knowledge. While there is a ranking of medical specialties, the profession is suffused with a fierce internal egalitarianism''. Among the doctors in our sample, communication flows horizontally, whereas in the nurses' networks communications tend to move vertically. These findings seem to reflect the more autonomous role of members of the medical profession and the greater emphasis on the hierarchical organisation of the nursing profession. It may also be due to the greater managerial role performed by directors of nursing in this sample. It would be interesting to find out whether nurses and doctors at different levels in the occupational hierarchy also show these patterns. In the meantime we believe that these results are consistent with the literature on medicine and nursing, which Strong and Robinson (1990) describe, from the perspective of managers as having ''a strange symmetry''. These authors identify gender, numbers, power, influence, education, pay, scientific basis of practice, professionalism, autonomy, hierarchy and discipline, as key characteristics on which the two professions can be seen as ''bizarre reverse images of each other''. We can now add network characteristics to this list.

The main hypothesis underlying this study was that professional social networks are related to professional socialisation and occupational status. Our results support the conclusion that clinicians in the NHS are embedded in social networks that are characteristic of the occupational groups to which they belong. This is an important finding since social networks are often held to be purely related to characteristics of the individual, such as their sociability or level of interpersonal skill. Although these variables may too play a role, we have found that structural factors are very important in determining the kind of social networks that an individual can develop and sustain. These results should be of general interest to organisational sociologists because they suggest that the formal structure is an important determinant of informal social relations.

7. Implications for the design of dissemination strategies

Two important questions remain. What are the implications of these findings for the development of new strategies to inform clinicians and to influence their uptake of research findings? And, how can we use this, essentially descriptive, research to develop hypotheses about the effectiveness of dissemination and implementation strategies in the context of different forms of social organisation?

First, in developing new strategies we believe these findings reinforce the need to know the characteristics of the audience and their social context and suggest that strategies designed to build on structures that already exist might be most effective. We have used the terms 'cliques' and 'hierarchies' to characterise some of the differences we have found. They are not applied to the two professions for the first time in this paper, but

we provide objective, quantitative evidence of their continuing relevance.

Neither hierarchical nor non-hierarchical forms of organization is intrinsically superior, but they do have their own strengths and weaknesses that are relevant to the dissemination of information and persuasive messages. Hierarchies are stable structures capable of co-ordinating and implementing complex plans (Weber, 1978). Traditionally, information flows vertically through a hierarchy and orders are sent from the top down with the expectation that lower levels will implement them. Hierarchies have well known weaknesses as well as strengths, such as communication failures, individual alienation and the inability to respond rapidly to environmental changes.

This research suggests that senior nurses are good targets for persuasive messages because they are in a position to mediate and control, not just passively receive, information. Also, their networks are such that they can send information and influence long (social) distances. Relative to the doctors in this sample, they occupy powerful positions in their profession. Part of this power derives from their control over information. Clinical directors are at a lower level in their own occupational hierarchy but are more likely to be powerful locally, partly because of their continuing clinical focus, but also because they are embedded in peer group networks where the members are tied both as individuals and through the others. Cascading information from the top down may work for the nursing profession, especially if your first point of contact is a director of nursing. They have access to information and their networks are far-reaching. Certain behaviours which are acceptable in a hierarchy, such as orders, would not be acceptable in the more egalitarian structure of medical communities.

The social organization of cliques has also been well studied. Cohesive sub-groups formed by informal social relations can appear to the outsider as separate sub-cultures with their own norms, values, expectations and orientations, which may run counter to the official or formal social structure. The main problem with cliques, for outsiders, is one of access. Strong boundaries can insulate the group from other social groups. Groups can also mobilise to resist change. That is, groups may, under certain circumstances, choose to behave in a very different way from that sought by the persuasive source. Simply recognizing some of the strengths and weaknesses of the social structures that characterise these two professions and using this information could be enormously beneficial in implementing health policy and advances in clinical practice.

Although the autonomy of individual clinicians is reified by the medical profession, here we see how important it is for doctors to have input from their peers. The fact that doctors most often discuss important professional matters with equals suggests that the process of social comparison is very important. They want to know whether their own practice is similar to others. This suggests that any attempts to change will be difficult, because it will often involve group processes rather than simply convincing individuals of the need to change. If it is important for each member of the group to conform to the group norms, then innovations will be met with resistance, but once a certain number of individuals adopt the practice and the 'tipping point' is reached, then the rest of the group will soon follow. We need to know much more about how to get information into medical communities and about ways to influence them to change without provoking resistance.

This discussion has revealed many interesting avenues for further exploration. Interesting questions remain about the relative importance of professional socialisation, occupational status and the formal structure of the organisation in determining the composition of social networks. We want to know how networks change over time and as the individual moves from job to job. Also, what kind of information is likely to be passed on through informal networks and when are dense networks likely to mobilise against pressure to change? Finally, we develop the argument, from theory, that while dense networks will be better at spreading information once it has penetrated the groups' boundary, less dense networks will have better access to diverse sources of information and will send and receive messages from relatively long social distances. Conversely, we argue that the strength of dense networks lies in the fact that they tend to be more solidary groups on which members depend for important resources. In theory, they ought therefore to be able to exert greater control over members behaviour. This study suggests that the medical and nursing professions, which show characteristic variations in network density, might be an interesting arena in which to test these hypotheses.

In conclusion, we believe that social structure is given inadequate consideration in the design of dissemination and influence strategies. The network differences that we have shown in this work suggest that further investigations of the social structure of medical communities could inform the design of more sophisticated and accurate ways of disseminating information and social influence.

Acknowledgements

We would like to thank Vivianne Crombie for research assistance and Valerie Seagroatt, Carol Edwards and colleagues at the Institute of Health Sciences who made helpful comments on previous

drafts of this paper. This research was supported by the National Health Service Research and Development Programme. A previous version of this paper was presented at the American Sociological Association Meetings in Toronto, August 1997.

Appendix A

A.1. Density

A tie between ego i and alter j is denoted by x_{ij}, which takes the value 1 if a tie exists and the value 0 if a tie does not exist. Network density can therefore be defined as:

$$\Delta = \frac{\sum_{i=1}^{g}\sum_{j=1}^{g} x_{ij}}{g(g-1)}, \tag{A.1}$$

where there are g actors (ego and alters) in the network and $x_{ij}=1$ if a tie exists and $x_{ij}=0$ if the two actors are strangers[4].

A.2. Group degree centralisation

Group degree centralisation is defined as:

$$\Gamma = \frac{\sum_{i=1}^{g}[\max(D_i) - D_i]}{(g-1)(g-2)}, \tag{A.2}$$

where D_i is the number of people in the network that are directly linked to person i.

A.3. Actor information centrality

Actor information centrality is calculated in several steps. First, construct a $g \times g$ matrix $\mathbf{V}$ which consists of the following elements:

$$\begin{aligned} v_{ij} &= 0 \quad \text{if } i = j, \\ v_{ij} &= 1 \quad \text{if } i \neq j \text{ and if the two actors know each other,} \\ v_{ij} &= 2 \quad \text{if } i \neq j \text{ and if the two actors are especially close} \end{aligned} \tag{A.3}$$

Matrix $\mathbf{V}$ can then be used to calculate a second matrix $\mathbf{A}$ as follows. The diagonal elements of the matrix are given by:

$$a_{ii} = 1 + \sum_{j=1} g v_{ij}. \tag{A.4}$$

The other elements of the matrix are calculated as follows:

$$a_{ij} = 1 \quad \text{if } v_{ij} = 0, \qquad a_{ij} = 1 - v_{ij} \quad \text{if } v_{ij} > 0. \tag{A.5}$$

The next step is to calculate a third matrix, $\mathbf{C} = \mathbf{A}^{-1}$. We need to define two other quantities. The *trace* (T) of the matrix $\mathbf{C}$ is the sum of its diagonal elements. The row sum (R) is the sum of one of the rows of $\mathbf{C}$ (all the row sums are equal). Finally, the actor information centrality, $C_I(i)$ is calculated:

$$C_I(i) = \frac{1}{c_{ii} + (T - 2R)/g}. \tag{A.6}$$

This measure was originally proposed by Stephenson and Zelen (1989) and is described in detail by Wasserman and Faust (1994, pp. 194–197). Since this measure has no maximum value, Stephenson and Zelen (1989) recommend standardizing the measure by dividing by the total of all the actor information centralities in the network:

$$C_I'(i) = \frac{C_I(i)}{\sum_i C_I(i)}. \tag{A.7}$$

This relative actor information centrality index varies between 0 and 1 and the sum of all the $C_I'(i)$ scores in a network is 1.

[4] As is standard practice, we define all the x_{ii} elements of the network to be 0. In other words, people cannot have a 'network connection' to themselves.

References

Burt, R.S., 1984. Network items and the general social survey. Social Networks 6, 293–339.

Burt, R.S., 1987. Social contagion and innovation: cohesion versus structural equivalence. American Journal of Sociology 92, 1288–1335.

Burt, R.S., 1991. Structural Holes. Harvard University Press, Cambridge, MA.

Carroll, G.R., Teo, A.C., 1996. On the social networks of managers. Academy of Management Journal 39, 421–440.

Coleman, J.S., Katz, E., Menzel, H., 1966. Medical Innovation: A Diffusion Study. Bobbs-Merrill, Indianapolis.

Cook, K.S., Yamagishi, T., 1992. Power in exchange networks: a power-dependence formulation. Social Networks 14, 245–265.

de Sola-Pool, I., Kochen, M., 1978. Contacts and influence. Social Networks 1, 5–51.

Erikson, B.H., 1988. The relational basis of attitudes. In: Wellman, B., Berkowitz, S.D. (Eds.), Social Structures: A Network Approach. Cambridge University Press, Cambridge, pp. 99–121.

Festinger, L., 1954. A theory of social comparison processes. Human Relations 7, 117–140.

Freeman, L.C., 1979. Centrality in social networks. 1. Conceptual clarification. Social Networks 1, 215–239.

Granovetter, M.S., 1973. The strength of weak ties. American Journal of Sociology 78, 1360–1380.

Hechter, M., 1987. The Principles of Group Solidarity. University of California Press, Berkeley and London.

Hirschman, A.O., 1970. Exit, Voice and Loyality: Responses to Decline in Firms, Organizations and States. Harvard University Press, Cambridge, MA.

Knoke, D., 1994. Networks of elite structure and decision making. In Wasserman S., Galaskiewicz, J. (Eds.), Advances in Social Network Analysis. pp. 274–294 .

Knoke, S., Kuklinski, J.H., 1992. Network Analysis. Sage, Newbury Park, CA.

Marsden, P.V., Friedkin, N.E., 1994. Network studies of social influence. In: Wasserman, S., Galaskiewicz, J. (Eds.), Advances in Social Network Analysis. Sage, London, pp. 3–25.

Ramsey, P.G., Carline, J.D., Inui, T.S. et al, 1991. Changes over time in the knowledge base of practicing internists. Journal of the American Medical Association 266, 1103–1107.

Raven, J.R.O., Raven B.H., 1959. The bases of social power. In: Cartwright, D. (Ed.), Studies in Social Power. University of Michigan Press, Ann Arbor, pp. 150–167.

Scott, J., 1991. Social Network Analysis: A Handbook. Sage, London.

Stephenson, K., Zelen, M., 1989. Rethinking centrality: methods and applications. Social Networks 11, 1–37.

Strong, P., Robinson, J., 1990. The NHS Under New Management. Open University Press, Buckingham.

Wasserman, S., Faust, K., 1994. Social Network Analysis. Cambridge University Press, Cambridge.

Weber, M., 1978. Economy and Society. University of California Press, Berkeley and London.