# 8
# Evaluation in Health Informatics: Social Network Analysis

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## Introduction: The Social Network Perspective

Social network analysis comprises a set of research methods that can be used to analyze the relationships among entities such as people, departments, and organizations. The purpose of the analysis is to discover patterns of relationships that affect both individual and organizational attitudes and behavior such as the adoption, discussion, and use of new medical informatics applications. This chapter presents an introduction to the concepts and methods of social network analysis. Several applications to health informatics are described.

Attitudes toward information technology, its adoption and use in healthcare settings are strongly influenced by the pattern of relationships among the individuals who make up the organization [1–5]. Many different occupational groups interact in providing healthcare. These groups include physicians, nurses, administrators, medical technicians, clerical workers, and patients. These groups belong to different professional and organizational groups and different departments. Yet they are interdependent and the provision of healthcare requires cooperation and coordination [6]. Interpersonal interactions among the members of these groups and between groups are essential in sharing information and resources in order to deliver health services. In addition, communication among professionals strongly affects the rate of adoption and diffusion of new information technology [1,2].

Furthermore, electronic medical record systems (EMRs), telemedicine systems and the Internet, where geographically dispersed professionals share a common database or consult and collaborate with one another, create "virtual" departments or organizations whose boundaries are defined by tasks and information flow rather than traditional organizational departments or occupations. Frequently, the introduction of an electronic medical record with its common database alters policies, procedure, work assignments, and interactions among individuals and occupational groups [7].

Traditionally evaluation of information technology has focused on technical aspects of the system and on individual attitudes, work roles, and utilization. However, an understanding of the effects of the introduction of information technology into organizational settings requires an approach that considers patterns of relationships among members of the organization [8,9]. Social network analysis can be used to identify different patterns of relationships within and between occupational groups, departments, and organizations; and to analyze the effects that these patterns have on individual member's attitudes, behavior, and performance [10]. This approach is based on the premise that individuals are influenced by direct and indirect exposure to other person's attitudes and behavior; by access to resources through the network; and by the individual's location in the interpersonal network. For example, studies of the diffusion of innovations have found that individuals who have extensive relations with other professional are more likely to adopt an innovation sooner. In contrast, individuals with fewer relations with other professionals are slower to adopt new approaches [11].

## Social Network Analysis

Social network analysis is the study of the pattern of relations among a set of people, departments, organizations, and so on. For example, physicians consult with one another in diagnosing a patient's illness. They interact with nurses, pharmacists, and medical technicians in providing patient care. Physicians, clinics, hospitals, medical laboratories, home care agencies, and insurance companies may all share a common electronic medical record system.

Network analyses may take many forms depending on the purpose of the evaluation. There are four elements of an evaluation design, namely, the units that comprise the network, the type of relations among the units, the properties of the relation, and the level of analysis [12,13].

The units to be studied comprise the nodes of the network. The units or nodes of the network may represent individual; professional or occupational groups, for example, physicians, nurses, technicians; hospital departments; organizations that make up an integrated delivery system; or larger units such as state Medicaid programs.

The type of relation among the units may vary. Frequently, the relation involves communication (i.e., face-to-face, via telephone or the Internet). Other types of relations may involve authority or the exchange of resources or money. Properties of the relations among units also may be of interest. Some of these properties are frequency of interaction, strength of the relation, and whether the relation is reciprocal or multiplex (i.e., involves two or more types of relations).

There are several levels at which the network can be analyzed. One level involves ego networks. Each individual unit or node is involved in a network that comprises all other units with which it has relations and the relations among these units. At another level, a dyad, a pair of units, or a triad, three units, can be investigated. In these networks, relations between or among the units under investigation may be direct or indirect via other units in the network. Most studies involve an analysis of the entire network or system.

Network analysis requires the collection of relational, positional, or spatial data. Usually attributes of individual units are collected as well. Once collected, the relational data are organized into a matrix. Rows and columns represent individuals, departments, or organizations. Within each cell of the matrix, numbers are used to represent the existence or absence of a direct relation or the frequency or strength of the relation. The network also is displayed in graphical form.

Data for a network analysis may be collected by a variety of methods. Members of the organization under study can be provided with a roster of names and asked to indicate the frequency, strength, or importance of their relations with each person. They can be asked to list those with whom they interact. Direct observation by an investigator can also be used to identify relations among individuals.

Information systems also permit the construction of networks involving users. Computers keep track of the number, length, and timing of e-mail messages that are sent among system users [14,15]. Logs are kept of individuals who access electronic patient records. System files of hospital information systems can be used to identify attending and consulting physicians for each patient, and frequency and types of usage of the information system [16].

Network analysis can provide descriptive and inferential information. For example, the strength and direction of relations among units may be of interest. The analysis can be used to identify individual roles in the network such as leaders and isolates. Characteristics of the network as a whole may be important such as density of relations and the cohesiveness of the network. In the next section several applications of social network analysis will be described.

## Applications to Health Informatics

### *Networks and Use of a Hospital Information System*

The process by which information technology diffuses in medical settings is poorly understood. The objectives of this study were to identify the structure of the referral and consultation networks that link 24 physicians in a group practice; and to study the effect of the physicians' location in the network on their use of the hospital information system (HIS) [17]. The study site was a large private teaching hospital that had implemented the TDS HC 4000 system. Patient records were accessible by remote terminals throughout the hospital. The system provided communication among hospital services, physicians, nursing services, the medical laboratory, and the hospital pharmacy. Physicians could directly enter medical orders into the HIS and could retrieve patient information.

A questionnaire was used to collect relational data from the 24 physicians. Each physician was asked to indicate which of the other physicians in the group they referred patients to, consulted with, discussed professional matters with, and took on-call coverage for. Self-reported measures of HIS usage were also obtained. A questionnaire was developed to obtain information on physician attitudes toward medical computer applications. Individual attributes measured included the physician's age, speciality, board certification, number of hospital admissions during the past 6 months, involvement in professional activities, and participation in graduate medical education.

Based on the relational data, a number of indices were created for subgroups of physicians and for individual physicians. Densities of relations within subgroups of physicians and between groups were computed. Density measures the proportion of actual relations among group members compared to all possible relations. This measure can range from 0 to 1. Second, a measure of centrality that ranges from 0 to 1 was computed for each group of physicians. This measure describes the degree to which information and resources in the group are dispersed throughout the group or centered on a few individual physicians. A third measure was calculated to describe each physician's role in the network. Physicians were classified as sending, relaying or receiving patients or information based on the ratio of interactions the physician initiated compared to those that were initiated by other physicians. A measure of multiplexity was calculated as the proportion of group members who had more than one type of relation with other physicians in the group. Finally, for each physician, a measure of prestige was calculated ranging from 0, if no one consulted the physician, to 1, if everyone in the group consulted the physician.

The relational data were analyzed by hierarchical clustering and blockmodel analysis [18]. This analysis identified four subgroups of physicians who had similar patterns of referrals, consultations, discussion, and on-call coverage. The results are shown in Figures 8.1 and 8.2.

Figure 8.1 shows the four subgroups of physicians that were identified by the cluster analysis. In Figure 8.2, a circle or a line linking groups indicates that the density of relations among physicians in a group or between groups of physicians is greater than the density of relations in the total network. The results are similar to those of other studies of communication among members of professional groups. Professionals are generally organized around a core of influential individuals who direct and control the flow of information and resources. The results of the current analysis reveal a similar pattern. Physicians in Group 1 control the referral of patients in the network. They consult with and refer patients to physicians in all three of the other subgroups. In a sense, they act as gatekeepers for the group practice.

Figure 8.3 shows the shared attributes and network or relational characteristics of physicians who make up the four subgroups. Physicians in Group

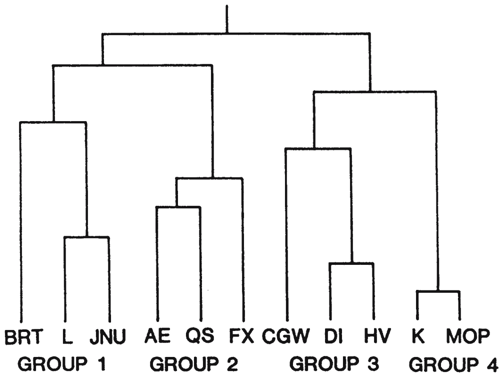


**Figure 8.1.** Clustering of 24 physicians in a group practice. (Reprinted with permission from JG Anderson and SJ Jay. Computers and clinical judgment: the role of physician networks. *Soc Sci Med* 20(10) 1985, 969–979.)

1, who act as gatekeepers, are older and more professionally active than the other physicians. They are central in the referral and consultation networks as evidenced by their scores on the indices of centrality, multiplexity, and role in the network. In general, they initiate 1.5 times as many referrals, consultations and discussions with other physicians as they receive from others. The physicians in Group 1 began using the HIS soon after it was implemented. Also, they are the heaviest users of the system in practice. They directly entered 45% of their own medical orders over a 6-day period.

## *A Network Intervention*

The benefits of direct computer-based physician order entry are significant. However, many attempts to implement such systems have met with limited

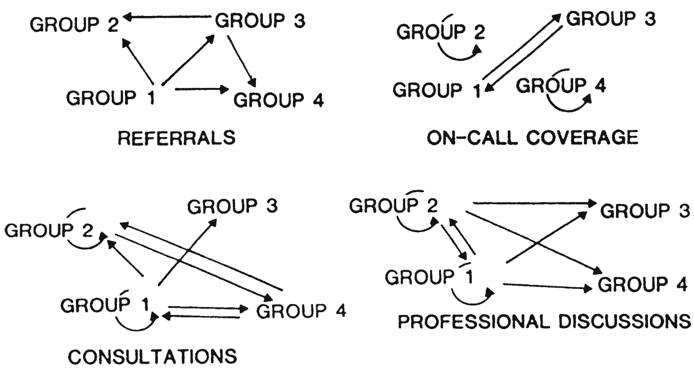


**Figure 8.2.** Professional relations among groups of physicians. (Reprinted with permission from JG Anderson and SJ Jay. Computers and clinical judgment: the role of physician networks. *Soc Sci Med* 20(10) 1985, 969–979.)

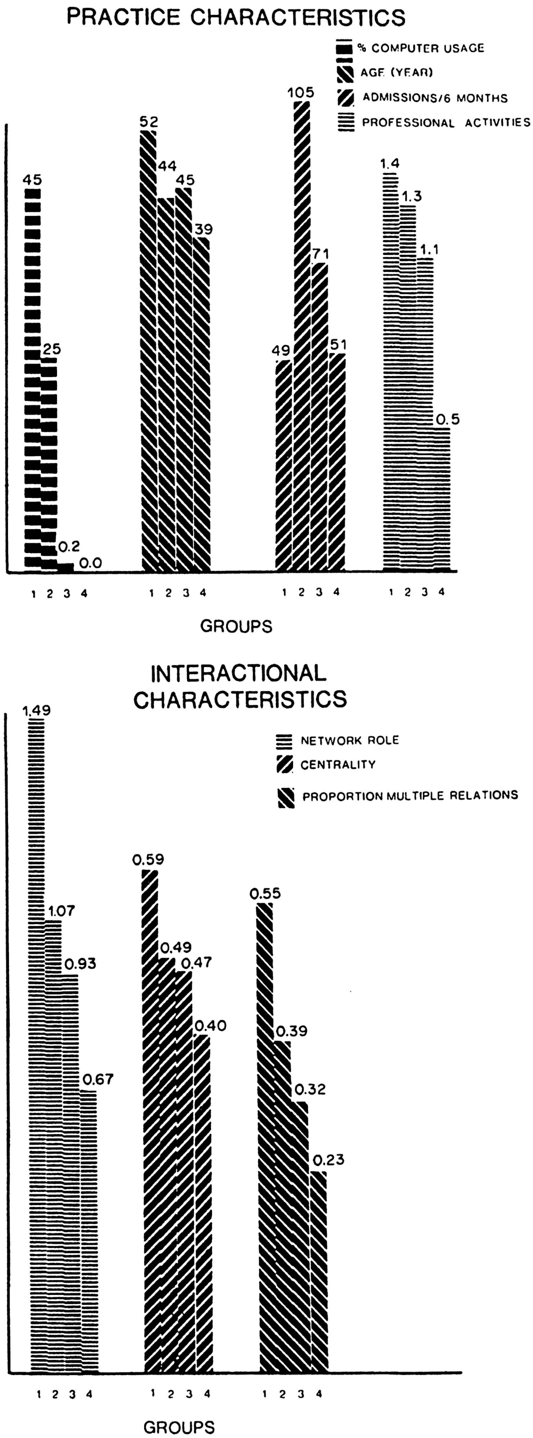


**Figure 8.3.** Characteristics of four groups of physicians. (Reprinted with permission from JG Anderson and SJ Jay. Computers and clinical judgment: the role of physician networks. *Soc Sci Med* 20(10) 1985, 969–979.)

success. The primary objectives of this research was to design, implement, and evaluate an intervention to increase direct order entry into a HIS by physicians' and, secondly, to increase overall physician use of the HIS [16,19]. The study was conducted in the same private teaching hospital described above. The hospital information system permits physicians and other personnel to enter and retrieve patient data at computer terminals through the hospital. Data can be entered with screens that are provided by the vendor of the hospital information system. As an alternative, physicians can create personal and departmental order sets for order entry. These order sets are tailored to the specific procedures that physicians frequently order for their patients. It was hypothesized that if physicians could be encouraged to develop personal order sets, they would use them more frequently for direct order entry and, subsequently, would increase their use of the HIS.

A quasi-experimental design was used. The following hospital services were selected as the experimental group: cardiovascular disease, general surgery, obstetrics and gynecology, and orthopedic surgery. Based on studies of the diffusion of innovations, we initiated an experimental program on these services utilizing physicians identified as educationally influential among their peers. The program was designed to increase the use of the hospital information system through the use of personal and departmental order sets for medical order entry. Physicians on 10 other hospital services were assigned to the control group. Data were collected from 109 and 231 physicians on the experimental and control services, respectively.

Influential physicians were identified on each experimental service by constructing a consultation network such as the one shown in Figure 8.4 for general surgery. Physicians in Group 3 are consulted by physicians in all of the other groups. Consequently, several physicians in this group were recruited to participate in this study to increase the use of personal order sets for direct physician order entry. All of the physicians who were contacted agreed to participate in the study.

At individual meetings with project staff, influential physicians were provided with data that indicated their overall use of the hospital information system as well as their use of personal order sets for order entry. Individual physician profiles were compared to profiles for physicians on their service and to the total hospital medical staff. During the meeting, the project staff discussed with the physician the advantage of using personal order sets to enter medical orders into the hospital information system. Following these meetings, physicians continued their normal practice on their hospital services. A second meeting was held with the educationally influential physicians 6 months later. They were provided with data on order entry times and error rates using the two modes of order entry (i.e., regular hospital information system pathways and personal order sets).

In order to determine whether increased use of personal order sets and overall use of the HIS occurred on the experimental and control services, data were collected before and 6 months and 12 months after the intervention. These data included use of personal and departmental order sets;

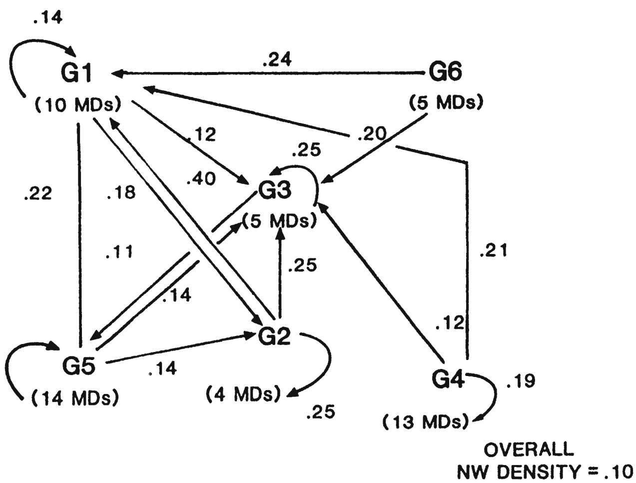


**Figure 8.4.** Groups of physicians with similar consultation patterns on general surgery. (Reprinted with permission from JG Anderson, SJ Jay, H Schweer, M Anderson and D Kassing. Physician communication networks and the adoption and utilization of computer applications in medicine. In: JG Anderson, SJ Jay (eds.), *Use and Impact of Computers in Clinical Medicine* (Springer, New York, 1987), pp. 185–199.)

and frequency of use of the HIS to retrieve patient lists, to access and print laboratory test results, and to access and enter medical orders.

A multivariate analysis of variance with repeated measures was performed on the use of personal order sets by physicians, nurses, and unit secretaries to enter medical orders into the HIS. The mean number of orders entered using personal order sets at three points in time is shown in Figure 8.5. The results of the analysis of variance indicate significant differences between the experimental and control groups ($F_{1,338} = 15.58$, $p < 0.000$) and between persons entering the orders ($F_{1,338} = 10.78$, $p < 0.000$). Significantly more orders were entered on the experimental services using personal order sets. Also, unit secretaries entered significantly more orders using personal order sets than physicians or nurses. Moreover, the group by time interaction was significant ($F_{1,338} = 5.80$, $p < 0.003$). The use of personal order sets for medical order entry on the experimental services increased significantly over the 12 month period.

Significant changes were observed on the experimental services as a result of the network intervention. The use of personal order sets for medical order entry into the HIS significantly increased. In fact, the effect of the educationally influential physicians extended beyond the other physicians on the service. Use of personal order sets for order entry also increased among nurses and unit secretaries on the experimental units.

## *Computers in the Consulting Room*

Computer-based record systems have been rapidly introduced into family practice in the UK. In contrast, only about 1% of physicians in the United

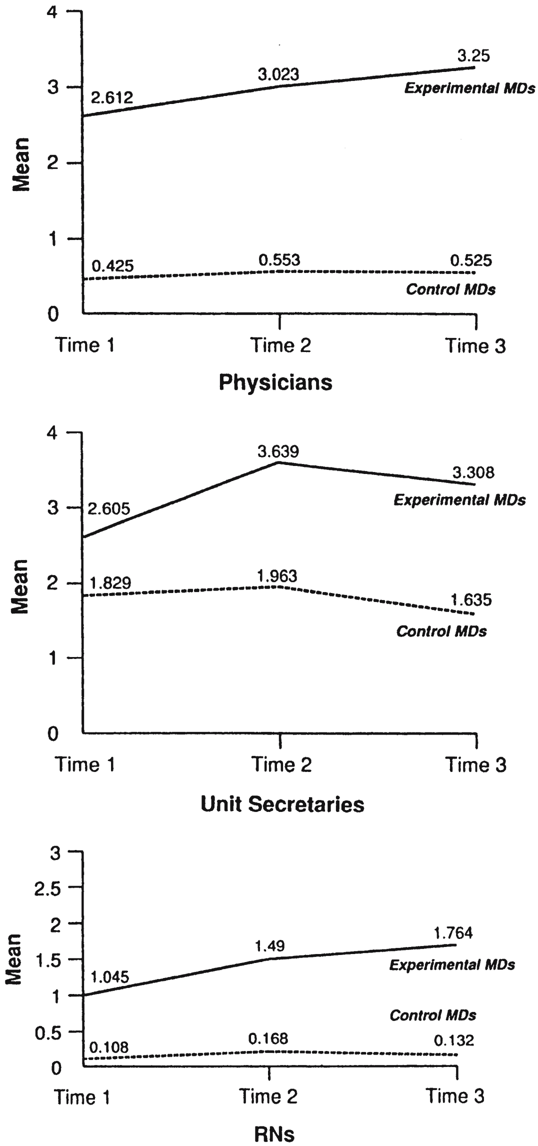


**FIGURE 8.5.** Mean number of medical orders entered into the HIS using personal order sets. (Reprinted with permission from JG Anderson, SJ Jay, J Perry, and MM Anderson. Diffusion of computer applications among physicians: a quasi-experimental study. *Clin. Soc. Rev*. 8 (1990) 116–127.)

State uses computer-based patient records [20,21]. This study evaluated clinician reactions to the introduction a computer-based health appraisal system, CompuHx, into the examining rooms at the Department of Preventive Medicine at Kaiser-Permanente, San Diego [22,23]. Initially five of the 22 nurse practitioners and physician assistants who perform examinations began using the system in practice. One user took maternity leave during the study and was excluded from the analysis. The department provides a complete history and physical examination for 50,000 HMO members each year. The CompuHx system is designed to assist practitioners in gathering diagnostic information. A computer database is created during a patient visit containing the patient's history and laboratory results. During the examination, the system assists the practitioner in clarifying items on the patient questionnaire and findings during the physical examination. At the end of the visit, the system produces a summary of the findings.

As part of a social network analysis, examiners were provided with a list of all nurse practitioners and physician assistants, doctors, data processing clerks, chart room clerks, the radiology department, the medical laboratory, and so on. They were asked to indicate the frequency with which they communicated with each person or occupational group while performing their jobs. The frequency of interaction was coded as follows: 0 = never, 1 = once a month, 2 = several times a month, 3 = once a week, 4 = several times a week, 5 = once a day, 6 = several times a day. For the analysis, frequencies of communication of CompuHx users and nonusers with other personnel in the department and with other departments were computed. Also, densities of communication for CompuHx users and nonusers were computed.

Figure 8.6 shows the average frequency of communication for users and nonusers with other examiners and physicians. CompuHx users reported that they communicated several times a week with one another and with the medical director while examining patients. They communicated with other physicians about once a week on average and with nonusers of the system only several times a month. Communication among nonusers of

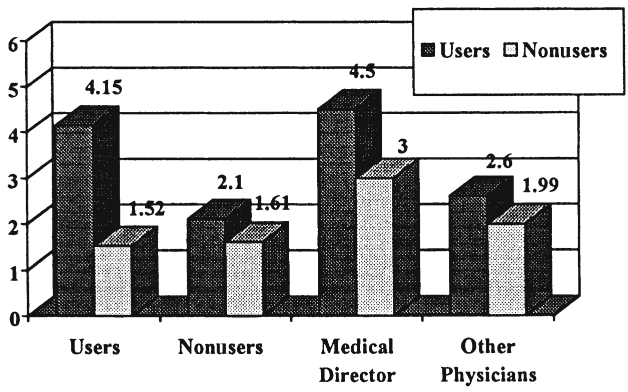


**Figure 8.6.** Frequency of communication with other examiners and physicians. (Score: 0 = no contact to 6 = several times a day.)

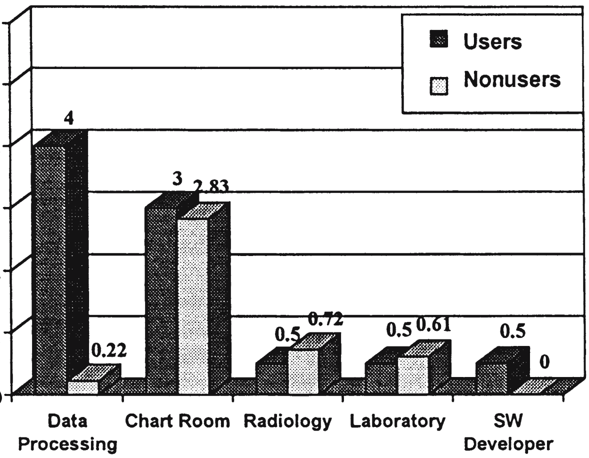


**FIGURE 8.7.** Frequency of communication with other department staff. (Score: 0 = no contact to 6 = several times a day.)

CompuHx and between nonusers and others in the department was much less frequent.

Figure 8.7 shows the frequency of communication with other department staff. CompuHx users communicated with staff in the data processing department several times a week on average. Nonusers rarely communicated with this department. Communication with the other departments was about the same for both users and nonusers of the system.

Figure 8.8 illustrates the communication patterns for users and nonusers of the CompuHx system. Densities of communication within and between groups are shown. In comparison to nonusers, CompuHx users have higher densities of communication with one another and with nonusers of the system, the medical director, other physicians in the department, and other departments in general.

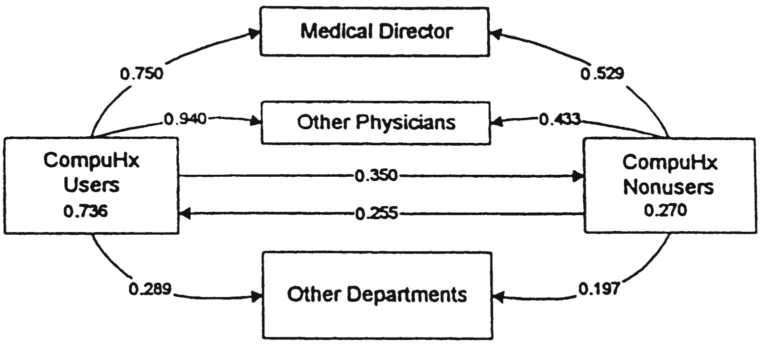


**FIGURE 8.8.** Network density of CompuHx users and nonusers. (Reprinted with permission from CE Ayding, JG Anderson, PN Rosen, VJ Felitti and HC Weng. Computer in the consulting room: A case study of clinician and patient perspectives. *Healthcare Manag. Sci.* 1 (1988) 61–74.)

The study found that nurse practitioners and physician assistants who used the CompuHx system in their practice communicated more frequently with one another and with other staff who could assist them in performing their professional duties. These communication patterns may have important implications for quality of care and productivity of the department. Other studies indicate that the more co-workers an individual worker communicates with about a new technology, the more productive he or she is likely to be in using the system [24–26].

## Computer-Mediated Collaborative Design

The importance of multi-institutional collaboration in medical informatics is increasing. Collaboration allows geographically dispersed institutions and investigators to share resources, to pool expertise, and to standardize tools and methods [27]. Developments in information technology such as the Internet make collaboration at a distance feasible. This study evaluated the InterMed Collaboratory, an Internet-based medical informatics project that involved four institutions [28]. The purpose of the project is to further the development and sharing of software, data sets, procedures, and tools that support the development of new biomedical and clinical applications.

A sociometric analysis was undertaken to measure patterns of interaction among participants in the project [29]. E-mail communication among participants over a 96-week period was analyzed. In Figures 8.9 and 8.10

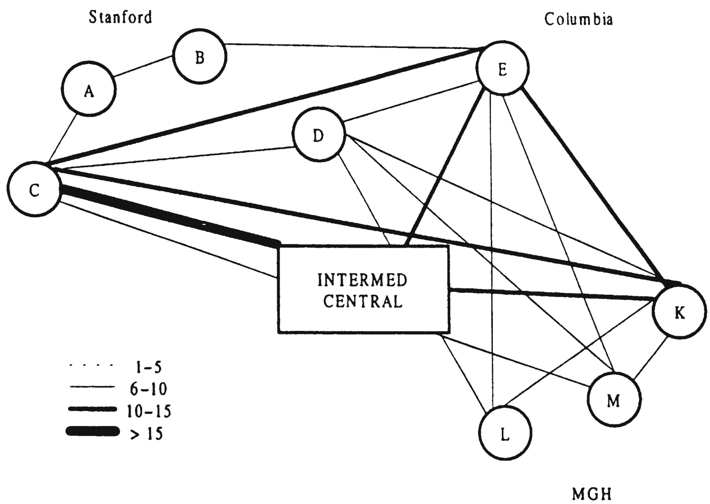


**Figure 8.9.** Sociometric graph of e-mail communication between members of the InterMed group in January and February 1995. (Reprinted with permission from VL Patel, DR Kaufman, VG Allen, EH Shortliffe, JJ Cimino, and RA Greenes. Toward a framework for computer-mediated collaborative design in medical informatics. *Methods Inform. Med.* 38 (1999) 158–176.)

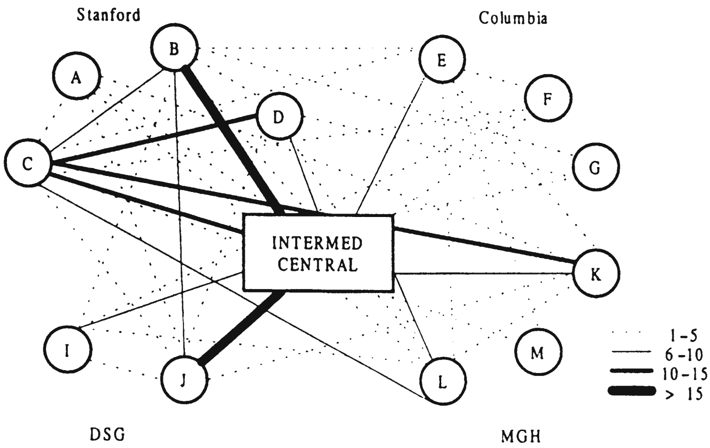


**Figure 8.10.** Sociometric graph of e-mail communication between members of the InterMed group in January and February 1996. (Reprinted with permission from VL Patel, DR Kaufman, VG Allen, EH Shortliffe, JJ Cimino and RA Greenes. Toward a framework for computer-mediated collaborative design in medical informatics. *Methods Inform Med*. 38 (1999) 158–176.)

each node represents a participant from one of four principal sites. InterMed Central is the e-mail distribution list for the entire project.

A comparison of the two networks indicates that participation in the project and communication among participants increased over time. E-mail activity related to guideline development during January and February 1995 was limited. During this period, there were only 45 messages sent between eight participants from three sites. Two individuals, C and E, communicated frequently with the list serve and with individuals at two of the other sites. No members of the DSG group participated during this period.

This reflected a period during which the collaboratory was working on many different activities including creating a common vocabulary and designing clinical guidelines that could be accessed over the Internet. In general, there was a lack of consensus on the goals of the InterMed Collaboratory. Individual roles and tasks were not clearly delineated and areas of focus were unspecified.

Figure 8.10 depicts the communication patterns among participants during April 1996. By this time, the number of participants in the project and the volume of communication had doubled. Eleven active participants generated a total of 107 e-mail messages during this four-week period. Many more of the participants communicated with the list serve at InterMed Central. Individuals B and J appear to have provided leadership on projects underway at this time. Group activities involved intense efforts to complete guideline models and data sets. The distribution of roles and tasks were clearer and more efficient that at the outset of the project.

The results of the analysis of e-mail communication support the findings that the computer-mediated collaboratory design process led to the evolution and refinement of project goals. Over time there was greater differentiation and clarification of individual roles. This led to greater participation from all of the sites involved in the InterMed collaboratory.

## Discussion

This chapter demonstrates how social network analysis can be used in evaluating responses to and the impact of the introduction of medical informatics applications into practice settings. The adoption, diffusion and use of information technology in practice settings are influenced by characteristics of the organization's structure and by relationships among individuals and units that make up the organization. The distinguishing characteristic of this approach is that it uses information about relations between individuals and organizational units and their attributes to understand individual and organizational behavior.

From this perspective, the practice setting is conceptualized as a structure of relations among healthcare providers, departments, or organizations. The behavior of providers or units making up the network is explained in terms of the structure of relations in which the behavior occurs. Analyses of these social networks can be used to identify influential individuals or opinion leaders who are critical in the introduction of new information technology. As demonstrated by one application, these influential individuals can be enlisted in planning and implementing new information technology. Evaluation of social networks also helps the investigator to better understand the dynamics of the introduction of new systems or applications into practice settings. In one example, nurse practitioners and physician assistants responded to the introduction of computers into the examining rooms by intensifying their communication with one another and with other practitioners and departments. In a second application, social network analysis indicated that communication patterns among participants in a multi-institutional collaborative project increased significantly over time. The analysis identified individuals who provided leadership on projects.

## Summary

Social network analysis can be used to analyze relationships among healthcare providers, departments within healthcare organizations and other organizations. Information obtained using this evaluative methodology can be used to identify influential individuals or opinion leaders who are critical to the successful implementation of medical informatics applications. This methodology can also be used to better understand changes in communication patterns or other interactions over time. Several examples that illustrate this evaluation methodology are presented.

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## *References*

[1] J.G. Anderson and S.J. Jay, Physician utilization of computers: a network analysis of the diffusion process, in: L. Frederiksen, A. Riley, editors, *Computers, People and Productivity* (Haworth Press, New York, 1985), pp. 21–36.
[2] J.G. Anderson, S.J. Jay, H.M. Schweer, and M.M. Anderson, Diffusion and impact of computers in organizational settings: empirical findings from a hospital, in: G. Salvendy, S.O. Sauter, J.J. Hurrell Jr., editors, *Social, Ergonomic and Stress Aspects of Work with Computers* (Elsevier, New York, 1987), pp. 3–10.
[3] J. Kimberly and M. Evanisko, Organizational innovation: The influence of individual, organizational and contextual factors on hospital adoption of technological and administrative innovations, Acad. Manag. J. 24 (1981) 689–713.
[4] R.E. Rice, A. Grant, J. Schmitz, and J. Torobin, Individual and network influences on the adoption and perceived outcomes of electronic messaging, Soc. Networks 12 (1) (1990) 27–55.
[5] J.K. Stross and W.R. Harlan, The dissemination of New Medical Information, J. Am. Med. Assoc. 241 (1979) 2822–2824.
[6] C. Aydin and R.E. Rice, Bringing social worlds together: Information systems as catalysts for interdepartmental interactions, J. Health Soc. Behav. 33 (1992) 168–185.
[7] C.E. Aydin, Occupational adaptation to computerized medical information systems, J. Health Soc. Behav. 30 (1989) 163–179.
[8] J.G. Anderson and C.E. Aydin, Overview: Theoretical perspectives and methodologies for the evaluation of healthcare information systems, in: J.G. Anderson, C.E. Aydin, S.J. Jay, editors, *Evaluating Healthcare Information Systems: Methods and Applications* (Sage Publications, Thousand Oaks, CA), 1994, pp. 5–29.
[9] J.G. Anderson and C.E. Aydin, Evaluating the impact of healthcare information systems, Int. J. Technol. Assess. Healthcare 13 (1997) 380–393.
[10] R.E. Rice and J.G. Anderson, Social networks and healthcare information systems, in: J.G. Anderson, C.E. Aydin, S.J. Jay, editors, *Evaluating Healthcare Information Systems: Methods and Applications* (Sage Publications, Thousand Oaks, CA, 1994), pp. 135–163.
[11] T.W. Valente, *Network Models of the Diffusion of Innovations* (Hampton Press, Cresskill, NJ, 1995).
[12] D. Knoke and J. Kuklinski, *Network Analysis* (Sage, Newbury Park, CA, 1982).
[13] J. Scott, *Social Network Analysis: A Handbook* (Sage, Newbury Park, CA, 1991).
[14] R.E. Rice, Computer-mediated communication and organizational innovation, J. Commun. 37 (4) (1987) 65–94.
[15] R.E. Rice, Computer-mediated communication system network data: Theoretical concerns and empirical examples, Int. J. Man–Machine Stud. 30 (1990) 1–21.

[16] J.G. Anderson, S.J. Jay, H. Schweer, M. Anderson, and D. Kassing, Physician communication networks and the adoption and utilization of computer applications in medicine, in: J.G. Anderson, S.J. Jay, editors, *Use and Impact of Computers in Clinical Medicine* (Springer, New York, 1987), pp. 185–199.
[17] J.G. Anderson and S.J. Jay, Computers and clinical judgment: The role of physician networks, Soc. Sci. Med. 20 (10) (1985) 969–979.
[18] P. Arabie, S.A. Boorman, and P.R. Levitt, Constructing blockmodels: How and why, J. Math. Psychol. 17 (1978) 21.
[19] J.G. Anderson, S.J. Jay, J. Perry, and M.M. Anderson, Diffusion of computer applications among physicians: A quasi-experimental study, Clin. Soc. Rev. 8 (1990) 116–127.
[20] I.N. Purves, Implications for family practice record systems in the USA: Lessons from the United Kingdom, *Proceedings of the American Medical Informatics Association, Spring Congress*, St. Louis, MO (1993), p. 54.
[21] G.L. Solomon and M. Dechter, Are patients pleased with computer use in the examination room? J. Family Practice 41 (3) (1995) 241–244.
[22] J.G. Anderson, H.C. Weng, C.E. Aydin, P.N. Rosen, and V.J. Felitti, Computers in the examining room: Evaluating the social impact on practice patterns, in: J.N.D. Gupta, editors, *Association for Information Systems, Proceedings of the American Conference on Information Systems*, Indianapolis (August 15–17, 1997), Association for Information Systems, Georgia State University, Atlanta, pp. 909–911.
[23] C.E. Aydin, J.G. Anderson, P.N. Rosen, V.J. Felitti, and H.C. Weng, Computers in the consulting room: A case study of clinician and patient perspectives, Healthcare Manag. Sci. 1 (1998) 61–74.
[24] M.J. Papa, Communication network patterns and employee performance with new technology, Commun. Res. 17 (1990) 344–368.
[25] J.G. Baggs, S.A. Ryan, C.E. Phelps, J.F. Richeson, and J.E. Johnson, The association between interdisciplinary collaboration and patient outcomes in a medical intensive care unit, Heart Lung 21 (1) (1992) 18–24.
[26] A.B. Flood, The impact of organizational and managerial factors on the quality of car in healthcare organizations, Med. Care Rev. 51 (4) (1994) 381–428.
[27] R.T. Kouzes, J.D. Myers, and W.A. Wulf, Collaboratories: Doing science on the internet, IEEE Comp. 229 (1996) 40–46.
[28] E.H. Shortliffe, V.L. Patel, J.J. Cimino, G.O. Barnett, and R.A. Greenes, A study of collaboration among medical informatics laboratories, Artif. Intell. Med. 12 (1998) 97–123.
[29] V.L. Patel, D.R. Kaufman, V.G. Allen, E.H. Shortli, J.J. Cimino, and R.A. Greenes, Toward a framework for computer-mediated collaborative design in medical informatics, Methods Inform. Med. 38 (1999) 158–176.