THE EFFECT OF ICT ENABLED SOCIAL NETWORKS ON PERFORMANCE

Kon Shing Kenneth Chung and Liaquat Hossain

School of Information Technologies, University of Sydney, Camperdown, NSW 2006, Australia

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Abstract: Research in sociology of information and technology use highlight the importance of information and communication technology (ICT) for supporting networks among professional peers. This paper explores the effects of different types and patterns of ICT usage for supporting professional networks. In this study, we ask—how can different types ICT help support professional networks? What are the implications of patterns of ICT usage on supporting professional networks? Given an association between ICT types, usage, network structure for supporting professional networks, what are its implications on performance? In our study, we apply the theory of structural holes and its underlying assumptions (i.e., efficiency and effectiveness) to develop a theoretical framework and propositions for exploring interlock between types and patterns of ICT usage, network structure, and professional support networks for measuring the performance of effective clinical care. Empirical evidence from Australian rural general practitioners' data show that both network structure and Internet-enabled ICT use play a crucial role when it comes to performance in the medical consultation.

1 INTRODUCTION

The introduction of information and communication technologies (ICT) into organisations and occupational communities has produced unfathomed changes in work patterns and communication structure (1991). Literature in Information Systems widely recognises that ICT allows for synergistic goal achievement when used and aligned properly with the task at hand (Goodhue et al., 1995). In general practice, a number of studies highlights the extent of computerisation in general practice, although recent studies have surveyed actual use of ICT by general practitioners (GPs). Australian national surveys on ICT use by GPs was conducted in 1998 (Nielsen, 1998), 2001 (Western et al., 2001), and most recently in 2006 (Henderson et al., 2006; McInnes et al., 2006). Although these studies explore the use of ICT for clinical tasks in general practice, none questions its use for communication with peers, especially in rural practice. Building upon theories of social network structure, we introduce a conceptual model for exploring the relationship between network structure, ICT use and attitudes to processes of medical care. We associate density, efficiency and effective size of a GP's professional network with attitudes to processes of medical care. Based on literature on impacts of technology use, we also explore task-level effects and communication-structural effects on attitudes to medical care. Preliminary results show that while professional networks are important, internet-enabled ICT use rather than ICT use for clinical tasks accounts higher for performance in the medical consultation. The following section discusses the importance of professional networks and ICT use in the context of rural general practice.

2 CONTEXT OF THE STUDY

The first study conducted nationally in Australia claimed that computers were present in 31% of Australian general practices (Nielsen, 1998). In 2001, this figure increased to 86% (with a likelihood of 95% of Australian general practices to be computerised by 2005), indicating that Australian general practices were highly computerised (Western et al., 2003). The study also showed that GPs practising in capital cities were less likely to be computerised than in the rural practices. The primary reason was because rural GPs were

geographically distant from other health care centres, general practices, and hospitals. McInnes et al's (2006) recent study found that Australian general practice has achieved near-universal clinical computerisation, although Henderson et al's (2006) study show that GPs are still reluctant to fully embrace the technology. Both studies confirm Western et al's (2001; 2003) speculation that Australian general practices are more likely to use computers for administrative rather than clinical tasks.

2.1 Research Questions

It is interesting that ICT is hardly used as a communication medium amongst GPs in Australia. Given the significant problems that characterise the rural GP workforce, empirical studies highlighting GPs' professional support network structure related with ICT use are relatively few. The motivating questions for this research are thus —what are the implications of patterns of ICT usage on supporting professional networks? Is there any correlation between patterns of ICT usage and the social network structures of the professional networks? Can we make any distinction between the types, usage patterns, and network structure for supporting professional network? Given an association between types, usage, network structure for supporting professional networks, what are the implications on performance? How do these factors relate to improved performance of the knowledge intensive work groups?

3 THEORETICAL MODEL

In the following section, we discuss the development of the constructs of our conceptual model based on literature review.

3.1 Performance: Attitudes to Care

General practice is the "provision of primary continuing comprehensive whole patient medical care" (RACGP, 2004). Therefore, we regard the *'process of care'* dimension provided by GPs to patients as relevant for the study. In particular, we are interested in the *effectiveness* of the GP in delivering clinical and interpersonal care. Previous studies show that comprehensively measuring the GP's attitude towards these dimensions of care comes closest to measuring their actual behaviour (Cockburn et al., 1987; Howie et al., 1992). Research in social psychology suggests that a

person's attitude towards an object may be related to the overall pattern of a person's response to that object (Ajzen et al., 1980). In other words, the attitude towards behaviours is a direct determinant of the behavioural intention to perform the behaviour. It can therefore be argued that perceptions that the GPs hold are likely to influence their behaviour in the consultation.

3.2 Network Structure

A social network consists of a group of human actors that have relationships or ties amongst themselves (Scott, 2000). Since 1970s, social networks have been regarded as a promising concept for becoming a unifying framework in clinical practice (Erickson, 1975) and hospital settings (Anderson et al., 1985; West et al., 1999). In general, social networks theory and practice is regarded useful for clinical practice in location of resources and serves as an interpreter of help-seeking behaviour and utilisation of services. Numerous studies have documented GPs' need for immediate access to information and the importance of the social network of peers and colleagues. As Dee and Blazek (1993, p. 263) maintains, "…colleagues are familiar, reliable, immediately available, and inexpensive; they give concise, organised answers that synthesize available information". The value of a social contact is hence much more profound in rural areas, where the existence of social networks amongst GPs is highly valued.

Structural properties of social networks have been known to bear significant impacts on an individual's performance. Granovetter (1973) argues that individuals are more likely to benefit from novel information if they capitalise on weak ties in their social network. This implies actors ought to maintain a number of weak ties in order to capitalise on information benefits. Coleman (1988) argues that closure, or closed networks, enables individuals to combine forces, and provide collective sanctions and thus create trust by ensuring that obligations and promises are kept and norms are followed. Thus, denser networks attain higher closure. Previous studies have shown that denser ties in an individual's social network is conducive to intellectual performance (Coleman, 1988), job performance (Sparrowe et al., 2001) and knowledge-sharing (Cross et al., 2004). Burt (1992) however, takes on a structural perspective by suggesting that dense networks are far more inefficient than sparse networks because (1) they are costly to maintain, and (2) they provide redundant information. Structural holes theory is based on the idea that

actors are in a better position to benefit from their interactions and transactions with others if actors are connected to others who are not connected themselves or well organised. Thus, an optimised network yields information benefits through non-redundancy. Optimisation of a social network of an individual is measured by effectiveness and efficiency of one's personal network. Efficiency is about the channels of access offered by a primary contact (broker) in a brokerage position to access all others (ie. secondary contacts) in the network. Effectiveness is about the total number of contacts reached along with all the primary contacts. Effectiveness is hence the yield of the entire network. In the context of rural GPs, we propose the following:

- **Proposition 1:** *Density of a rural GP's network is positively associated with attitudes to process of care*
- **Proposition 2:** *Effectiveness of a rural GP's social network is positively related with attitudes to process of care*
- **Proposition 3:** *Efficiency of a rural GP's social network is positively related with attitudes to process of care*

3.3 ICT Use: Clinical and Internet based

ICTs are replacing traditional resources for developing an actor's social network (Nardi et al., 2000) as they shape personal networks and re-draw social boundaries. Therefore, a significant construct in our model is *'ICT use'*. Computer supported social networks (Wellman, 1996) that connect people sustain ties that provide information and social support in both specialized and broadly-based relationships. Katz and Rice (2002) consider the Internet as having great potential for connectivity without much intention or social cost. This is particularly useful for occupational groups such as dispersed rural GPs who find maintenance of ties with peers and communities difficult and expensive (Pickering et al., 1995). ICT use hence fosters the connection of ties and contributes to the growth of social capital by supporting many-to-many information exchanges among geographically dispersed people.

At the task-level, research on ICT use by GPs extend beyond informatics in hospitals and specialty medicine to include computing in general practice settings (Aydin et al., 1997). ICT use contributes to process of care by providing benefits to GPs such as better storage and retrieval of information, consistent and accurate records, improved drug management,

and integration of clinical and administrative functions (Nielsen, 1998). It appears that ICT is utilised, and is a good fit with the general practice tasks it supports (Goodhue et al., 1995). Given the above arguments, we derive the following propositions:

- **Proposition 4:** *Frequency of use of ICT by rural GP for clinical-tasks is positively associated with attitudes to process of care*
- **Proposition 5:** *Frequency of use of ICT by rural GP for internet-based tasks is positively associated with attitudes to process of care*
- **Proposition 6:** *ICT use significantly moderates the interaction between network structure and process of care*

4 RESEARCH METHODOLOGY

The following section discusses the operational model highlighting the significance of ICT use as a variable that moderates the inherent relationship between network structure and process of care attitudes.
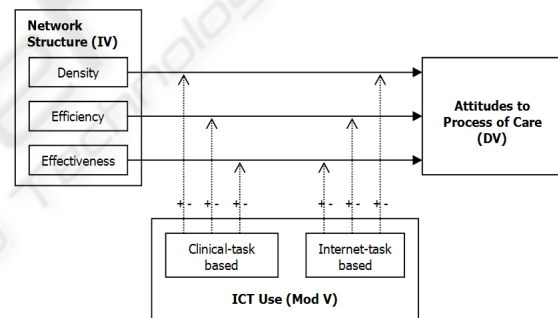

Figure 1: Operational Model for the Research.

4.1 Egocentric Network Approach

In the egocentric approach, the actor is the "ego" and his affiliates, advisors, or friends, are known as "alters" (Scott, 2000). Name generators are used to elicit alters' names. To elicit names from a GP's professional network, we asked:

"Looking back over the last six months, please identify people (up to 15 maximum) who are important in providing you with information or advice for providing care to patients."

Other name interpreter items solicited were strength of each tie, measured by "time known the person", "frequency of interaction", "type of relationship", and "degree of closeness" (Marsden et al., 1984). Attribute data about frequency of

interaction via email, telephone (including mobile), and video conferencing were also included in the instrument to segregate face-to-face and ICT media interactions. Finally, we asked GPs to determine how the members of their professional network relate to each other based on a five point degree of closeness scale ranging from 'especially close' to 'do not know each other'.

4.2 Survey Administration

The original survey was pre-piloted amongst a group of 5 students (in the research laboratory) and three rural GPs. Experts in the domain of general practice, including former president of a rural doctor's association in Australia, professor and head of discipline of general practice in a renowned university, and rural GPs vetted the survey instrument, which was then pre-tested for comprehension and ease-of-use. Finally, the survey was administered in two phases: first to sixty rural GPs practising in a southern region of rural NSW with nineteen responding (response rate: 31%); second to 46 GPs in a rural doctors conference with 17 responding (response rate: 37%). Administration was personal, which allowed for capturing of survey duration, respondent reaction and errors in the survey, which we eventually rectified.

4.3 Measures

Density is the ratio of existing number ties to the maximum possible ties possible. *Effectiveness* is a measure of the number of alters minus the average degree of alters within the ego network, not counting ties to the ego. *Efficiency* is measured by dividing effectiveness by the number of alters in the ego's network.

For performance, we adapted Cockburn et al's (1987) validated instrument to measure four dimensions of care: mutuality, communication, responsibility for decisions and appropriateness of consultations.

Clinical ICT task measures were based on the reliable and valid item sets used by Western et al (2001) and includes items such as frequency of using ICT for "Generating health summaries", "Writing prescriptions", and so on, measured on a five point scale ranging from 'Daily use' to 'Never'. Internet task items were adapted from Andrews et al's (2004) and included "accessing medical journals", "accessing databases", "consultation with colleagues", and so on.

5 RESULTS

There were 36 responses in total. However, 5 specialised in areas such as gynaecology and orthopaedics, and were excluded from the analysis. Of the remaining 29 GPs, the mean number of years practised in a rural setting was 17.21 years (max=40 years; min=1 year).

To associate network structure, ICT use and the dimensions of care, we ran a multiple regression based on the four dimensions of care – communication, mutuality, decision responsibility, and appropriate consultation as the dependent variable. We used density, efficiency and effective size of the network as the network predictor variables (model 1) and ICT use for clinical functions and ICT use requiring internet functions as the second block of predictor variables (model 2).

5.1 Communication Dimension

Table 1: Model summary for Communication Dimension.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.405(a)	.164	.059	5.67385
2	.408(b)	.166	-.023	5.91807

(a) Predictors: (Constant), Network Density, Effective Size, Efficiency; (b) Predictors: (Constant), Network Density, Effective Size, Efficiency, Internet Functions, Clinical Functions

Our results indicate a multiple R of 0.405 (model 1) and 0.408 (model 2), which shows substantial correlation between the predictor variables and the variable 'communication', where approximately 16% of the variance in 'communication' is explained by the two blocks of predictor variables. In model 1, effective size bears greatest influence on 'communication' ($\beta=0.002$). In model 2, ICT use (requiring Internet) bears greatest influence on 'communication' ($\beta=0.066$).

5.2 Mutuality Dimension

Table 2: Model Summary for Mutuality Dimension.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.417(a)	.174	.071	4.11406
2	.431(b)	.186	.001	4.26593

(a) Predictors: (Constant), Network Density, Effective Size, Efficiency; (b) Predictors: (Constant), Network Density, Effective Size, Efficiency, Internet Functions, Clinical Functions

There is substantial correlation between the predictor (independent) variables and the dependent variable 'communication' (R = 0.417 and 0.431 respectively), where approximately 17-18% of the variance in 'mutuality' is explained by the two blocks of predictor variables. In model 1, effective size bears greatest influence on 'mutuality' (β=0.209). In model 2, effective size bears greatest influence on 'mutuality' (β=0.204), followed by ICT use (requiring Internet) (β=0.134).

5.3 Decision Responsibility Dimension

Table 3: Model Summary for Decision Responsibility.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.316(a)	.100	-.013	3.20666
2	.363(b)	.132	-.066	3.28896

(a) Predictors: (Constant), Network Density, Effective Size, Efficiency; (b) Predictors: (Constant), Network Density, Effective Size, Efficiency, Internet Functions, Clinical Functions

The results indicate considerable correlation between the predictor (independent) variables and the dependent variable 'decision responsibility' (R = 0.316 and 0.363 respectively), where approximately 10-13% of the variance in 'decision responsibility' is explained by the two blocks of predictor variables. In model 1, effective size bears greatest influence on 'decision responsibility' (β=0.127). In model 2, effective size also bears greatest influence on 'decision responsibility' (β=0.240), followed by ICT use (requiring Internet) (β=0.116).

5.4 Appropriate Consultation Dimension

Table 4: Model Summary for Appropriate Consultation.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.070(a)	.005	-.120	6.35078
2	.260(b)	.068	-.144	6.42042

(a) Predictors: (Constant), Network Density, Effective Size, Efficiency; (b) Predictors: (Constant), Network Density, Effective Size, Efficiency, Internet Functions, Clinical Functions

There is considerable correlation between the predictor (independent) variables and the dependent variable 'appropriate consultation' (R = 0.070 and 0.260 respectively), where approximately 6% of the variance in 'appropriate consultation' is explained by predictor variables in the second model. Model 2 also indicates that efficiency (β=0.796) and network density (β=0.779) bears greatest influence on 'appropriate consultation', followed by ICT use (requiring Internet) (β=0.343). This is probably true because GPs are known to consult with their peers and specialists for appropriate treatment. In such cases, GPs consult those who can provide information benefits to them in the shortest amount of time (efficiency). Furthermore, it also indicates that GPs who use internet functions (eg. for communicating with peers and for accessing educational materials) are more likely to provide appropriate consultations.

6 CONCLUSION

Although our results are limited and not generalisable to the population of GPs in Australia, it shows that while individual professional network properties are important in explaining process of care attitudes, ICT use that required internet access was equally important. GPs who used the internet for communication (with professional networks of peers, special interest groups) and accessing online materials were better in communicating with patients, making decision responsibilities, and conducting appropriate consultations. Such GPs also shared mutuality with their patients. ICT use for clinical tasks did not contribute to either of the dimensions of care. This is most likely the case because GPs in the consultation process do not usually have time to retrieve and digest information from most forms of ICT (Bolton, 2006). At best, ICT for clinical tasks are useful for quality assurance such as checking drug interactions. Our results also confirmed that effective size (or reach in the network) was the most important predictor of communication, decision responsibility and mutuality dimensions of care. Efficiency (or access to novel and useful information) and network density (closure), on the other hand, were most important predictors for appropriate consultation.

REFERENCES

Ajzen, I., & Fishbein, M., 1980. *Understanding Attitudes and Predicting Social Behavior*. Engelwood Cliffs New Jersey: Prentice Hall.

Anderson, J. G., & Jay, S. J., 1985. Computers and Clinical Judgement: The Role of Physician Networks. *Social Science & Medicine, 20*(10), 969-979.

Andrews, J. E., Pearce, K. A., Sydney, C., Ireson, C., & Love, M., 2004. Current State of Information Technology Use in a US Primary Care Practice-based Research Network. *Informatics in Primary Care, 12*(1), 11-18.

Aydin, C. E., & Forsythe, D. E., 1997, 25th-29th October. *Implementing Computers in Ambulatory Care: Implications of Physician Practice Patterns for System Design.* Paper presented at the Proceedings of the American Medical Informatics Association 1997 Annual Fall Symposium, Nashville.

Bolton, P. G. M., 2006. Information Mastery and 21st Century General Practice. *The Medical Journal of Australia, 185*(2), 94.

Burt, R. S., 1992. *Structural Holes: The Social Structure of Competition.* Massachusetts: Harvard University Press.

Cockburn, J., Killer, D., Campbell, E., & Sanson-Fisher, R. W., 1987. Measuring General Practitioners' Attitudes Towards Medical Care. *Fam. Pract., 4*(3), 192-199.

Coleman, J. S., 1988. Social Capital in the Creation of Human Capital. *The American Journal of Sociology, 94*, S95-S120.

Cross, R., & Cummings, J. N., 2004. Tie and Network Correlates of Individual Performance in Knowledge-Intensive Work. *Academy of Management Journal, 47*(6), 928-937.

Dee, C., & Blazek, R., 1993. Information Needs of the Rural Physician: A Descriptive Study. *Bulletin of the Medical Library Association, 81*(3), 259-264.

Erickson, G. D., 1975. The Concept of Personal Network in Clinical Practice. *Family Process, 14*(4), 487-498.

Goodhue, D. L., & Thompson, R. L., 1995. Task-Technology Fit and Individual Performance. *MIS Quarterly, 19*(2), 213-236.

Granovetter, M. S., 1973. The Strength of Weak Ties. *The American Journal of Sociology, 78*(6), 1360-1380.

Henderson, J., Britt, H., & Miller, G., 2006. Extent and Utilisation of Computerisation in Australian General Practice. *The Medical Journal of Australia, 185*(2), 84-87.

Howie, J. G. R., Hopton, J. L., Heaney, D. J., & Porter, A. M. D., 1992. Attitudes to Medical-Care, the Organization of Work, and Stress among General-Practitioners. *British Journal of General Practice, 42*(358), 181-185.

Katz, J. E., & Rice, R. E., 2002. *Social Consequences of Internet Use: Access, Involvement, and Interaction* (1st Edition ed.). London: MIT Press.

Marsden, P., & Campbell, K. E., 1984. Measuring Tie Strength. *Social Forces, 63*, 482-501.

McInnes, D. K., Saltman, e. C., & Kidd, M. R., 2006. General Practitioners' Use of Computers for Prescribing and Electronic Health Records: Results from a National Survey. *The Medical Journal of Australia, 185*(2), 88-91.

Nardi, B. A., Whittaker, S., & Schwarz, H. (2000). It's Not What You Know: Work in the Information Age. Retrieved 12th January, 2005, from http://www.firstmonday.org/issues/issue5_5/nardi/index.html

Nielsen, A., 1998. *A Study into Levels of, and Attitudes Towards Information Technology in General Practice* (No. S2587/NG2132). Sydney: Commonwealth Department of Health and Family Services.

Pickering, J. M., & King, J. L., 1995. Hardwiring Weak Ties: Interorganizational Computer-mediated Communication, Occupational Communities, and Organizational Change. *Organization Science, 6*(4), 479-486.

RACGP. (2004). Rural General Practice - Definition. Retrieved 14th November, 2004, from http://www.racgp.org.au/document.asp?id=15301

Scott, J., 2000. *Social Network Analysis: A Handbook.* London: SAGE Publications.

Sparrowe, R. T., Liden, R. C., Wayne, S. J., & Kraimer, M. L., 2001. Social Networks and the Performance of Individuals and Groups. *Academy of Management Journal, 44*, 316-326.

Sproull, L., & Kiesler, S., 1991. *Connections: New Ways of Working in the Networked Organization.* Cambridge: MIT Press.

Wellman, B., 1996. *For a Social Network Analysis of Computer Networks: A Sociological Perspective on Collaborative Work and Virtual Community.* Paper presented at the Proceedings of the 1996 ACM SIGCPR/SIGMIS conference on Computer Personnel Research Denver, Colorado, United States

West, E., Barron, D. N., Dowsett, J., & Newton, J., 1999. Hierarchies and Cliques in the Social Networks of Health Care Professionals: Implications for the Design of Dissemination Strategies. *Social Science and Medicine, 48*, 633-646.

Western, M., Dwan, K., Makkai, T., Mar, C. d., & Western, J., 2001. *Measuring IT use in Australian General Practice.* University of Queensland: General Practice Computing Group.

Western, M. C., Dwan, K. M., Western, J. S., Makkai, T., & Mar, C. D., 2003. Computerisation in Australian General Practice. *Australian Family Physician, 32*(3).