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Network Structure, ICT Use and Performance Attitudes of Knowledge Workers

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Abstract

In this study, we examine the effect of social network structure and information and communication technologies (ICT) use on performance attitudes of knowledge-intensive workers in dispersed occupational communities. We first develop a theoretical framework and use it to develop a valid and reliable survey instrument. Secondly, we apply structural hole measures (constraint and efficiency) for exploring the association with ICT use and attitudes to performance. Empirical results suggest that density of knowledge workers' professional network is positively associated with ICT use whereas network efficiency is negatively correlated with ICT use at both task and communication-structure level. The findings show that social network structure measures of density, efficiency and constraint are important factors that influence patterns and frequency of ICT use by knowledge workers rather than attitudes to performance.

Keywords: Social Network, Structure, Information and Communication Technology Use, performance attitude

1 INTRODUCTION

The use of information and communication technologies (ICT) developed recently has caused dramatic changes in task-level processes, workflow and communication structures of individuals and groups. While organizations and knowledge workers recognize the value of ICT use for work, appreciation for the influence of social contexts and networks that underpin the use of ICT and its impact on performance remains unclear. Information systems (IS) research has shown that ICT use influences task performance and social networks studies have associated ICT use with communication structure. However, literature on the interaction effects and joint effects of these concepts are relatively few. For instance, Kraemer and Danziger (1990) assessed the impact of information technologies use on decision making, productivity, and job enhancement. Pickering and King (1995), on the other hand, examined the use of information and communication technologies (ICT) in organizations and highlight the role of ICT in maintaining weak ties, especially between dispersed occupational communities. Recent research evidence indicate a positive relationship between ICT and productivity, and that structure and size of communication networks of individuals are highly correlated with performance (Aral et al., 2006).

In this paper, we examine the inherent relationships between patterns of ICT use, professional network structure and individual self-performance ratings by developing a theoretical framework based on these constructs. By ICT use, we focus on the use of information and communication technologies in a professional context for achieving a certain set of tasks as well as for the purpose of communication to obtain information for accomplishing the task(s). By obtaining a pattern of ICT use, we examine its correlation with the individual's network structure, which is measured by his or her ability to obtain information (efficiency and constraint), and its relationship with performance, which is measured by the individual's performance attitude about various dimensions of task-level activities. The next section provides the theoretical basis and justification of the hypotheses for the study followed by survey development procedure, methodology, results and discussion.

2 CONCEPTUAL FOUNDATIONS

2.1 Social Network Analysis, Network Structure and Performance

By social network, we mean a constituent of two or more actors (individuals) who are connected through one or more relationships such as providing advice, information and so on. Social network studies have long been concerned with exploring structural and tie effects with a view to illuminating and explaining patterns of relationships for inferring some outcome. For social network scholars, the raison d'être is that the structure of relations among actors and the location of individual actors in the network have important behavioral, perceptual and attitudinal consequences both for the individual units and for the system as a whole. At the individual level, the debate concentrates on how the structural position of an individual in the network impacts outcome, such as performance, of that person.

Beginning with early literature about communication patterns and performance of groups and individuals in organizational contexts, researchers demonstrated that, rather than being remote, impersonal, and rigid, knowledge intensive work was actually communal, reflecting a strong interpersonal network of interconnected workers. The studies also suggested that informal networks were equally or more important than formal networks in knowledge intensive work, with the premise being that individual performance was a function of network structure (Gabbay and Leenders, 2001). In fact, studies relating network structures to performance have shown that in-degree centrality, betweenness centrality and density in network structures such as advice networks were related to coordination and project related performance (Hossain et al., 2006).

In knowledge-intensive work, literature on relational aspects of network structure show that weak ties play a crucial role in fostering innovation diffusion and knowledge exchange. Individuals obtain new and novel information from weak ties rather than from strong ties within the individual's group or clique structure (Granovetter, 1973). Scholars whose work focused on the dichotomy of ties found that weak ties were really important for information search and especially for tasks where the information needed was simple, but strong ties were particularly helpful for transfer of complex knowledge (Hansen, 1999). More generally, an individual's ties to a diverse group of people influenced performance in knowledge-intensive work (Cummings, 2004).

In light of the above, Burt (1992) focuses on structural aspects of an individual's social network and contends that maintaining a large number of ties can be rather costly in terms of information redundancy, and resource and opportunity costs. Instead, by observing whether an individual occupies a structural location within the network, one may be able to suggest his or her capabilities in terms of resource benefits such as information efficiency and the extent to which he or she is constrained by the configuration of the network structure. The *efficiency* of an individual's network is high if the individual has non-redundant contacts and is able to access most, if not all, of the contacts through a primary contact. *Constraint* on the other hand, dictates the extent to which an individual's opportunities are limited by investing the bulk of his or her network time and energy in relationships that lead back to the single contact (Burt, 1992). Efficiency and constraint are thus measures of structural holes and are useful indicators of an individual's ability to produce good ideas, "getting ahead" in terms of job performance and promotion and greater career mobility (Burt, 1992; Podolny and Baron, 1997). Consistent with these arguments, we derive the following hypotheses:

H1: Efficiency of an individual's network position is positively associated with performance attitudes in knowledge-intensive work

H2: Constraint of an individual's network position is negatively associated with performance attitudes in knowledge-intensive work

2.2 ICT Use: Efficiency and Sociological Effects

The introduction of information and communication technologies (ICT) in organizations and occupational communities has produced profound changes in terms of work patterns and communication structure. Literature in Information Systems widely recognizes that ICT allows for adding intellectual content to work and synergistic goal achievement when used and aligned properly with the task at hand (Sproull and Kiesler, 1991). The social influence model of technology use explains ICT use as a function of social presence, cues and relationships more so than the rational choice model (Fulk et al., 1990). To this end, most literature on ICT use are task-level studies of associations between ICT use and productivity (Drury and Farhoomand, 1999). However, the mechanisms by which ICT affect performance in these studies remains poorly modeled and understood (Aral et al., 2006). Furthermore, these studies tend to undermine the significance of ICT in enabling new forms of communication and work organization that overcome synchronous-asynchronous, temporal and spatial barriers (Hinds and Kiesler, 1995).

Generally, the term *ICT use* connotes technology acceptance and is a primary variable which affects individual performance. The technology acceptance model postulated by Davis et al (1989) argues that the degree of user acceptance of technology positively affects the *usage* of technology, which in turn affects performance. Users therefore do not use the technology if it constrains them or does not satisfy the accomplishment of their task or communication purpose. Conversely, the *patterns* and *frequency of usage* of certain ICT by an individual for certain tasks indicates one's willingness, comfort and ease of use, and therefore, acceptance of the technology. According to DeLone and McLean (1992), patterns and frequency of usage of ICT are influential factors of individual impact such as quality, productivity and performance. In Igbaria et al's (1997) study of 625 employees in a large organization, it was found that user satisfaction on individual performance was actually mediated by ICT use, therefore suggesting the ICT use variable as an indicator of performance.

ICT use has been primarily ascertained by measuring the attitudes of individual users in terms of tasks for which it is used, the frequency of use, and perceived ease and comfort of use. Such attitudes of individual users towards ICT are quite important, mainly because a positive attitude is usually indicative of technology acceptance (Mahmood et al., 2000), which in turn allows the user to believe that using the ICT would enhance his or her performance (Davis et al., 1989). The premise of measuring attitudes stems from the theory of reasoned action which describes attitude as a "predisposition to respond favorably or unfavorably to an object, person, event, institution, or another discriminable aspect of the individual's world" (Ajzen, 1988). Therefore, this study argues that attitude towards behavior is a direct determinant of the behavioral intention to perform the behavior.

As indicated earlier, the use of ICT does not impact individuals at the task level only but has also revolutionalized ways in which individuals communicate, acquire, share and utilize information. New developments in ICTs and the Internet have allowed individuals to seek advice, information, collaborate and communicate overcoming temporal and spatial barriers as well as offer new modes of communication (synchronous and asynchronous). The extent to which information or advice is accessed in terms of usefulness, quality and speed are critical to performance of individuals in knowledge-intensive work. Many studies have reported on how communication technologies have extended information reach and enabled acquisition of useful information for individuals (Constant et al., 1994) and occupational communities (Pickering and King, 1995) through weak ties, despite lack of personal connections with others (Constant et al., 1996). Furthermore, individuals tap into online communities and portals where benefits of social support, influence and information advantages are plenty (Butler, 2001). However, such online communities and other artifacts within the online space also serve as a non-relational source of information. For instance, most Internet-based discussion groups provide summaries of communications to its members via email digests, irrespective of whether members participate or lurk. Furthermore, professional associations, company newsletters, online databases, journal repositories and online search engines such as Google provide readily available information matching almost the same credibility and quality as from a relational source (Zimmer and Henry, 2007). In light of these arguments, we state the following hypotheses:

H3: Use of context-specific ICT for task-level activities is positively associated with individual performance attitudes in knowledge-intensive work

H4: Use of Internet-related ICT for communication and task-level activities is positively associated with individual performance attitudes in knowledge-intensive work

H5: Use of ICT for task and communication-level activities is positively associated with ego-density in knowledge-intensive work

H6: Use of ICT for task and communication-level activities is negatively associated with efficiency in knowledge-intensive work

2.3 Network Structure, ICT Use and Individual Performance

Compared to past studies which have only examined impacts on performance using either constructs of network structure or ICT use (without examining in detail their relationships), there have been relatively few efforts designed to increase our understanding of how network structure and patterns and use of ICT influence individual performance. In Papa's (1990) study of the relationship between employee performance with new technology and employee communication network variables (activity, size, diversity and integrativeness) in two corporate offices consisting of 301 employees, it was found that network structure was a significant predictor of speed with which employees increased their productivity ratings. Network diversity, network integrativeness and size were also significant predictors of how quickly employees implemented an innovation in ICT use.

Aral et al's (2006) more recent study of the detailed relationship between information worker output, information flow (measured using betweenness and structural hole measures), information technology, multitasking and project duration (as performance measures) showed that network structure was

highly correlated with performance. The domain of the study was a mid-sized recruitment firm with team-level and individual-level data available. Two significant contributions from the study were: (1) demonstration of detailed task-level evidence of information worker output, and (2) objective measures of information flows through social networks, thereby allowing a higher resolution microscopic view to study organizational phenomena.

2.4 Toward a Social Network-based Model for ICT Use and Performance

A commonality of Papa's (1990) and Aral et al's (2006) studies is that both focused on knowledge-intensive individuals working within the boundaries of an organization defined by corporate structure and hierarchy. In our case, we focus on individuals within organizations which defy such structure and who are rather dispersed across geographical areas, yet having the same occupational values and organizational goals. While both research utilized the sociocentric network approach (social network data gathering approach within fixed boundaries or settings, eg. firms) to gather data from individuals, the novelty of our egocentric study lies in the fact that we are able to highlight a feasible approach for measuring an individual's (1) *personal* and *professional* network for seeking advice (2) extent of *ICT use*, and (3) *performance attitudes* in rural and geographically dispersed settings (discussed in the next section). Furthermore, each knowledge worker's case is quite unique or disparate to some extent depending on the demographics (eg. education, population) characterizing the area they work in.

3 DATA AND METHOD

56 rural general practitioners (GP) within two divisions of rural general practice (south and north of Sydney, New South Wales, Australia) participated in the study. Rural GPs are considered knowledge intensive workers because of the nature of their work – extensive medical expertise, high patient to GP ratio, long work hours, usage of advance medical technologies, provision of diverse healthcare services and so on (Humphreys and Rolley, 1998). In knowledge-intensive work, knowing where and whom to obtain information from is crucial for performance. Problems such as decreasing performance as GPs age, lack of association with professional peers, being updated with modern technology, and isolation from community hinder performance and provide justification for the GPs as knowledge-intensive work subjects for this study (Choudhry et al., 2005; Chung et al., 2005b). These problems make this study potentially important as well.

An initial survey was developed and pre-piloted amongst a group of 5 students within the research laboratory. Ten copies of the survey were then sent out to rural GPs, with only three who responded. With low response rates, 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 were consulted about the survey instrument. Qualitative interviews lasting at least an hour were conducted with these experts individually. Subsequently, the research design and theoretical constructs were further refined. The experts also vetted the instrument, which was then pre-tested for comprehension and ease-of-use. The general response from them was that the design of the network component in the survey was visually complex and confounding. As this not only deters response rates but also add cognitive load to survey completion, advice and suggestions from the experts were accepted and the survey was modified accordingly. The second version of the survey was designed to cater for improved ease of comprehension and completion. Attribute items such as asking whether the GPs were trained overseas or locally were included. Other items to determine whether they were accredited with fellowships from the RACGP (Royal Australian College of General Practitioners) and ACRRM (Australian College of Rural and Remote Medicine) were also included in order to allow for cross demographic comparisons (although not shown in this study). The survey was piloted to 136 rural GPs practising in two different divisions of rural general practice. 56 agreed to fill out the survey thus achieving a response rate of about 41%. The survey was mostly

personally administered in order to allow for capturing of survey duration, respondent reaction and errors in the survey. Only one was administered through telephone and five others through postal mail.

3.1 Egocentric Network Items & Measures

We utilized the egocentric approach for collecting network data because of its practicality and feasibility (Chung et al., 2005a). In this approach, the actor of interest is referred to as the "ego" and the actors referred to by the "ego" as his affiliate, advisor, friend, or relative, are known as "alters" (Scott, 2000). Name generators are used in order to elicit alters' names. In our study, we used the following name generator to elicit names from a GP's professional network:

"By 'professional network', we mean professional people whom you associate, interact or work with for the provision of care to patients (eg. nurses, admin staff, specialists, pathologists, doctors etc.) 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."

Name interpreter questions are also commonly asked to elicit some attribute data about the alters and ties. In our case, we requested GPs to indicate the strength of each tie, measured by "time known the person", "frequency of interaction", "type of relationship", and "degree of closeness" (Marsden and Campbell, 1984). Attribute data about the frequency of interaction via email, telephone (including mobile phone), and video conferencing were also included in the instrument to segregate face-to-face and ICT media interactions.

To determine the relationship between elicited alters in order to complete the network structure, 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'. That is, for each alter nominated, the GP would determine a closeness scale for every other alter. Although this approach has been criticised in the past for its recall reliability and accuracy (Bernard et al., 1985), later studies confirmed that people also remembered long-term or typical patterns of interaction with other people rather well (Freeman et al., 1987). Furthermore, the free recall method elicits a richer data on the social networks of people whereas the fixed choice method influences people to elicit accurate information on the most important relationships (ie. strong ties) (Hammer, 1984).

In order to ascertain efficiency and constraint of an individual within a network, the results should be interpreted in light of the cohesiveness of the network - *Density* or *ego density* (in this case), which is the ratio of existing number ties to the maximum possible ties possible. Mathematically, for an undirected graph with N nodes and N_t ties density D is defined as (Scott, 2000):

$$D = \frac{2N_t}{N(N-1)}$$

Effective size is a measure of the number of alters minus the average degree of alters within the ego network, not counting ties to the ego (Burt, 1992). Effective size of an actor's (ego) network is thus:

$$\sum_j \left[1 - \sum_q p_{iq} m_{jq} \right], \qquad q \neq i, j$$

where *i* is the ego, actor *j* is a primary contact, and actor *q* is also a primary contact who has strong ties with the ego *i* (represented by strong tie - p_{iq}) and actor *j* (represented by marginal tie - m_{jq}). *Efficiency* is measured by dividing the effective size by the number of alters in the ego's network.

Finally, ego c*onstraint* measures the opportunities held back by the extent to which the ego has invested time and energy in relations with alters that lead back to a single contact (Burt, 1992). In other words, it measures the extent to which the ego's connections are to others who are connected to one another. Constraint on an actor's network is defined as:

$$\left(p_{ij} + \sum_{q} p_{iq} p_{qj} \right)^2, \quad q \neq i, j$$

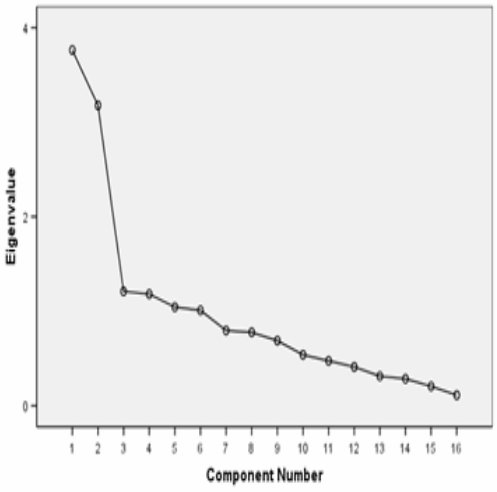
where i is the ego, actor j is a primary contact, and actor q is also a primary contact who has strong ties with the ego i (represented by p_{iq}) and actor j (represented by p_{qj}).

3.2 ICT Use Items

In our study, ICT includes computers, technological software applications and systems such as Medical Director (a customised medical practice software popular among GPs), PDA (personal digital assistants), email, fax, telephone, video conference and so on. Based on Sproull and Kiesler's (1991) categorization of the effects of ICT use as efficiency (task-level) and social (communication-structure) effects, ICT use in our case was divided into *context-specific ICT use* (or task-level activities – eg. clinical tasks) and *internet-related ICT use* (communication and task-level activites). Task-level 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", "Running a recall system to remind patients for routine tests", and so on. The items were measured on a five point scale ranging from 'Daily use' to 'Never'. In our study, the eight items demonstrated excellent internal consistency (Cronbach's $\alpha = 0.954$).

Internet-related ICT use items were adapted from Andrews et al's (2004) and included "accessing medical journals", "accessing databases", "finding information to help patients", "consultation with colleagues", and so on. These item sets were developed by the University of Kentucky's Department of Family Practice in a project supported by the Agency for Healthcare Research and Quality (AHRQ) in the US. In our study, the ten items demonstrated high reliability (Cronbach's $\alpha = 0.911$).

3.3 Performance Attitude Scale Items



Item Description	Factor	
	1	2
Partnership with patient (g8)	0.89	
Be frank and open with patients (g10)	0.74	
Identifying modifiable risk factors (g6)	0.70	
Counseling patients personal problems (g4)	0.70	
Emotional support for patients (g9)	0.60	
Should always inform patients (g2)	0.57	
Listen patient worries (g3)	0.56	
GPs are influential for lifestyle change (g11)	0.42	
Don't help with psychological problems (g16)		0.76
Treating disease is most important (g12)		0.67
Patient involvement in medical decisions (g14)		0.66
Medical expertise wasted (g5)		0.64
GP responsible for medical problems (g17)		0.57
Patients make convenience of me (g7)		0.55
Patients likely to follow GP advice (g13)		0.48
Give up smoking (g1)		0.45

(a) Rotation converged in 6 iterations. Loadings of > 0.4 shown.

Table 1. Scree Plot of Factor Eigenvalues (left) & Pattern Matrix for Medical Care (right)

A validated and reliable questionnaire (Cockburn et al., 1987) for assessing GPs' performance attitudes to medical care to ascertain their perceived effectiveness of clinical and interpersonal care was used in this study, since objective measures of performance were unavailable in this field. In order

to validate the item sets to see if they can be clustered into few dimensions, we conducted a factor analysis by first performing the principal components analysis without rotation on the 17 items. Six factors were extracted with eigenvalues greater than one. These factors accounted for 68.53% of the variance, which is considered adequate in previous research (Hair, 1995). However, the first two factors captured much more of the variance (41.40%) than the other four factors. This was also clearly evidenced from the scree plot (Table 1). Therefore, we decided to retain two factors only. The second step involved performing the exact same steps but rotating the two factors to simple orthogonal structure using direct oblimin rotation with Kaiser normalisation. Finally, items with a high factor loading of at least 0.40 on only one factor in the pattern matrix were retained (Table 1). One item (g15) that loaded relatively high on both factors was discarded. We describe factor 1 as aspects of interpersonal care, and factor 2 as aspects of technical care (Brook et al., 2000; Campbell et al., 2000).

A reliability analysis demonstrated good internal validity for both factors 1 and 2 (Cronbach's α=.756 & .795 respectively). The scores were summed up forming a composite score for technical and interpersonal care.

4 RESULTS

Using SPSS v0.14, we ran a Pearson's bivariate correlation using the following variables – ego constraint, ego efficiency, ego density, ICT use for internet-related tasks, ICT use for task-level activities (ie. clinical tasks), technical care and interpersonal care. Cross tabulations of the demographic variables suggest that 41 are male and 15 are female. Table 2 shows descriptive statistics for the 56 respondents. These include the years in rural practice (mean = 18.7 years), number of practitioners in their current practice (mean = 4.45), hospital appointments, and whether they are accredited with fellowships at different colleges.

Variables - Frequencies	**N**	**Min**	**Max**	**Mean**	**Std. Dev**
Years in rural practice	56	1	42	18.73	11.3
No of GPs in current practice	56	1	12	4.45	2.87
Variables – Cross tabulations	**Male**	**Female**	**Total**		
Hospital appointment – Yes	32	5	37	-	-
Hospital appointment – No	9	10	19	-	-
Total	41	15	56	-	-
FRACGP* member – Yes	19	11	30	-	-
FRACGP* member – No	22	4	26	-	-
Total	41	15	56	-	-
FACRRM** accreditation – Yes	16	2	18	-	-
FACRRM** accreditation – No	25	13	38	-	-
Total	41	15	56	-	-

** Fellowship of the Royal Australian College of General Practitioners*
*** Fellowship of the Australian College of Rural and Remote Medicine*

Table 2. Descriptive Statistics of Demographics

Results from the correlation matrix in Table 3 suggest that there is statistically significant correlation between the network structure and ICT use variables. It is interesting to note that task-based ICT use is positively correlated to the number of GPs in the current practice ($R=.332, p < .05$). Task-based ICT use is also positively correlated to ego-density ($R=.335, p < .05$) but negatively correlated to efficiency ($R=-413, p < .01$). When it came to Internet-based ICT use, there was no significant correlation with the number of GPs in the current practice, but it had significant positive correlations with ego-density ($R=-.273, p < .05$) and negative correlations with efficiency ($R=-.305, p < .05$). There is also high positive correlation with both forms of ICT use (Internet and task-based), where $R=.645, p < .001$.

	1	2	3	4	5	6	7	8	9
1. Years in Rural Practice	1								
2. No of GPs in Current Practice	-.136 (.318)	1							
3. Density	-.102 (.453)	.087 (.523)	1						
4. Constraint	.047 (.731)	-.093 (.496)	.464 (.000**)	1					
5. Efficiency	.121 (.372)	-.119 (.381)	-.981 (.000**)	-.303 (.023*)	1				
6. Interpersonal Care	.102 (.456)	-.106 (.435)	-.023 (.864)	.223 (.099)	.050 (.716)	1			
7. Technical Care	.177 (.191)	-.032 (.816)	-.159 (.241)	.012 (.930)	.174 (.200)	.085 (.531)	1		
8. Task based ICT Use	-.251 (.062)	.332 (.012*)	.335 (.012*)	-.048 (.723)	-.413 (.002**)	-.108 (.427)	.003 (.982)	1	
9. Internet based ICT Use	-.234 (.082)	.174 (.199)	.273 (.042*)	.067 (.623)	-.305 (.022*)	.022 (.873)	.005 (.969)	.645 (.000**)	1

** Correlation is significant at the 0.05 level (2-tailed).*
*** Correlation is significant at the 0.01 level (2-tailed).*

Table 3. Correlation Matrix of Social Network, ICT Use and Performance Variables

5 DISCUSSION & CONCLUSION

The findings from this research extend current understanding of the relationship between professional network structure and ICT use of knowledge workers. As expected, as rural GPs' personal professional networks become denser; they also become highly constrained and highly inefficient in terms of seeking advice in their network structure. The network is highly constrained to the extent that the rural GP seeks advice and information from peers and colleagues which lead back to the same person. It is inefficient in that they interact with those who provide the same or redundant information.

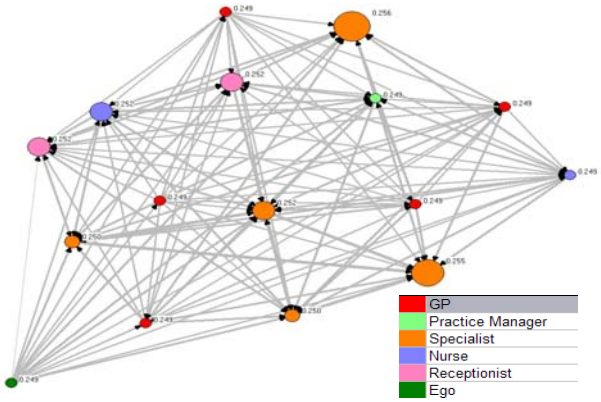


Figure 1. A GP's Professional Network

To illustrate, Figure 1 depicts a professional network of a rural GP (ego node highlighted in green). The ego's constraint is 0.249 and is relatively *unconstrained* compared to others in the network (as indicated by size of the nodes), despite the high overall network density of 0.924 (which indicates high cohesiveness and possibly high information redundancy). The ego GP has quite a number of strong ties with others (colours of node depict occupation) in the network, demonstrated by the thickness of lines (1=distant, 5=very close). The low constraint factor of the ego GP indicates the ability of the GP to seek advice and information from useful sources.

In terms of network structure and ICT use, we find that the number of GPs in the current practice is significantly correlated with task-based use of ICT. The network structure variable, density, is also positively and significantly correlated with task-based ICT use (support for H5). This may be attributed to the fact that when a practice is computerized, all GPs in the practice tend to use computers for medical tasks. However, the presence of other GPs within the same practice did not seem to be significantly correlated with internet-based use of ICT (eg. accessing online medical journals, and online communication with peers). In this context, however, density was found to be positively and significantly correlated with internet-based ICT use. One may thus infer that as GPs whose professional networks become denser, the information-spread encourages both task-based ICT use for medical tasks and internet-based ICT use for online resource access and communication. There was also highly significant negative correlation found between task-based ICT use and ego-network efficiency, and significant negative correlation between task-based ICT use and ego-network efficiency. This finding is quite interesting and suggests that as a GP's personal network increases in efficiency, ICT use for task-based use and internet-based use decreases (support for H6). As stated earlier, a GP with high efficiency in the professional network benefits from novel information and useful advice through brokerage with diverse medical professional groups. This may explain why the need for online resources (and hence usage of internet-based ICT) may diminish as GPs become more efficient in their professional network. The 'efficient' GP in this case knows where to best to obtain information or advice from his personal network of professional contacts. Furthermore, GPs in rural areas operate in communities where members know each other relatively well. Therefore, the highly *efficient* GP is not likely to use the Internet media for communication especially where relational sources are readily known and accessible; and this finding is consistent with literature (Henry and Butler, 2001). There was no significant correlation and support for hypotheses H1-H4.

In summary, this study contributes to the growing body of literature on the impact of social network structure and ICT use on individual performance attitudes. By developing a theoretical model and through qualitative interviews with domain experts, we constructed a survey instrument for measuring structure, ICT use and performance attitudes. The instrument demonstrated both validity and reliability. A limitation concerning this study is that data from 56 general practitioners in rural NSW medical practices were collected. As such, it is important that our results and findings be interpreted within this scope. The findings however, allow us useful insights into the interplay and interactions between social network structure, ICT use (patterns and frequency of use) and performance.

Rather than finding support for the positive associations with performance attitudes, it was interesting to note how social structure influences the use of ICT. In particular, we note that as professional networks of knowledge workers grow denser, there is a corresponding growth in the use of ICT at both task and communication-structure levels. However, when there is an increase of similar knowledge workers who are co-located, only the use of ICT for task-level activities increases. It is also important to highlight the fact that as knowledge workers become more efficient in obtaining (new and novel) information, their tendency to use ICT for communication and as channels of information supply significantly decreases. Interestingly, as ego-network efficiency increases, there is also a corresponding significant decrease in the use of ICT for task-level activities.

The implications of this finding is significant in that while designing technology and environments for ICT use, much attention needs to be devoted to the sociology of technology use, which is an important factor for understanding the patterns and frequency of ICT use by knowledge workers, who are geographically dispersed. As quoted by one respondent –

"When GPs are in doubt regarding a diagnosis or a problem, they always refer to specialist or their colleagues or the hospital. The other thing that I would certainly do and wish others would do is refer to some electronic resources. For example, there is the ciap.health.nsw.gov.au website which is the most fantastic site I have ever seen. There, you can read most of the electronic journals and medical textbooks for free….I have seen 60-70% of the medical textbooks online…

…Doctors will be isolated (in rural areas). I think the rural GPs should be given not only computers but at least video conferencing facilities. This is because if they need to call another doctor, they need to be able to just dial and talk to them (through video-conference). I believe this is quite important otherwise they will be practicing in isolation"

We found no significant support for the association between internet-related ICT use for communication and task-level activities and performance attitudes. We argue that there may be other variables that mediate the use of Internet-related ICT such as internet literacy, time spent on internet and so on, thus allowing avenues of future research. Investigation of whether the relationship between task-level ICT use and performance is also mediated by other factors such as productivity, quality, or the extent to which the knowledge worker can acquire new and useful information for performance would also seem fruitful.

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