KNOWLEDGE TRANSFER AND SOCIAL NETWORKS IN HEALTH CARE

Abstract:

The ability to transfer knowledge effectively among professionals represents a critical issue to a host of organizational processes. In practice, however, knowledge transfer has proven a difficult challenge, as information tends to "get stuck" when it is required to be spread between individuals and professional boundaries. Collecting data in a sample of 118 professionals in a hospital department, we found that professional boundaries still existing between nurses and clinicians inhibit the effective flow of clinical information in a hospital department. Professional boundaries, however, do not tell the whole story. The network structure of interactions among professionals can help explain patterns of knowledge exchange. Network cohesion, in terms of individual embeddedness in communication networks, significantly predicted ease of knowledge transfer. Moreover, the position people occupy in their structure of relationships, in terms of brokerage, might affect the quality of the knowledge they receive from others. The overall picture painted by these results is one of network structure and structural position shaping the dynamics of social interactions and predicting knowledge exchange among healthcare professionals.

Keywords: *Social Networks, Knowledge Transfer, Embeddedness, Brokerage*

KNOWLEDGE TRANSFER AND SOCIAL NETWORKS IN HEALTH CARE

Clinical knowledge consists of interpretive action and interaction, elements that involve communication, cognition and experience (Malterud, 2001, p. 397). The ability to transfer knowledge effectively among professionals represents a critical issue to a host of organizational processes in healthcare, including the transfer or best practices and routines and the diffusion of medical innovation (Schon, 1991). In practice, however, knowledge transfer has proven a difficult challenge, as information tends to "get stuck" when it is required to be spread between individuals and professional boundaries (Argote & Ingram, 2000). Informal interpersonal networks are thought to play a critical role in facilitating knowledge transfer (cf. Hargadon, 2002). These informal patterns are an important way that clinicians exchange information and experience social pressure to conform to standard practice.

Although the importance of knowledge exchange has been widely emphasized by sociological and organizational research in healthcare (for a complete review, see Mitton et al., 2007), previous studies have left unexplored whether and to what extent social networks either enable or constrain the spread of information in clinical settings. Drawing on social network theory, we address this intriguing puzzle by analyzing quantitative and qualitative evidences collected in a hospital department situated in northern Italy. We collected data on the informal network of 1,288 knowledge exchanges among 118 professionals (53 clinicians and 65 nurses) through a socio-metric survey and triangulated those data by conducting fifteen semi-structured interviews. First, we asked whether and to what extent the different professional groups of clinicians and nurses display different behaviors in knowledge exchange. Then we considered the overall network including both clinicians and nurses and

asked whether network cohesion -- in terms of density -- and structural position -- in terms of brokerage -- can affect processes of knowledge exchange.

In this paper, we make three contributions to theory and research. First, we explore the network structure of two professional groups, namely clinicians and nurses, and examine the extent to which network attributes, in terms of cohesion and brokerage, affect the transfer and the receipt of clinical knowledge. Following previous studies (e.g., Swan et al., 2002; Ferlie, Fitzgerald, Wood & Hawkins, 2005), we suggest that strong social boundaries exist between different professions, even though people are nominally members of a multidisciplinary team; the structure of interpersonal relationships, however, can facilitate knowledge transfer by enhancing interdependence and cooperation. Second, we shed light on the relationships between structural position and human agency in constituting these very social networks that so powerfully constraint actors in turn (Emirbayer & Goodwin, 1994, p. 1413). Although individual action can either be enabled or constrained by the structure of interpersonal relationships with others at the workplace, we aim to face the question of how much control individuals have over the networks that facilitate and constrain the flow of knowledge and other valuable resources (Kiduff & Brass, 2010). Third, we deepen the understanding of the role of actors' position in informal structures of interaction in predicting network outcomes (cf. Burt, 1997). Although both strength and quality of dyadic interactions between professionals can help explain processes trough which knowledge is transferred in clinical contexts, we argue that also the micro-structure of relationships surrounding the focal dyad can help shed more light on the processes of clinical knowledge exchange.

THEORY AND HYPOTHESES

Network structure of professional groups and knowledge transfer

Conventional wisdom holds that the evolution of organizational arrangements in healthcare toward enhanced multi-professionalism and inter-professional collaboration represents a favorable setting for the transfer of knowledge and information (e.g., Ferlie et al., 2000; Edmonson, 2003). Information, however, is seldom fully detectable and available to everyone in organizations. Work settings often resemble "small worlds of variable segregated groups where knowledge is more homogeneous within groups than between groups" (see the discussion in Burt, 2007, p. 123). As knowledge transfer represents a cost to the source of knowledge, in terms of time and efforts spent translating information in a language accessible to others, both individuals and social boundaries might inhibit the effective flow of knowledge within organizations. To what extent do social boundaries between professional groups, namely clinicians and nurses, affect processes of knowledge transfer in hospital settings characterized by a high degree of multi-professionalism?

One class of explanations is grounded in theory on the sociology of professions (cf. Davies, 1996). Socio-cultural and professional accounts tend to offer richer explanations for the stickiness and leakiness of knowledge in organizations than focusing on the properties of knowledge itself. As argued by Strong and Robinson (1990), members of professional groups are "bound together by their long initiation, common practice and shared technical knowledge". Cohesive sub-groups formed by members of the same professional cliques tend to appear to relative strangers as distinct sub-cultures with their inherent values and orientations, which may run counter to the official or formal social structure. Being part of a professional group, in this sense, exerts a relevant social influence both in the members' behavior and in the structure of infra-professional relationships. Common wisdom about the structure of medical and nursing professions, for example, has emphasized that doctors'

social networks tend to be more egalitarian, whereas nurses' networks are more hierarchical and dominated by senior nurses as actors in a position to "mediate and control, not just passively receive, information". As a result of those differences in building their social networks, previous studies have shown that communication tends to flow horizontally among doctors, whereas in the nurses' networks communication tends to move vertically (e.g., West et al., 1999, p. 642). Based on this insights, we argue that knowledge will tend to diffuse within communities of practice, whereas it will "get stuck" when shared between different professional groups. As professions display different cultures, agendas and styles of practice, those differences imply relevant barriers which might inhibit effective flow of information.

A second class of explanations draws on socio-psychological accounts for absorptive capacity and associative learning theory (e.g., Cohen & Levinthal, 1990; Argote, 1999). Individuals tend to learn new ideas and practices by associating those ideas with what they already know (Simon, 1991). As a consequence, people find it easier to absorb new knowledge in areas in which they have expertise, and find it more difficult to absorb a new idea when it is shared with a language outside of their immediate area of expertise (Strang & Tuma, 1993). A result of this argument is that people tend to more easily transfer information to others when both the source and the recipient have knowledge in common and are members of the same professional group (cf. Rogers, 1995). Consistent with arguments based on theory on the sociology of professions and social-psychological explanations, we hypothesize:

Hypothesis 1a: Nurses will transfer knowledge more easily when interacting with other nurses rather than with clinicians

Hypothesis 1b: Clinicians will transfer knowledge more easily when interacting with other clinicians rather than with nurses

Network cohesion and knowledge transfer

In modern hospitals, both clinicians and nurses are increasingly required to work in multi-professional teams. A fundamental requisite of worthwhile inter-professional collaboration is the effective flow of clinical knowledge among all members of multi-disciplinary teams. Thus, a relevant question for policy makers and managers emerge: how can healthcare organizations improve knowledge transfer in multi-professional settings? An intriguing class of explanations is grounded in theory and research on social networks.

A leading idea germane to the distinctiveness of the organizational social network research program is structural patterning (cf. Kilduff & Brass, 2010). The structure of relations among actors and the location of individuals in the networks have important behavioral consequences for single individuals and for the system of relationships as a whole (Oh, Chung & Labianca, 2004). The network approach assumes that beneath the complexity of social relations there are enduring patterns of "connectivity and cleavage" (Wellman, 1988, p. 26) that, once revealed, can help explain how ideas, knowledge and other resources are shared within a social system. Social network research also provides distinctive methods to analyze the structure of interactions (Wasserman & Faust, 1994). Overall system indicators of structure including clustering, connectivity, and centralization can be precisely identified through such approaches as clique analysis, block model analysis (e.g., DiMaggio, 1986), core-periphery analysis (Van Rossem, 1996), and small-world analysis (e.g., Kogut & Walker, 2001).

Based on this theory, how and to what extent can different patterns of ties surrounding a knowledge transfer dyad affect the flow of knowledge from a source to a recipient? Network-based models of social capital emphasize the importance of social cohesion in influencing knowledge transfer, by affecting the willingness of individuals to spend time and efforts to helping others (Reagans et al., 2003). Cohesion, specifically, refers to the extent

that a relationship between a source and a recipient is embedded in strong third-party ties surrounding the focal dyad (Granovetter, 1985). Reduced social distance and cooperative norms are two general explanations given for why social cohesion promotes knowledge exchange (cf. McEvily & Tortoriello, 2011). In terms of social distance, knowledge transfer between clinicians and nurses embedded in multi-professional teams could be hampered by the presence of enduring social and cognitive barriers between those professional groups. Such distance might be reduced through social interaction, trust and motivation, such that traditionally subordinated professions can develop legitimacy and build "autonomy and jurisdiction vis-à-vis the elite profession of medicine" (Ferlie, 2005, p. 131). In terms of cooperative norms, individuals are more likely to cooperate when are embedded with others in dense networks of relationships: co-cliques members might function as watchdogs who sanction other members' uncooperative behaviors. Based on the arguments above, we hypothesize:

> *Hypothesis 2: Looking and the overall network of relationships between clinicians and nurses, network cohesion will be positively associated with ease of knowledge transfer*

Structural position and receipt of useful knowledge

Although network characteristics, in terms of social cohesion, can contribute to explain ease of knowledge exchange among individuals in organizational settings, there is evidence in everyday life that some people still outshine others in the race for valuable work-related knowledge. As knowledge often tends to be "sticky" in informal networks", controlling the flow of diverse and timely information is likely to facilitate the race to get ahead and achieve status and social acceptance (cf. Brass, 1984). As suggested by structural-hole theory, individuals may outperform others in detecting relevant knowledge because of differences in the structure of the networks to which they belong. Cohesion can provide support and social

assistance, but not all network configurations are likely to be equally helpful. Individuals who connect disconnected others (or "brokers", using the language of Burt, 1992) are more likely than co-members to earn information returns, such as access to non-redundant, valuable knowledge (Burt, 1997).

The information capacity of structural positions in networks is particularly salient in contexts requiring high levels of professional interaction, such as clinicians' and nurses' activities in hospital wards. Clinical decisions are based on heterogeneous and often complex knowledge and data thus entailing high levels of uncertainty (Malterud, 2001; Mano-Negrin & Mittman, 2001). Although some of this knowledge is explicit and codified in practice guidelines, journal articles, and textbooks (Ferlie et al., 2005), there is evidence that physicians are likely to learn directly from interaction with others (Anderson, Schweer & Anderson, 1987; Stross & Harlan, 1989; Jippes et al. 2010). As integration plays a crucial role in regulating processes of communication and knowledge transfer, individuals who occupy more advantageous positions in the informal structure of interactions might be more likely to achieve relevant information returns. Knowledge, indeed, tends to flow from a diversity of social actors to the central actor whose ties link disconnected others (cf. Burt, 2000). Individuals whose social ties are limited to one clique are less likely to receive diverse information than are individuals whose ties span cliques, because information that circulates within a clique of highly connected professionals is likely to be redundant. A wide range of empirical research has shown that, by mediating between unconnected contacts, brokers not only access diverse information from different people but also enjoy the opportunity to combine them to create novel ideas (Lingo & O'Mahony, 2010). The accumulating evidence also suggested that individuals who span across social divides, acting as go-betweens between disconnected others, gain non-redundant information concerning knowledge, opportunities and resources. Therefore, we hypothesize:

Hypothesis 3: Looking and the overall network of relationships between clinicians and nurses, structural position, in terms of brokerage, will be positively associated with the receipt of useful knowledge

METHODS

Data for our study were collected at the nephrology, nutrition and general medicine department of a hospital located in the north of Italy. The study included all 170 observations of employees in the department. The occupational structure and roles of members of the department mainly include the joint activity of clinicians and nurses. Clinicians are responsible for the overall patients' care, for interpreting results of examination, determining diagnosis and defining pathways of care. Nurses are responsible for providing care to patients, planning and controlling the compliance with clinical guidelines previously defined by clinicians and daily assisting patients in their dialysis at home. Clinicians and nurses, therefore, are required to display deep and continuous interaction and transfer timely clinical information concerning patients' therapies and outcomes. Effective knowledge transfer, in this sense, represents a fundamental requisite for the successful management of clinical activities within the department. Although in the department there are also members of the administrative staff, they have not been included in the study, as their role mainly concerns the management of bureaucratic records which do not imply any exchange of clinical knowledge.

We collected network data by conducting a paper-and-pencil sociometric survey within the department. All questions included in the survey were translated (and back-translated) from English to Italian by three independent translators and pre-tested for face validity and acceptability at a different department. The survey was administered to all the clinicians and nurses working within the department and we collected 118 observations (65 nurses and 53

nurses), with a response rate of 80% of the overall target sample of 147 professionals. Non-respondents did not significantly differ from respondents with respect to age, gender, function, rank and tenure. The sample size is in line with similar studies on organizational social networks in healthcare settings (cf. Sasovova et al., 2010). Data on gender, function, and tenure came from departmental records.

Administrative and network data were triangulated by qualitative evidences arising from semi-structured interviews conducted with respondents within the department. Fifteen face-to-face interviews (20-30 minute) were conducted with 8 nurses, 6 doctors and a member of the hospital top management. Participants were asked to describe (1) the main activities involving knowledge exchange in their daily work and (2) the way in which clinical knowledge is managed within the department, including the presence of both formal and informal opportunities of interaction with peers and other professions. Most of interviews were audio-recorded and then transcribed and analyzed following qualitative methods analysis for mixed method studies (Creswell & Clark, 2010). For four of them, due to confidentiality issue, we were not allowed to record the interviews. In those cases, extensive notes were taken during the interviews.

Dependent variables

Ease of knowledge transfer. We focused on the ease of transfer from a source to a recipient, emphasizing both the source's and the recipient's assessment of the ease of knowledge transfer. We looked at both the source's and the recipient's assessment because individuals are presented with numerous opportunities to share their knowledge with other members of the organization, although not all opportunities are acted upon. Moreover, source and recipient might develop different perceptions of the ease of the communication flow, which could represent a potential distortive bias for our data while looking only at the source's or at

the recipient's assessment. Understanding why knowledge exchange happens in certain network contexts but not in others is an important precursor to explaining successful knowledge transfer. Ease of transfer, therefore, is a primary explanation for why specific network structures might either enable or hamper the flow of knowledge among people in healthcare organizations. Ease of knowledge transfer was measured with a seven-item scale adapted from Reagans and coauthors (2003). The scale includes items such as "It would be easy for me to share with this person a key idea, concept, or theory in my area of expertise". Each item was measured with a 7-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). For each relationship between a source and a recipient, we measured the extent to which sources and recipients were concordant in assessing ease of knowledge transfer. As we found strong and robust agreement between sources and recipients (Cronbach's alpha between source's and recipient's items was.89), we took into account for each episode of knowledge transfer the mean of the answers displayed both by the source and the recipient .

Perceived receipt of useful knowledge. This variable assesses the extent to which each recipient of a knowledge exchange relation perceives the helpfulness of the knowledge received from others. Conceptually, this variable is based on the argument that the knowledge used in clinical settings entails insights, interpretation and experience arising from reciprocal interaction among professionals. As a result, knowledge exchange relies on the quality of a knowledge seeker's relationship with a knowledge source. Our prediction is that individuals who occupy structural positions in informal communication networks aimed at bridging disconnected cliques will be more likely to access to valuable, non redundant knowledge. We measured perceived receipt of useful knowledge using a seven-item scale modeled after the scale tested by Levin and Cross (2004) and adapted to a clinical context. This scale included items such as "The information/advice I received from this person allowed me to better

perform my clinical activity" and is anchored on a 7-point Likert scale, from 1 ("contributed very negatively") to 5 ("contributed very positively"). The complete list of items used for assessing the dependent variables is provided in Appendix 1.

Social networks

We collected data on knowledge exchange relations using the roster method. Network data, specifically, were assessed through two network questions: (1) "Please indicate to whom you generally go for clinical knowledge, help or advice work-related topics" and (2) "Please indicate who generally comes to you for clinical knowledge, help or advice on work-related topics." Collecting data on both sides of each dyadic exchange relation (R) reduces the potential distortive effects arising from the possibility that two parties can have different impressions of the same interaction (Krackhardt, 1990). Data for each relation were arranged in binary matrices, according to the type of analyzed network: data on knowledge exchange among nurses were arranged in a 65 x 65 binary adjacency matrix, data on exchange among clinicians in a 53 x 53 matrix, and data on exchange among both clinicians and nurses in the overall departmental network in a 118 x 118 matrix. The first matrix contained 4,225 observations on all possible pairs of nurses, the second matrix 2,809 observation on all possible pairs of clinicians, and the third matrix 13,924 observations on all possible pairs of clinicians and nurses in the department. For each relation in each matrix, a value of 1 in the cell *x ij* corresponded to *i* declaring to share knowledge with *j* and j confirming knowledge exchange with i. A value of 0 indicated no confirmed relation from *i* to *j* .

Network measures

Social cohesion: Following Burt (1992), we measured network cohesion using a measure of indirect structural constraint. The variable is a triadic density measure. Network density

indicates the presence of strong third-party connections around a focal relationship between a knowledge source and recipient. Given a pair of individuals *i* and *j* with a common third party tie with person *p*, strong third-party ties connect person *i* to person *j* indirectly to the extent that person *i* has a strong network connection with person *p* and person *p* has a strong network connection with person *j*. For each knowledge exchange relation between two individuals *i* and *j*, therefore, the adopted measure of indirect structural constraint assesses the overall strength of the third- party connections around the focal relationship between *i* and *j*. The measure of indirect structural constraint was calculated using the network program UCINET VI (Borgatti et al., 2002).

Brokerage. As a measure of the extent to which each individual occupied a structurally advantageous position, connecting otherwise unconnected others in the knowledge exchange network, we assessed betweenness centrality (Freeman, 2004). Betweeness centrality measures the extent to which the individual sits on the shortest path between all dyads in the network. For example, if *i* and *k* do not know each other, but both *i* and *k* know *j*, then interactions between *i* and *k* depend on *j* acting as an intermediary. If *j* is in the middle of many pairs of actors in the network, then *j* has high betweenness centrality. The 118 x 118 network matrix taking assessing knowledge exchange among both clinicians and nurses was submitted to the betweenness procedure in the network program UCINET VI (see Freeman, 2004, for the formula). The higher the betweenness score of an actor, the greater the extent to which that actor serves as a structural conduit moving knowledge between unconnected others in the network (Wasserman & Faust, 1994).

Control variables

Formal structure: Differences in formal structure are likely to influence patterns of interaction and distribution of power within organizations. Those in power in the formal

structure, by virtue of their control over valuable resources and information flow, are better positioned to emerge in social networks. In this sense, formal roles may influence the characteristics of informal social networks (Ibarra, 1992). We controlled therefore informal network relationships for the formal rank individuals occupy in the organization, ranging from 0 = no formal responsibility to 2 = clinical manager.

Professional group. In the overall departmental network, we controlled for the professional group, coding nurses with 0 and clinicians with 1.

Tenure: The length of time an individual has been within the organization is also a potential predictor of inclusion in social networks. Higher tenure may be related to higher centrality in the informal network structure. Using administrative records, we coded tenure as the number of years an individual has been employed by the hospital.

Gender: As differences in gender may be related to network configuration and prominence, we controlled for gender in each analysis, coding 0 for women and 1 for men.

Analysis

To test the difference in ease of knowledge transfer in nurses' interaction with other nurses rather than clinicians (Hypothesis 1a), and the difference in ease of transfer between clinicians and other clinicians rather than nurses (Hypothesis 1b), we conducted T-test. The t-test allows determining how much variation there is in the outcome variable between the two groups and then to determine how much of this variation is systematic. In technical term, the T-test can be defined as the ratio between the observed difference between groups (systematic variance) and the estimate of standard error of difference (unsystematic variation). To measure clinicians' and nurses' ease of knowledge transfer, we took into account all the interactions displayed by clinicians with other clinicians and nurses, and all the nurses' interactions with other nurses and clinicians. The (53 x 53) matrix of relationships

among clinicians generated 389 dyads in terms of observed confirmed knowledge exchange interactions between pairs of clinicians. The (65 x 65) matrix among nurses generated 590 observations. The (118 x 118) complete matrix representing the overall departmental network generated 1,288 observations, of which 309 between clinicians and nurses. For each clinician and nurse, we calculated an individual score of his or her ease of knowledge transfer with both clinicians and nurses. Thus, we assessed T-test by comparing means of individual scores of ease of transfer.

To assess the relationships between our predictors and our dependent variables (Hypothesis 2 and 3), we performed ordinary least squares (OLS) regression model. Our dependent variables, ease of knowledge transfer and perceived utility of received knowledge, were calculated by looking at the confirmed relationships between pairs of actors. The (118 x 118) complete matrix representing the overall departmental network generated 1,288 observations. The observations taken into account to measure the dependent variables, however, were not independent. There can be multiple observations for each respondent and multiple observations for each contact. This might violate a key assumption in ordinary least squares regression. Error terms in the regression can risk to be correlated across observations from the same source or object of a relationship, which is known as network autocorrelation. Without accounting for this non-independence, we improved two solutions to reduce potential errors. First, we developed the measure of ease of knowledge transfer by taking into account both the source's and the recipient's assessment of ease of transfer. This helps limit the risk of network autocorrelation. Second, we introduced a fixed effect for each source or recipient of a relationship. We created a dummy variable for each person who received or sent a tie. Within a particular dyad, the dummy variables for the focal respondent and the focal contact were set equal to one, and all other dummy variables were set equal to zero. The

fixed effects estimation also serves as a control for any unobserved heterogeneity among respondents.

RESULTS

We begin with a description of the communication networks of both clinicians and nurses. Figure 1 shows patterns of knowledge exchange among clinicians; Figure 2 shows patterns of interaction among nurses, whereas Figure 3 shows the overall network of interactions among both clinicians and nurses. Table 1 presents multiple network measures for each network. The description of the measurement methods for each network measure is provided in Appendix 2.

INSERT FIGURE 1,2,3 AND TABLE 1 ABOUT HERE

As displayed by both sociograms and network measures, nurses tend to inhabit more dense but hierarchical networks, whereas clinicians tend to experience more equalitarian but fragmented interactions. Directors of nursing, specifically, tend to be more central to their networks than clinical directors (average degree centrality), and tend to broker the transfer of information between other nurses and the clinicians (average betweeness). Our qualitative data offer support for this evidence. Consistently with what found by West (1999), a young nurse we interviewed in the nephrology unit said:

> "In my daily activity, I mainly interact with my colleagues, and rely on the senior nurse. Then, she reports all our questions or complaints to the clinical director, and they try to find the best solutions for managing our activity."

The same impression was shared by a junior doctor in the medicine unit:

> "Interactions among nurses are always surprising. The senior nurse tends to behave like a mother with her chicks. When I try to speak with a nurse, few seconds later she stops our chat and wants to be involved in our discussion".

The question therefore arises. Do differences in the network structure of professional groups affect patterns of knowledge transfer among professionals? Table 2 reports mean values of ease of knowledge transfer within and between professional groups. As argued by Hypothesis 1, clinicians tend to more easily move knowledge to other clinicians than to nurses, and nurses to other nurses rather than to clinicians. T-statistics in Table 2 confirm that the mean differences are statistically significant.

INSERT TABLE 2 ABOUT HERE

Socio-psychological accounts for absorptive capacity theory seem to provide a plausible explanation for this evidence, as explained by a senior clinician in the nephrology unit:

> "When I speak with young nurses, I feel they often do not understand what I mean, and also their words are biased by this basic misunderstanding…. What is the reason for this communication gap? The most important problem, I think, is the lack of common knowledge. This can inhibit the flow of information."

The same impression is shared by a senior nurse, who emphasized how the professional boundaries posited by theory on the sociology of professions could offer a valuable explanation for our findings:

> "Although the hospital is changing, in terms of new technology, new organization of daily activities and higher accountability, the gap of status between us and the doctors still remains intact… This is not a personal issue, but a professional one. They are and will be clinicians; we are and will remain nurses."

Does the structure of the communication network surrounding the individual affect ease of transfer and receipt of knowledge among professionals? Table 3 reports means, standard deviations and correlations for variables measured in the (N = 118) overall network of

interactions including nurses and clinicians within the department. We used ANOVA to analyze the relations between ease of knowledge transfer and receipt of useful knowledge. None of the multiple comparisons in the post-hoc analyses showed a statistically significant difference in ease of knowledge transfer and receipt of information between functions and organizational roles. Moreover, the correlation values < .50 did not suggest any particular risk of multicollinearity among variables.

INSERT FIGURE TABLE 3 ABOUT HERE

Hypothesis 2 predicted a positive correlation between network cohesion, measured as constraint, and ease of knowledge transfer among professionals. The results of ordinary least squares regression models with ease of knowledge transfer as the dependent variable are shown in Table 4. Looking at control variables (model 1), rank was positively associated with ease of knowledge transfer: prominent people felt more able and confident in sharing knowledge to others than their subordinates. Moreover, knowledge circulated more easily between women than man. Profession and tenure, instead, did not show any significant correlation with our dependent variable. The results of model 2 in Table 4 indicate that network cohesion was positively related to ease of knowledge transfer ($B = .53$; $p < .01$). Including network cohesion strongly improved overall model fit (Model $F = 53.36$; $p < .01$) compared to model 1 (Model $F = 13.61$; $p < .01$), whereas adding betweeness centrality (model 3) did not improved model fit (Model $F = 45.01$; $p < .01$) compared to the model 2. Consistently with our hypothesis, those results show that being part of a dense, cohesive networks helps professionals exchange clinical knowledge and reduce the professional boundaries between nurses and clinicians. A senior nurse we interviews offered qualitative explanation to this point:

> "I have worked in many hospital units, and information exchange among professionals is always a troubled issue…. In my experience, however, the key factor for facilitating information sharing is integration. Where people participate to the life of their unit and interact with each other, there information flows. Otherwise you do not know what the colleague in front of you is doing".

Hypothesis 3, instead, considered receipt useful knowledge as the dependent variable, and stated that brokerage position, in terms of betweeness centrality, was positively related to useful knowledge received by individuals. In model 1 of table 5, which includes only control variables, rank was positively related to receipt of useful knowledge, whereas differences in profession, gender and tenure did not matter. Model 2 offers support for our hypothesis: controlling for tenure, gender, profession and rank, the more individuals were occupying brokerage positions connecting unconnected others, the more they were likely to receive useful information in the process of knowledge exchange ($B = .22$; $p < .01$). Compared to the baseline model including only control variables (model 1), adding brokerage to the baseline regression significantly improved overall model fit (Model $F = 17.78$; $p < .01$). Adding network cohesion to the model (model 3), instead, did not enhance the overall fit.

Hypothesis 2 and 3 together help therefore understand how network structure affects the process of knowledge transfer in clinical settings: the more the communication network is cohesive the more professionals tend to develop interpersonal trust and share information with each other. But only individuals who are positioned at spanning social divides and brokering disconnected others are likely to benefit of valuable, non redundant information. A senior clinician we interviewed well exemplified this insight:

> "I tend to work for most of the time in my ward with my colleagues and my patients. I have strong boundaries with everyone here and we do not have any secret… A young clinician working with me, however, behaves in a complete different way. He has frugal relationships with others inside the ward but tends to speak with everyone all across the department… We always share the same information, but he

> has every day some new information. He knows who detects valuable knowledge in the department, and he brings that knowledge from outside to inside the ward".

DISCUSSION

This research represents a theory-driven, empirical examination of the social network mechanisms affecting knowledge exchange in healthcare settings. First, we predicted that professional boundaries still existing between nurses and clinicians can inhibit the effective flow of clinical information in a hospital department. Professional boundaries, however, do not tell the whole story. The network structure of interactions among professionals can help explain patterns of knowledge exchange. Looking at the overall departmental network of clinicians and nurses, we found that network cohesion, in terms of individual embeddedness in communication networks, significantly predicted ease of knowledge transfer: the more people enjoy dense and cohesive interactions the more likely they exchange clinical information with other professionals. Moreover, we found that the position people occupy in their structure of relationships might affect the quality of the knowledge they receive from others: the more people span across social divides and connect disconnected others the more they detect non-redundant, valuable information. The overall picture painted by these results is one of network structure and structural position shaping the dynamics of social interactions and predicting knowledge exchange among healthcare professionals.

Implications for theory and research

The evidence produced by our study offers important contributions to knowledge exchange research and social network theory in healthcare. First, we fuelled the discussion between two long-debated market metaphors on information flow: the Austrian versus the neoclassical. The neo-classical metaphor is currently dominant, and it is taken-for-granted in claims that

information diffuses within organizations through direct interaction and contagion. However, network models in the real world have much in common with the Austrian market metaphor for knowledge, drawn by work Schumpeter and of Hayek (cf. Birner, 1999).Consistently with what found by previous studies, our evidence showed that clinical knowledge tends to get stuck in organizations (cf. Burt, 2007, p. 123). We looked for causal factors of stickiness and leakiness of information and we found that professional boundaries can provide valuable explanations of this phenomenon.

Socio-psychological accounts for absorptive capacity and associative learning theory have been traditionally used by organizational researchers to argue that differences in educational background and lack of common knowledge could negatively affect both ease of knowledge transfer and the dissemination of ideas and innovation. Moreover, we found that inherent differences in the structure of the social networks of both clinicians and nurses could help explain why knowledge less easily flows across than within professional boundaries. Clinicians' social networks tend to be more fragmented and less hierarchical, whereas nurses' networks tend to be more cohesive but built around the dominant figure of the charge nurse, who also acts as the broker between others nurses and the senior clinicians. The communication flow between clinicians and nurses tends to be therefore inhibited by the evidence that nurses seldom speak directly with the clinician when they have to share clinical knowledge or ask for advice, but tend to rely on the "bridging" figure of the charge nurse. A young nurse we interviewed came up with a very insightful metaphor enlightening this argument:

> "Sometimes I really feel uncomfortable in speaking with our chief clinician. I feel a sense of responsibility either in giving or receiving clinical information from him… Our senior nurse tends to act as 'Google translator' in my relationship with the chief doctor. Whatever I say, I can be sure she might say that in such words the clinicians perfectly understand and it also happens in the other way around".

This evidence thus far could be read as though knowledge exchange springs directly from the macro-network structure of professional groups. But everyone knows that networks do not act – people act. Networks can facilitate or inhibit human action, but individuals are the source of action (cf. Burt, Kilduff & Tasselli, forthcoming). Thus the agency question emerges: How much does the structure of interpersonal relationships in a given setting – and the position people occupy in the structure of relationships – matter?

The effects of network structure on knowledge transfer found in this study clearly show that the position people occupy in their structure of relationships matters in predicting the rewards they can get from the composition of their social world. What type of network structure, specifically, better allows individuals reap valuable knowledge and ideas? From an actor's centrality perspective, a major theoretical impetus in emphasizing the advantages arising from specific positions has come from structural hole theory: individuals who bridge across interpersonal gaps, connecting otherwise unconnected others, have distinctive advantages in terms of power (Brass, 1984), social knowledge (Krackhardt, 1990) and control of valuable information (Burt, 1992). As they span across social divides, indeed, go-betweens are more likely than others to earn information returns, such as access to non-redundant knowledge, timing and referrals (Burt, 1997). The more holes spanned, the richer the information benefits of the individual's network. A different, system-wide perspective focuses on network closure and cohesion as predictors of relevant outcomes both at personal and collective level. The case for network closure at the individual level is based on the idea that being embedded in a dense group helps forge a sense of personal belonging and identification with the group and develop a normative framework within which actors' social identity gradually emerges and is mutually reinforced through close interaction (Coleman, 1990). Related to personal achievements in organizational settings, this argument is well exemplified as follows: "A cohesive network conveys a clear normative order within which

the individual can optimize performance, whereas a diverse, disconnected network exposes the individual to conflicting preferences and allegiances within which it is much harder to optimize" (Podolny & Baron, 1997: 676).

As found in our research, the significant effects of cohesion on ease of knowledge transfer and of brokerage on receipt of useful suggest the compatibility of structural-holes and closure models of social capital, often viewed in opposition in previous research. The benefits of network cohesion might be complementay, not alternative, to the benefits arising from spanning structural holes. In this sense, the results are consistent with recent research on the optimal network structure as a combination of elements of cohesion and range (Reagans, Zuckerman, & McEvily, 2004).

Although different network structures might provide individuals with distincitve advantages, we are not suggesting they are equivalent. Looking at the results of interaction models, neither cohesion did predict receipt of useful knowledhe nor brokerage predict ease of knowledge tranfser. Strong, cohesive ties among professionals ease transfer. Individuals surrounded by a diverse network including multiple structural holes, instead, are more likely to benefit from fresh information, even when their connections are weak. Previous research has focused on the benefits of knowledge transfer across interpersonal gaps (e.g., Burt, 1997) but has not addressed the problematic nature of such transfers. It is possible for example that the professional at the middle of the disconnected dyad holds non-redundant knowlede, but that knowledge still gets stuck because the person has some strategic interest in non-spreading it. Future research could look at the micro-structure of interactions surrounding the broker and explain the extent to which brokerage can affect either the spread or the non-spread of ideas and innovation.

We found that structural position affects the spread of ideas and the likelihood to have access to new knowledge. But we are not arguing that the network structure surrounding the

individual is destiny. Although social structure imposes relevant constraints to individual action, people clearly differ in abilities, skills and willingness to use those skills and abilities to acquire different rewards from their social relationships (Brass & Burkhardt, 1993, p. 447). Following a Durkheimian agenda (Emirbayer & Goodwin, 1994), for a long time network researchers have declared their adherence to a view of structuralism that denies any agency to individuals and tends to treat actors' characteristics as "residues of social structure" (Kilduff & Brass, 2010). The increasing interest to networks and personality leads researchers to consider possible different explanations of how individuals' differences contribute to shape the structure of interactions. Recent studies, for example, have found that personality, in terms of self-monitoring, is associated with the prediction of brokerage, and that such network-relevant personality, together with experience in a role, is a key determinant for explaining achievement in that role (Burt, 2012). In contexts dominated by high frequency of interactions and need for timely reaction to external stimuli, such as hospital wards, individual differences in terms of personality, motivation and emotions could be likely to affects the people's likelihood to master communication networks with co-workers and successfully contribute to diffuse new ideas. Future research could take those variables into account and look at the extent to which they affect processes of knowledge transfer among healthcare professionals.

A potential limitation of our study is our focus on self-reported measures of ease of knowledge transfer. Following previous research, because knowledge transfer represents both a cost to the source of knowledge -- in terms of time and effort spent helping others to understand the source's knowledge -- and a benefit for the recipient, the source and the receipient of knowledge might be in different position to evaluate these costs. Therefore, we checked for both source's and recipient's assessment of ease of knowledge transfer. The

evidence of a strong and robust agreement between sources and recipients provided support for the reliability of our measure.

The organization we examined in this study was located in the North of Italy. It is possible that had we chosen for our research an organization located in a country with widely different likelihood to transfer knowledge among professionals -- or had we chosen a country with different views about broker's reputation -- our study might have produced different evidence. Mean and standard deviation values of network measures and ease of knowledge transfer, however, are consistent with what found in studies conducted in different countries, including the Netherlands and the US. The convergence of those measures makes us more confident about the reliability of our results.

In conclusion, hospitals are changing in ways that demand renewed attention to theorizing about social interactions. New organizational arrangements and technologies place professionals in ephemeral relationships with others quite different from themselves and make assumptions about relatively stable and mono-professional health organizations no longer holding true for workplaces in a globalized and multi-disciplinary world. Given these changing conditions in the workplace, a challenge for managers in healthcare is to ease interaction among different professionals and render them more willing and able to share knowledge and ideas with others. As shown by our research, studying the social structure of network interactions might help explain the processes through which knowledge flows and generate innovation.

APPENDIX 1. SURVEY ITEMS.

- Ease of knowledge transfer (cf. Reagans & McEvily, 2003).

(1) It would be easy for me to explain to this person a key idea, concept, or theory in my area of expertise. (2) This person's expertise makes it easy for me to explain a key idea, concept, or theory in my area of expertise. (3) Anyone in my area of expertise can explain easily to this person a key idea, concept, or theory in our area. (4) I can explain easily to anyone in this person's area of expertise a key idea, concept, or theory in my area. (5) It would be easy for me to explain to this person new developments in my area of expertise.

(Specify how much you agree with each of the statements above on a scale ranging from 1: "strongly disagree" to 5:"strongly agree").

- Perceived receipt of useful knowledge (cf. Levin & Cross, 2004).

The information/advice I received from this person allowed me to (1) better perform my clinical activity, (2) achieve higher performance in the clinical activity of my team, (3) enhance the appropriateness of the clinical activity of my team, (4) give my coworkers more accurate information, (5) reduce potential errors in the daily activity of my team, (6) be able focus my efforts in the most important activities in my ward, (7) better understand how to perform my job.

(1 = contributed very negatively; 2 = contributed negatively; 3 = contributed somewhat negatively; 4 = contributed neither positively nor negatively; 5 = contributed somewhat positively; 6 = contributed positively; 7 = contributed very positively)

APPENDIX 2. NETWORK MEASURES.

- Betweeness centrality (cf. Borgatti, Everett & Freeman, 2002).

Let *bjk* be the proportion of all geodesics linking vertex *j* and vertex *k* which pass through vertex *i*. The betweenness of vertex *i* is the sum of all *bjk* where *i, j* and *k* are distinct. Betweenness is therefore a measure of the number of times a vertex occurs on a geodesic. The normalized betweenness centrality is the betweenness divided by the maximum possible betweenness expressed as a percentage. For a given network with vertices *v1....vn* and maximum betweenness centrality *cmax*, the network betweenness centralization measure is *S(cmax - c(vi))* divided by the maximum value possible, where *c(vi)* is the betweenness centrality of vertex *vi.* The "betweeness centrality" routine in UCINET calculates the betweenness and normalized betweenness centrality of each vertex and gives the overall network betweenness centralization.

- Constraint (cf. Borgatti, Everett & Freeman, 2002).

The "constraint" routine in UCINET computes several measures of structural holes, including all of the measures developed by Ron Burt (equation 2.4, Burt, 1992, p. 55). It is essentially a measure of the extent to which ego is invested in people who are invested in other of ego's alters. The measures are computed for all nodes in the network, treating each one in turn as ego. There are two options. The first is to treat each actor as an ego and consider the ego network as if the rest of the network did not exist so that ties beyond alters have no effect. The second method is to look at all of the alters connections in the network whether they are tied to ego or not. The former is called the ego network model the latter is the whole network model. Consistently with the use of the roster method for collecting network data, in our paper we used the whole network model. Whole network model includes alter ties outside of

egonet in calculating the measures account is taken of all of alters ties whether they are connected to ego or not.

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FIGURES AND TABLES:

Figure 1: Communication network among clinicians (N = 53)

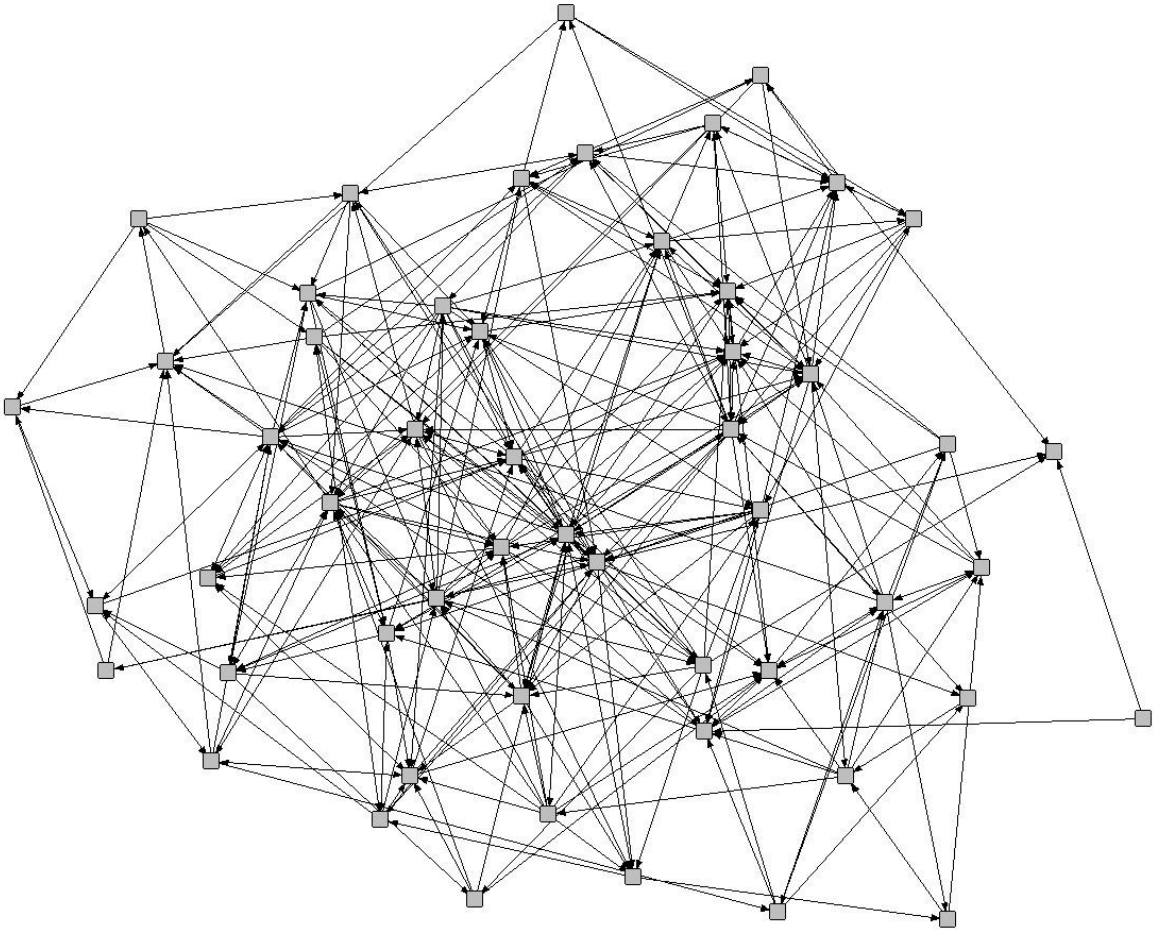

Figure 2: Communication network among nurses (N = 65)

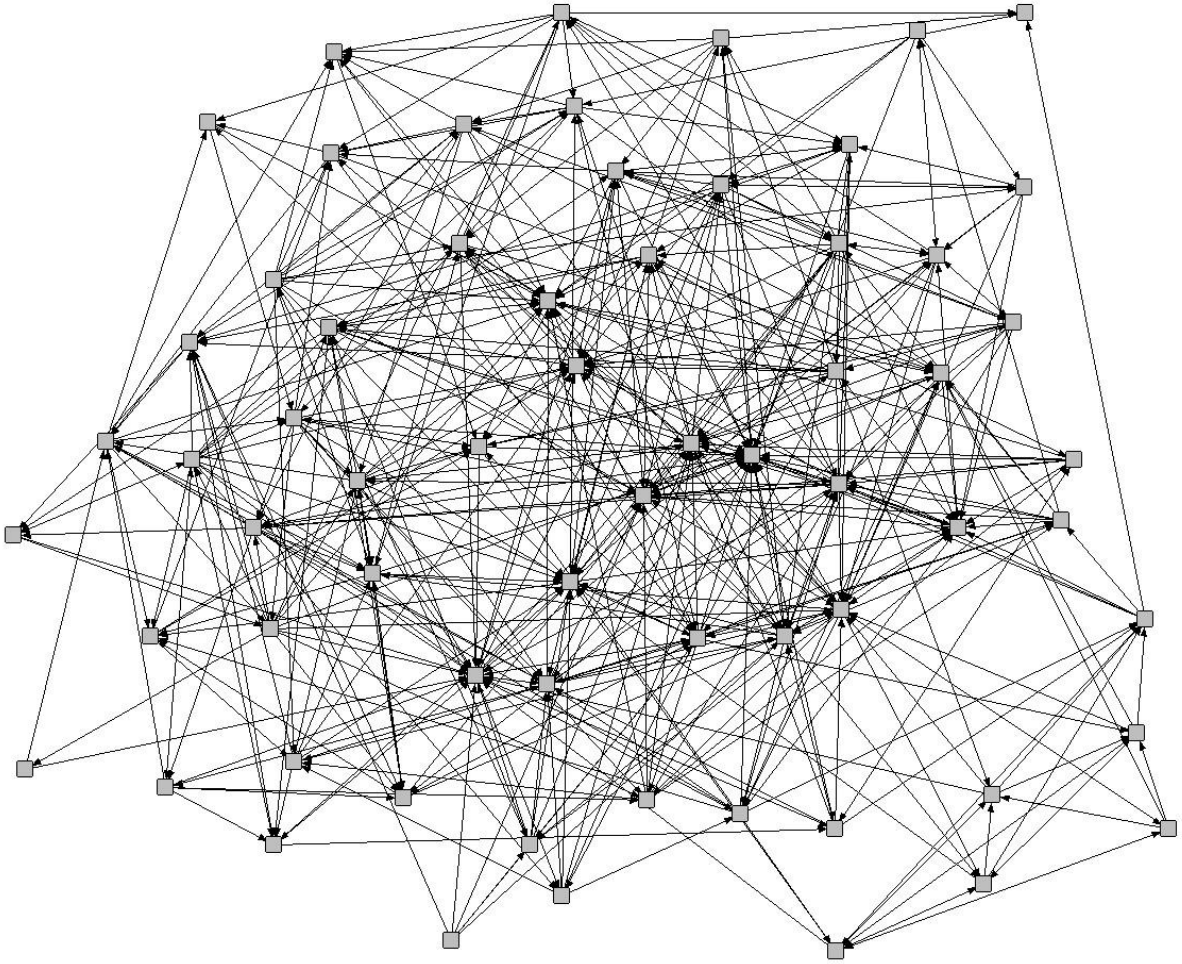

Table 1: Multiple network measures

Measures	**Clinicians' network (N = 76)**	**Nurses' network (N = 71)**	**Overall network (N = 131)**
Density	.12	.15	.10
Fragmentation	.11	.06	.07
Hierarchy (average social distance)	.64	.82	.77
Average degree centrality (number of connections)	8.41	12.54	6.56
Average betweeness centrality (brokerage)	1.37	1.73	1.52

Table 2: T-test predicting differences in ease of knowledge transfer between clinicians and nurses

Source of knowledge	Recipient of knowledge	N	Mean	Standard Deviation	t-Statistics
Clinicians	Clinicians	53	3.84	1.22	
Clinicians	Nurses	53	3.24	1.13	22.86••
Nurses	Nurses	65	3.63	1.18	
Nurses	Clinicians	65	2.86	1.05	24.71••

• $p < .05$; •• $p < .01$

Table 3: Means, Standard Deviations and Correlations among variables

Variable	Mean	SD	1	2	3	4	5	6	7
1.Profession	*.43*	*.49*	-						
2.Rank	*.18*	*.53*	.23•	-					
3.Gender	*.36*	*.47*	-.46••	-.23•	-				
4.Tenure	*11.14*	*8.02*	-.21	.24••	-.11••	-			
5.Network cohesion	*.29*	*.12*	-.14•	.12	-.13	.21•	-		
6.Brokerage	*1.52*	*1.41*	.15	.19•	.09••	-.21•			
7.Ease of knowledge transfer	*3.66*	*1.77*	-.09	.31••	-.12	.14•	.34••	-.18	-
8.Receipt of useful knowledge	*3.49*	*1.64*	.14•	.18••	-.16	.31	-.14	.32••	-.11

• $p < .05$; •• $p < .01$

Table 4: OLS regression models predicting ease of knowledge transfer among healthcare professionals (N = 118*)

Variable	Model 1	Model 2	Model 3
Profession	.07 (.12)	-.58 (.12)	-.56• (.12)
Rank	.40•• (.10)	.32•• (.09)	.38•• (.09)
Gender	-.31•• (.13)	-.25• (.11)	-.22• (.11)
Tenure	-.01 (.07)	-.35 (.09)	-.35 (.07)
Network cohesion		.53•• (.37)	.40•• (.24)
Brokerage			-.10 (.10)
Model F	13.61••	53.36••	45.01••
R^2	.06••	.24••	.22••
Adj R^2	.05••	.22••	.22••

• $p < .05$; •• $p < .01$
*Entries represent parameter estimates; standard errors are in parentheses. The intercept and dispersion parameters were included in the regression models but are not reported here.

Table 5: OLS regression models predicting receipt of useful knowledge among healthcare professionals (N = 118*)

Variable	Model 1	Model 2	Model 3
Profession	.39 (.10)	.15 (.11)	.16 (.11)
Rank	.12•• (.08)	-.12 (.08)	-.13 (.09)
Gender	.06 (.10)	.01 (.10)	.01 (.10)
Tenure	.02 (.06)	.10 (.06)	.08 (.07)
Brokerage		.22•• (.03)	.23•• (.05)
Network cohesion			-.10 (.06)
Model F	9.40••	17.78••	14.81••
R^2	.04••	.09••	.09••
Adj R^2	.03••	.08••	.08••

• $p < .05$; ••$p < .01$
*Entries represent parameter estimates; standard errors are in parentheses. The intercept and dispersion parameters were included in the regression models but are not reported here