



Social Networks and Inter-professional Knowledge Transfer: The Case of Healthcare Professionals

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Abstract

This study examines the relationship between the structure of professional networks and patterns of inter-professional knowledge transfer in the healthcare setting. Collecting survey data and qualitative evidence from 118 professionals in a hospital department, we used theory on the sociology of professions and social networks to investigate patterns of knowledge transfer between doctors and nurses. First we found that members of different professions tend to be embedded in distinctive professional cliques, which in turn inhibit effective inter-professional knowledge transfer. Network structure, however, combines with individual characteristics in predicting knowledge transfer patterns. By occupying central positions in closely knit networks, clinical directors can facilitate knowledge transfer patterns between doctors and nurses. And actors who are legitimated both intra-professionally and inter-professionally to occupy brokerage positions in social networks, namely junior doctors and nurse managers, are more likely to gain access to non-redundant, valuable knowledge. The overall picture is one of network structure interplaying with the characteristics of individual actors in shaping the dynamics of professional interactions.

Keywords

knowledge, social networks, professional groups, healthcare

Professional knowledge consists of interpretive action and interaction, elements that involve communication, cognition and experience (Malterud, 2001, p. 397; see also Argote & Ingram, 2000). The ability to successfully transfer knowledge among professionals represents a key issue for important organizational outcomes, including the diffusion of best practices, routines (Schön, 1991) and innovation (Carlile, 2002; Tortoriello & Krackhardt, 2010). In practice, however, knowledge transfer has proven a difficult task, as knowledge tends to ‘get stuck’ when it is required to be diffused between professional boundaries (Reagans & McEvily, 2003). Informal networks are

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supposed to exert a fundamental role in influencing inter-professional knowledge transfer (see Hargadon, 2002). Through interaction with co-workers, professionals can indeed gain access to knowledge and experience social pressure to conform to standard practice.

Although the importance of knowledge transfer has been widely emphasized by sociological and organizational research (for a review, see Argote, Ingram, Levine, & Moreland, 2000), previous studies have substantially left unexplored the micro-level mechanisms through which knowledge is transferred among individuals and professional groups. In this study, we draw on literature on the sociology of professions and social networks to assess whether considering the composition of social networks of professionals and the characteristics of individual actors helps explain patterns of inter-professional knowledge transfer. Important and still unanswered questions we aim to address are, thus, how does the structure of professionals' networks relate to inter-professional knowledge transfer in organizations? And how do individual characteristics of professionals combine with network structure in explaining knowledge transfer patterns?

We explored these questions through a mixed-method study conducted in a hospital department situated in northern Italy. We collected data on the informal network of 1,036 knowledge transfer ties among 118 professionals (53 doctors and 65 nurses) through a sociometric survey and qualitative data from 21 semi-structured interviews. Healthcare represents a suitable empirical setting for our research for several reasons. First, it is a context where occupational boundaries still imply a system in which status and persuasive rhetoric are of greater importance than the 'objective character of knowledge, training and work' (Freidson, 1970, p. 79). Second, the evolving organizational structures of hospital wards have enhanced the opportunities of interaction among doctors, other professions and the patient (see Barley, 1990). Third, recent health-care reforms in Western Europe and team-based approaches to patient care in the United States have promoted inter-professional cooperation as a means to diffuse knowledge, enhance accountability and, in the end, improve patient care (see Wagner, 2000). The network structure of intra-organizational relationships, in this sense, can represent a key variable predicting effective knowledge transfer (see Ferlie, Fitzgerald, Wood, & Hawkins, 2005).

In this paper we make three contributions. First we shed light on the mechanisms by which the structure of professional networks contributes to explain patterns of knowledge transfer between professions. We know that healthcare represents the archetypical professional bureaucracy (Mintzberg, 1979; Scott, Ruef, Mendel, & Caronna, 2000), in which a core group of professionals maintains institutionalized boundaries that can in turn inhibit inter-professional knowledge transfer. However, there is little conceptual work and empirical evidence of how informal processes of interaction within the networks of professionals influence communication processes (see Labianca & Brass, 2006). By investigating the mechanisms by which specific actors occupying idiosyncratic positions in professional networks facilitate knowledge transfer between doctors and nurses, we address the issue of whether and how processes of intra-professional stratification affect patterns of interaction among professional boundaries (see Currie, Lockett, Finn, Martin, & Waring, 2012).

Second, we contribute to research on network brokerage and knowledge transfer in organizations. Literature on knowledge brokering emphasizes the processes through which actors in linking positions provide the 'right knowledge, in the right hand at the right time' (Currie & White, 2012, p. 1335), by recombining and transferring knowledge between unconnected groups. But to the extent that 'people who do better are somehow better connected' (Burt, 2001, p. 32), organizational network research also calls for further attention to brokerage as a source of advantage for individuals who build bridges between otherwise disconnected parties. Thus we suggest that the more individuals span across social divides and connect unconnected others, the more they are likely to detect non-redundant, valuable knowledge.

Third is the contribution to the relationship between network structure – both in terms of intra-professional and inter-professional organization – and characteristics of individual actors as concurrent components of network outcomes (see Emirbayer & Goodwin, 1994). From a structural perspective, social network research has traditionally neglected the role of individual characteristics in affecting social structure, simply assuming that people act on all opportunities their network provides (see Mayhew, 1980; Wellman, 1988). However, accumulating evidence shows that outcomes vary widely between people who occupy similar positions in the structure of social networks (Buskens & Van de Rijt, 2008). Networks indeed do not act: individuals act, in their heterogeneity (Burt, Kilduff, & Tasselli, 2013). By showing that only specific actors are likely to fully exploit the structure of professional networks to access valuable knowledge, we face the issue of whether and how individual characteristics of actors combine with the structure of social interactions in explaining knowledge transfer.

Theory and Hypotheses

Structure of professional networks and inter-professional knowledge transfer

Knowledge transfer might be interpreted according to various theoretical perspectives (Tortoriello, Reagans & McEvily, 2012). Given the social network lens of this study, it appears more insightful to focus on the structural context through which knowledge is transferred, rather than on the inherent properties of knowledge itself (Brown & Duguid, 2002). To this aim, we consider knowledge transfer as the exchange of ‘facts, experiences and insights’ from one person to another (Hargadon & Sutton, 1997). Specifically, we argue that knowledge is transferred through a process in which individuals both share their own knowledge – in terms of facts, experiences and insights – with others and seek to acquire knowledge from their co-workers through interpersonal networks (Argote & Ingram, 2000). The role of social networks in influencing knowledge transfer is expected to be particularly relevant in the context of healthcare (Schön, 1991; Tasselli, 2014), in which clinical decisions are based on heterogeneous knowledge and data thus entailing high levels of uncertainty and requiring continuous interaction between different professions (see Mano-Negrin & Mittman, 2001).

To the extent that the transfer of knowledge in organizations entails inter-professional communication, how does the composition of professionals’ interactions relate to knowledge transfer patterns? On the one hand, organizational research has mainly given emphasis on professional networks as a way to recombine knowledge and create common meanings within the organization (see Levin & Cross, 2004). But increasing empirical evidence shows that work settings often resemble ‘small worlds of variable segregated groups’ where knowledge is more homogeneous within than between professional groups (Burt, 2007, p. 123). Accounts based on research on the sociology of professions can offer rich explanations for this evidence. Because members of professional groups are ‘bound together by their long initiation, common practice and shared technical knowledge’ (Strong & Robinson, 1990), they tend to develop jurisdictions over which they claim distinctive authority (Abbott, 1988; Davies, 1996). Jurisdictions are often associated with monopoly over specialist knowledge and techniques (Gherardi & Nicolini, 2000), and affect status differentials between distinct professions, such as nurses and doctors. It is worthwhile to remark that the status of professional groups tends to be institutionalized as ‘an effective claim to social esteem in terms of positive or negative privileges’ (Weber, 1978, p. 305), which in turn influences the actors’ social rank and their likelihood to interact with members of other professions (see Battilana, 2006; Washington & Zajac, 2005). As a result, status gaps can inhibit the inter-

professional transfer of knowledge, with high-status actors less likely and less motivated to transfer knowledge beyond their immediate peers (Addicott, McGivern, & Ferlie, 2007).

What is missing in previous research is a more detailed understanding of the micro-structural processes through which the informal networks of different professions, namely doctors and nurses, can influence the transfer of knowledge between these groups. Distinct occupational groups tend to create distinctive cliques that generate norms of conflict avoidance and knowledge dealing among peers (Lazega, 2001). The main problem of such cliques, for outsiders, is one of access to knowledge (West, Barron, Dowsett, & Newton, 1999, p. 644). Cohesive sub-groups formed by members of the same professional culture tend to appear to relative strangers as distinct sub-cultures with their inherent norms and values, which may insulate the professional group from other groups. Such insulation can be explained by tracking the internal structure of professional cliques and boundaries in the structure of idiosyncratic tasks assigned to each profession (see Lazega, 2000). We know from previous research that doctors' networks tend to be relatively decentralized, compared to those of other professions (Barley, 1986). Although based on formalized hierarchies, the structure of medicine is indeed mediated by the independent status of each professional (West et al., 1999). This structure reflects the autonomy of members of the medical profession and accentuates forms of lateral control based on the enactment of peer-to-peer knowledge transfer (see Lazega, Mounier, Jourda, & Stofer, 2006). Thus although knowledge tends to flow horizontally among doctors, they are expected to be less likely and less motivated to move knowledge outside the boundaries of their peer network.

Nurses' networks have instead been depicted by previous research as more centralized around nurse managers as players in a position to 'mediate and control, not just passively receive information' (West et al., 1999, p. 642). On the one hand, the structure of nurses' network accentuates forms of hierarchical control over knowledge (see Allen, 2000; Dingwall & Allen, 2001): centralized networks imply that knowledge tends to flow vertically, with the actors at the top of intra-organizational hierarchy inhibiting other group members from developing knowledge transfer ties outside the clique. On the other hand, the endurance of systems of task allocation to nurses (Allen, 1997) contributes to engender further professional boundaries, hampering knowledge transfer between nurses and doctors. Based on these insights, we hypothesize that knowledge will tend to diffuse within professional boundaries, whereas it will 'get stuck' when transferred between different groups.

Hypothesis 1a: Professional knowledge will be transferred more easily within than across occupational boundaries, such that nurses will transfer knowledge more easily when interacting with other nurses rather than with doctors.

Hypothesis 1b: Professional knowledge will be transferred more easily within than across occupational boundaries, such that doctors will transfer knowledge more easily when interacting with other doctors rather than with nurses.

Network centrality and inter-professional knowledge transfer

Although occupational boundaries might hamper social interaction, effective knowledge transfer still remains a fundamental requisite of worthwhile inter-professional collaboration (Sparrowe, Liden, Wayne, & Kraimer, 2001). Thus, central to our investigation is understanding which actors are more likely to facilitate knowledge transfer between distinct professions – that is, for which actors it is easier to transfer knowledge to members of others professions (see Reagans & McEvily, 2003). From social network theory, we know that the position occupied by individuals in intra-organizational networks can affect their likelihood to interact with others and, in the end,

transfer knowledge and other resource to co-workers (Coleman, 1990). Beneath the complexity of social relations and professional divides there are indeed 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.

Network research, specifically, focuses on the importance of centrality in closely connected networks in favouring knowledge transfer, by affecting the willingness of individuals to spend time and effort in joining others (Borgatti, 2005). Building on the work of Simmel, we argue that professionals occupying central positions in closely knit networks can act as 'mediators' or 'non-partisans' and facilitate knowledge transfer above and beyond professional divides:

The non-partisan either produces the concord of two colliding parties, whereby he withdraws after making the effort of creating direct contact between the unconnected or quarrelling elements; or he functions as an arbiter who balances, as it were, their contradictory claims against one another and eliminates what is incompatible in them. (Simmel, 1950, pp. 146–7)

The emphasis here on the joining of diverse people contrasts with the separation among professional cliques emphasized by research on the sociology of professions (see Abbott, 1988). The argument is that professionals who are central in closely connected networks are more likely to mediate inter-professional status gaps and frame knowledge in a language accessible to different cliques.

In the healthcare context, this focus on centrality entails consideration of how the situated interaction of specific actors in clinical settings influences patterns of knowledge transfer. Specifically, in the empirical setting of this study we focus on the role of clinical directors as players expected to act as mediators and to facilitate patterns of interaction between doctors and nurses (see Burgess & Currie, 2013). Clinical directors are responsible for providing clinical leadership to colleagues and junior medical staff, coordinating the activities within a department and taking overall responsibility for a budget (see Harrison & Miller, 1999). On the one hand, these actors can be more likely to occupy central positions in inter-professional networks, because they stand high both in professional status and organizational role (Battilana, 2011). Thus they may play the strategic role of mediating knowledge and cognitive barriers among different layers of the organization and between professional groups (Shi, Markoczy, & Dess, 2009). On the other hand, they can be inclined to deal with successful knowledge transfer as a way to preserve the institutionalized status quo and ensure their control over specialist knowledge within the organization (see Pfeffer, 1981). The claims related to clinical directors as mediators are the object of qualitative investigation in this study. Building on these arguments, we hypothesize:

Hypothesis 2: Looking at the overall network of relationships including doctors and nurses, centrality in the communication network will be positively associated with ease of inter-professional knowledge transfer.

Brokerage and perceived receipt of useful knowledge

Network centrality helps explain patterns of inter-professional knowledge transfer. But knowledge is not equally available to every individual and group in organizations: there is evidence in everyday life that some people still outshine others in the race for valuable work-related knowledge. According to structural-hole network theory, individuals may outperform others in detecting relevant knowledge because of differences in the structure of the networks to which they belong. Actors who bridge disconnected others (or 'brokers', using the language of Burt, 1992) can

be advantaged three ways by their network, in terms of knowledge breadth, timing and arbitrage (see Burt, 2007). With respect to breadth, individuals occupying brokerage roles tend to receive knowledge from multiple sources and to develop frameworks for interpreting knowledge from diverse perspectives. With respect to timing, they are positioned at a crossroads in the flow of knowledge between social groups, so they may be early to learn about activities in different groups, and often are the individuals introducing to one group innovation on another (Burt, 1999). Third, they are more likely to know when it will be rewarding to keep segregated distinct social divides (Burt et al., 2013, p. 531).

Thus, although knowledge brokering perspectives have been adopted by previous research to explain how pools of ideas are recombined and transferred across distinct contexts (Meyer, 2010; Waring, Currie, Crompton, & Bishop, 2013), this study emphasizes the knowledge advantages associated with the occupation of brokerage positions in organizational social networks: the more individuals span across inter-professional divides and connect otherwise unconnected co-workers belonging to different professional groups, the more they are expected to have access to non-redundant, valuable knowledge. Thus, we hypothesize:

Hypothesis 3: Looking at the overall network of relationships including doctors and nurses, brokerage in the communication network will be positively associated with the receipt of useful knowledge.

Structure of professional networks and brokerage

The position occupied by individuals in informal networks of professionals represents a reliable source of knowledge advantage. However, structural position does not tell the whole story: network structure provides the context in which actors operate, but individuals in the same network positions tend to display different knowledge outcomes (e.g., Buskens & Van de Rijt, 2008). To explain this variance, both intra-professional and inter-professional organization needs to be taken into account. More to the point, our argument is that the structure of professional networks of doctors and nurses can help explain the knowledge advantages that specific actors can reap from patterns of inter-professional knowledge transfer.

For what concerns the medical profession, relatively fragmented and less centralized professional networks can provide doctors with the opportunity to access non-redundant knowledge arising from distinct sources within and outside the network (see Sasovova, Mehra, Borgatti, & Schippers, 2010). But to the extent that brokers can control the flow of knowledge in the network, exploiting brokerage opportunities requires actors who are both willing and able to do so; that is, actors who are socially legitimated to occupy those idiosyncratic positions and who strive for high status (Burt, 2007). As argued above, clinical directors have social legitimacy in the network, but they already have acknowledgement of their social status; thus they are expected to privilege the occupation of central positions in closely knit inter-professional networks that conform to their status and aim at bringing doctors and nurses together.

Doctors who are junior in tenure, instead, may be more motivated to search for brokerage opportunities: they have the social capital crucial for inter-professional knowledge brokerage because they belong to the medical profession, and they can also borrow additional social capital by tending to orientate towards their senior medical peers (see McKee & Black, 1992). Given the relatively decentralized structure of medical networks, in which internal hierarchies still persist but tend to be less pervasive than in other professions, we expect a process of intra-professional stratification in which junior doctors are likely to reposition themselves as knowledge brokers between distinct professional groups. Thus, we hypothesize:

Hypothesis 4a: Tenure moderates the association between brokerage in the communication network and receipt of useful knowledge by doctors, such that junior doctors are more likely to receive useful knowledge associated with the occupation of brokerage positions in inter-professional networks.

Regarding the networks of nurses, they have been described as more hierarchical and centralized around the figure of the nurse manager as the actor who controls knowledge transfer patterns (see Dingwall & Allen, 2001). This implies that nurse managers tend to be active in controlling knowledge transfer by acting as a go-between for a number of nurses who would otherwise be disconnected from doctors (Fitzgerald, Ferlie, McGivern, & Buchanan, 2013). The influence of intra-professional hierarchy on inter-professional brokerage can be explained in terms of legitimacy: accessing the knowledge benefits associated with connecting otherwise disconnected others requires brokers to be legitimated in the eyes of the other parties (see Battilana, 2006). Because nurses belong to a lower-status professional group compared to doctors, being high in the formalized organizational hierarchy provides nurse managers with the necessary authority to sit in brokerage positions in inter-professional knowledge transfer networks (see Dopson & Fitzgerald, 2006). Thus, we hypothesize:

Hypothesis 4b: Organizational hierarchy moderates the association between brokerage in the communication network and receipt of useful knowledge by nurses, such that nurse managers are more likely to receive useful knowledge associated with the occupation of brokerage positions in inter-professional networks.

Methods

To study these topics requires a setting in which the process of knowledge transfer among professionals plays an important role. For this reason, we collected data in the nephrology department of a hospital located in the north of Italy, in which patterns of knowledge transfer are strictly related to organizational functioning (see Barley, 1990). The study included all observations of doctors and nurses in the department. The department is composed of three units: a specialist unit with focus on diagnosis of known or suspected kidney-related conditions, consultation service and planning of care (clinical nephrology); a less specialist unit following patients with kidney-related conditions in their care process (medical unit within the nephrology department); and a third unit providing daily services to patients in need of nutrition or dialysis (nutrition and dialysis unit). Considering the strong workflow connections between professionals working in the medical unit of the nephrology department and in the internal medicine unit of the general medicine department, observations of doctors and nurses belonging to the internal medicine unit have been added in our study. The organization of the nephrology department into units aims at improving the coordination of clinical activities in a traditionally less mandated (and less managerialized) department. The units were reorganized just prior to the time of data collection, before which the department was unitary. Thus the organizational partitioning in these units did not entail relevant variation in knowledge transfer ties in our sample.

The occupational structure and roles of members in the department mainly include doctors and nurses. Doctors focus their activity on interpreting results of examination, determining diagnosis, prescribing treatment and planning, controlling and updating pathways of care. Nurses are responsible for providing overall care to patients, planning and controlling the compliance with clinical guidelines previously defined by doctors, and daily assisting patients in their dialysis at home. Effective knowledge transfer between doctors and nurses therefore represents a fundamental requisite for the successful management of clinical activities in the department. Members of the

administrative staff were not included in the study, as their role mainly concerns the management of bureaucratic records that do not imply any transfer of clinical knowledge.

We conducted a convergent, mixed method study through both survey data and interviews (Creswell & Clark, 2010; Greene, 2007). The two types of data collection were concurrent but separate, and data were analysed separately using both quantitative and qualitative procedures. Findings were then reported and interpreted to show convergence. We conducted 21 semi-structured interviews with professionals in the department (see section '*Qualitative data*' below). We collected network data by conducting a paper-and-pencil sociometric survey within the department (see section '*Social network data*' below). 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. From the survey we collected 118 correct observations (65 nurses and 53 doctors), with a response rate of 80% of the overall target sample of 148 professionals. The survey took 20–30 minutes for each respondent. Non-respondents did not significantly differ from respondents with respect to tenure, gender, function and rank. The sample size is in line with similar studies on organizational social networks in healthcare settings (see Sasovova et al., 2010). Data on gender, tenure, function and rank came from departmental records.

Qualitative data

Twenty-one face-to-face semi-structured interviews lasting 20–30 minutes were conducted with eleven nurses, nine doctors and a member of the hospital top management. We interviewed seven people in each of the three organizational units. Seven people had managerial responsibilities (four clinical directors and three nurse managers), whereas fourteen did not have any managerial role. Twelve interviewees were female and nine were men. Eight interviewees were more than twenty years in tenure, seven people were between ten and twenty years in tenure, and six people were less than ten years in tenure. Participants were chosen consistently with the composition of the survey's sample.

Participants were asked to describe: (1) the main activities involving knowledge transfer in their daily work; (2) the way in which clinical knowledge is transferred between individuals and professional groups within the department, including the presence of both formal and informal opportunities of interaction with peers and other professions; and (3) perceived opportunities and threats for their personal career following the availability, or non-availability, of useful knowledge. Interviews were analysed following qualitative analysis methods (Corbin & Strauss, 1990).

Qualitative analysis required travelling back and forth iteratively between data and coding categories. Qualitative fieldwork aimed at understanding the intra-professional and inter-professional mechanisms explaining knowledge transfer within the department; it also informed further analysis of knowledge transfer patterns through social network analysis (see Pratt, 2009). The coding analysis comprised three major steps.

Step 1: Creating first-order categories. We began by identifying statements regarding our informants' view of informal interactions as related to knowledge transfer via open coding and then drew on such statements to form first-order categories (see Locke, 2001). After data were coded and categories were generated, we checked the data again to see which fitted each category. When the revisited data did not fit well into a category, that category was modified or abandoned.

Step 2: Integrating first-order categories and creating second-order themes. This stage involved consolidating first-order categories and collapsing them into more theoretically and abstract clusters or second-order themes. This was a recursive rather than a linear process; we moved iteratively between

first-order categories and the emerging patterns in data until higher-order conceptual themes emerged (Eisenhardt, 1989; Locke, 2001). This second stage of analysis allowed capturing what we understood to be the underlying mechanisms through which the characteristics of social interactions affected processes of knowledge transfer among professionals. To illustrate, coding statements about the likelihood of doctors to use professional knowledge to create professional embeddedness and maintain professional status led us to see that knowledge transfer was hampered by doctors' professional cliques.

Step 3: Organizing second-order themes into aggregate dimensions. Once second-order themes had been generated, we looked for dimensions underlying these themes in an attempt to understand how the structure of social interactions among professionals related to knowledge transfer. Three dimensions emerged strongly here. The first theme emphasized that knowledge remains stuck within professional groups; the second dimension was the issue of clinical directors being central in closed networks and favouring knowledge transfer between different professions; the third theme emphasized the role of bridging others in accessing knowledge. Once we identified these dimensions, we re-examined the data's fit with our emergent aggregate understanding.

In addition to carrying out these steps, we relied on two techniques to help ensure the robustness of our data. First, we carried out 'member check' (Nag, Corley, & Gioia, 2007) with professionals, managers and policy makers to make sure that our interpretive scheme made sense to subjects recognized as opinion leaders in healthcare. Second, we presented our findings in both written and verbal form to several professionals working in the department. Figure 1 illustrates the data structure. It shows the categories and themes that underpin the relationships between them. Additional supporting evidence is shown in Table 1 and is keyed to Figure 1. This table contains representative first-order data, which underpin second-order themes.

Social network data

We collected social network data on communication and knowledge transfer relations using the roster method. We asked respondents to look down an alphabetical list of all professionals working in the same department and place checks next to the names of individuals with whom they communicate, and specifically (1) to whom they go for work-related knowledge or (2) to whom they provide work-related knowledge. In line with previous network studies (Mehra, Kilduff, & Brass, 2001), we adopted the roster method instead of asking respondents to write the names of those co-workers with whom they share knowledge (also called as 'ego-network' method; Burt, 1992), because ego network data used to measure interconnections between actors to whom ego is tied are potentially distorted by ego's perceptual biases (Kilduff & Tsai, 2003).

Data for each relation were then arranged in binary matrices, according to the type of network analysed: data on knowledge transfer between nurses were arranged in a 65×65 binary adjacency matrix, data on transfer between doctors in a 53×53 matrix, and data on transfer between both doctors and nurses in the overall departmental network in a 118×118 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 doctors, and the third matrix 13,924 observations on all possible pairs of doctors and nurses in the department.

In each matrix, for each knowledge transfer tie between two professionals (R_{ij}), a focal person (i) can claim to go for knowledge to a co-worker (j) – but the co-worker (j) does not necessarily have to go for knowledge to the focal person (i) too. For this reason, knowledge transfer networks are not necessarily symmetric (see Tortoriello & Krackhardt, 2010). We took into account only confirmed ties, R_{ij} , in which both person i claims to go to person j for advice and person j confirms that person i comes for knowledge or advice. Confirmed ties are psychometrically more reliable than non-confirmed ties. The complete survey instrument is shown in the Appendix.

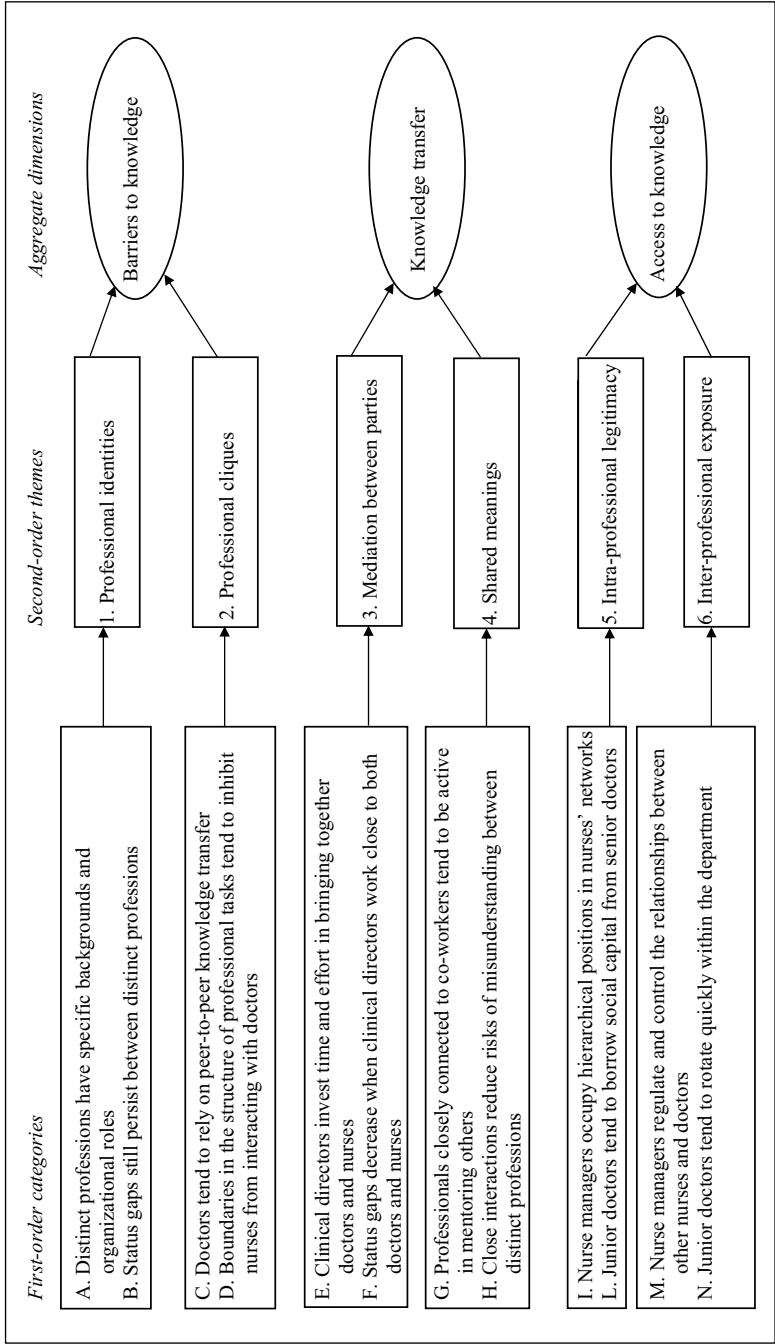


Figure 1. Qualitative data structure.

Table 1. Dimensions, Themes, Categories and Qualitative Data.

Second-order themes and first-order categories	Representative data
<i>Overarching dimension: Barriers to knowledge</i>	
I. Professional identities	
A. Distinct professions have specific backgrounds and organizational roles	<p>A1. 'When I speak to 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 knowledge.' (senior doctor in the nephrology unit)</p> <p>A2. 'To be honest, we only have to admit that doctors and nurses view the patient, the ward, the hospital from different perspectives. They had different background and this is mirrored in their approach to practice.' (senior doctor in the medical unit)</p>
B. Status gaps still persist between distinct professions	<p>B1. 'Although the hospital is changing, in terms of new technology, new organization of daily activities and higher accountability, the status differential between us and the doctors still remains intact... This is not a personal issue, but a professional one. They are and will be doctors; we are and will remain nurses.' (nurse in the nutrition unit)</p> <p>B2. 'I know that our work setting can appear elitist, but it is still obvious to everyone here that doctors and nurses are different in power, and represent two distinct professional groups.' (junior doctor in the medical unit)</p>
2. Professional cliques	
C. Doctors tend to rely on peer-to-peer knowledge transfer	<p>C1. 'My professional development is fostered by continuous interaction with my peers. They provide me with advice and I feel stimulated to reciprocate it. It is through knowledge and advice coming from peer interactions that I legitimate day by day my work as a doctor.' (junior doctor in the nephrology unit)</p> <p>C2. 'In this department you do not feel the oppressive presence of clinical directors as people who assess what you are doing. Rather, you feel pressure to collaborate with all the other doctors, and opportunistic behaviours are not well accepted.' (junior doctor in the nutrition unit)</p>
D. Boundaries in the structure of professional tasks tend to inhibit nurses from interacting with doctors	<p>D1. 'It is unusual for me to discuss clinical issues directly with doctors. With the exception of our nurse manager, I would say that nurses mainly speak with other nurses.' (nurse in the nutrition unit)</p> <p>D2. 'Often we feel that we work in isolation from the doctors. In pursuing our tasks, we mainly speak with other nurses, and we barely communicate with the doctors... I believe that this lack of communication substantially depends on how work tasks are designed.' (nurse in the nephrology unit)</p>
<i>Overarching dimension: Knowledge transfer</i>	

(Continued)

Table 1. (Continued)

Second-order themes and first-order categories	Representative data
<p>3. Mediation between parties</p> <p>E. Clinical directors invest time and effort in bringing together doctors and nurses</p>	<p>E1. 'Communication between us – the doctors – and nurses is a big issue in the department... To deal with this issue, I try to enhance the opportunities for both parties to share ideas, insights and experiences. These opportunities are often spontaneous, and in this case, I only incentivize them. But when people barely speak with each other, I actively spend my efforts in fostering the dialogue.' (clinical director in the medical unit)</p> <p>E2. 'Because of their role, clinical directors are expected to coordinate the activities of professionals. But this formal role is meaningful only when they spend effort in creating connections... For example, clinical directors are often involved in facilitating communication between professionals who would not otherwise speak with each other.' (junior doctor in the medical unit)</p>
<p>F. Status gaps decrease when clinical directors work close to doctors and nurses</p>	<p>F1. 'Doctors and nurses are divided by barriers in status. These barriers can create tensions. When clinical directors join different others, they tend to reduce tensions through close connections and try to create a better organizational climate.' (junior doctor in the nutrition unit)</p> <p>F2. 'Professional power might be reduced only through closed interaction. If we work closely with others, we just understand that most of the differences are prejudices.' (clinical director in the nephrology unit)</p>
<p>4. Shared meanings</p> <p>G. Professionals closely connected to co-workers tend to be active in mentoring others</p>	<p>G1. 'From my experience, I know that some people have a gift. They are surrounded by many colleagues and just make things work... How do they make things work? Maybe this is because they are close to a lot of others. They sit down, they spend time in giving help to their colleagues, and then the message flows.' (senior doctor in the nephrology unit)</p> <p>G2. 'It is only when we work with co-workers and mentor others that our activity becomes effective. Closed bonds and perseverance are fundamental requisites for nurturing others.' (clinical director in the nephrology unit)</p>
<p>H. Close interactions reduce risks of misunderstanding between distinct professions</p>	<p>H1. 'When I work close to other doctors and nurses, knowledge circulates more easily... This is because I try to speak not only my own language, as a doctor and as a manager, but also the language of others.' (clinical director in the nutrition unit)</p> <p>H2. 'What is important is to avoid any misunderstanding: words, concepts, activities can be misunderstood and then generate dangerous mistakes... The best way to deal with this issue is to work closely with people and spend time to understand their perspective.' (clinical director the medical unit)</p>

Table 1. (Continued)

Second-order themes and first-order categories	Representative data
<i>Overarching dimension: Access to knowledge</i>	
5. Intra-professional legitimacy	
I. Nurse managers occupy hierarchical positions in nurses' networks	<p>I1. 'For me what is important is to be at the centre of the connections among all my nurses in the ward. It helps me better coordinate the activities.' (nurse manager in the nephrology department)</p> <p>I2. 'When you are in the corridor with three nurses, you immediately feel the sense of hierarchy. The chief nurse controls all the activities and the interactions between the other nurses.' (senior doctor in the nephrology unit)</p> <p>L1. 'Junior doctors have good technical competence and are great in dealing with technology. Moreover, they search for the contact of their more experienced colleagues... And because senior doctors rarely strive to be directly responsible for regulating the communication flow between others, junior colleagues are often allowed to become the 'custodians' of most of the knowledge passing within the department.' (senior doctor in the medical unit)</p> <p>L2. 'Senior colleagues are important for me and other junior doctors. They provide us with brilliant suggestions, and they give us the right energy to be aware of our role and perform better.' (junior doctor in the medical unit)</p>
L. Junior doctors tend to borrow social capital from senior doctors	
6. Inter-professional exposure	
M. Nurse managers regulate and control the relationships between other nurses and doctors	<p>M1. 'She [the nurse manager] reports all our questions and complaints to the clinical director, and they try to find the best solutions for managing our activity... Our interactions with doctors are thus often introduced by her [the nurse manager].' (nurse in the nephrology unit)</p> <p>M2. 'Our nurse manager tends to work as a 'drawbridge' in regulating the contacts between other nurses and the doctors. She leverages this separation to maintain the control over what other nurses know, and over the knowledge they share with doctors.' (nurse in the medical unit)</p>
N. Junior doctors tend to rotate quickly within the department	<p>N1. 'In my first three years in this department, I worked in several wards. This was for me a valuable experience. Indeed it boosted my professional competence and gave me the chance to meet new people to whom I can go for advice.' (junior doctor in the nutrition unit)</p> <p>N2. 'Junior doctors are usually more open than their senior colleagues to go for advice to nurses... They are technically competent and used to rotate across wards and interact with different professions.' (nurse in the nutrition unit)</p>

Measures: dependent variables

Ease of knowledge transfer. Understanding why knowledge is transferred in certain network contexts but not in others is an important way of explaining successful knowledge transfer. Ease of transfer, therefore, is a primary explanation for why specific network structures might either enable or hamper the transfer of knowledge among people in healthcare organizations. We focused on the ease of transfer from a source to a recipient, emphasizing the source's assessment of the ease of knowledge transfer for several reasons. First, knowledge transfer is a discretionary activity: individuals are presented with distinct chances to transfer their knowledge to others at work, but not all those opportunities are acted upon. Focusing on the source of knowledge is therefore an important antecedent to explaining successful knowledge transfer, as it helps understand why professionals move knowledge to some people but not to others (see Levin & Cross, 2004). Second, previous work has shown that the recipients of knowledge may not always acknowledge whether it is easy or difficult for the source to transfer knowledge to others (Argote & Ingram, 2000). Assessment of ease of knowledge transfer could thus be biased from the recipient's perspective. Third, recipients may access knowledge from a variety of sources. When knowledge is conveyed in a group setting, the source may be misattributed (see Nadler, Thompson, & Van Boven, 2003). Emphasizing the source's assessment therefore provides a more reliable measure of ease of transfer.

Ease of knowledge transfer was measured using a five-item Likert scale adapted from Reagans and McEvily (2003). For each relationship in the roster in which a professional (the source) claimed to be asked for and provided knowledge to a recipient, the source completed a scale ranging from 1 ('strongly disagree') to 5 ('strongly agree') including items such as 'It is easy for me to explain to this person a key idea, concept, or theory in my area of expertise'. In cases in which a professional did not claim to provide knowledge to any co-worker, he/she did not complete the scale. All the items composing the scale are shown in the survey instrument reported in the Appendix (question 3B).

Perceived receipt of useful knowledge. This variable assesses the extent to which each recipient of a knowledge transfer relation perceives the helpfulness of the knowledge received from others. As we measure the perceived usefulness of knowledge received from co-workers, we focused on the knowledge seeker's perception of usefulness. Our choice is based on the argument that, because the knowledge used in clinical settings entails insights, interpretation and experience arising from reciprocal interaction among professionals (Anderson, Jay, Schweer, & Anderson, 1987), the usefulness of that knowledge relies on the structure of a knowledge seeker's ties with knowledge sources. We measured this variable using a seven-item Likert scale modelled after the scale tested by Levin and Cross (2004) and adapted to a clinical context. For each relationship indicated in the roster in which a professional (the seeker) claimed to ask for a co-worker's knowledge, the seeker had to complete a scale ranging from 1 ('contributed very negatively') to 7 ('contributed very positively') including items such as 'The knowledge I received from this person allowed me to better perform my clinical activity'. In cases in which a professional did not claim to receive knowledge from any co-worker, he/she did not complete the scale. All the items composing the scale are shown in the survey instrument reported in the Appendix (question 2B).

Overall network structural measures

Average degree centrality: This measure has been assessed as the average of all the individual values of degree centrality. Average degree centrality reflects therefore the density of a network,

because it indicates the average size of each individual's network of interactions (Freeman, 2004). Specifically, we took into account the average number of relationships of each professional with other professionals in the network. We assessed degree centrality using the routine in the network program UCINET VI (Borgatti, Everett, & Freeman, 2002).

Hierarchy: In a given network, we assessed hierarchy by measuring power distance between actors occupying managerial positions and actors not occupying managerial positions. We measured power in the informal network by tracking Bonacich centrality, in which the centrality of each vertex is determined by the centrality of the vertices it is connected to (Borgatti et al., 2002). Power distance is therefore measured as the difference between the Bonacich centrality score of doctors and nurses with managerial roles and doctors and nurses without managerial role. The higher the difference, the higher the power distance between those actors. We assessed Bonacich centrality in UCINET VI for doctors, nurses and the whole network.

Average betweenness centrality: Betweenness centrality is a measure of each individual's direct and indirect brokerage (Freeman, 2004). At the network level, average betweenness centrality represents the propensity of nodes to occupy brokerage positions in the whole network. Average betweenness centrality can thus be considered a proxy for network fragmentation in the network. We assessed betweenness centrality using the routine in the network program UCINET VI.

Individual-level network measures

Closeness centrality: To understand an actor's centrality in closely knit social networks, we measured closeness centrality (Freeman, 2004). The higher the score for each actor, the easier it is for the actor to reach all other actors in the network. An actor has therefore high closeness centrality when he/she is able to reach lots of other actors in a well-connected network. For this reason, closeness centrality assesses the extent to which a focal actor occupies a central position in a closely knit network of relationships and is relatively autonomous in terms of being less dependent on intermediaries (see Powell, Koput, & Smith-Doerr, 1996). We measured closeness centrality on the (118 × 118) matrix including both doctors and nurses using the network program UCINET VI; the resulting score was used as a continuous measure for each respondent.

Brokerage. As a measure of the extent to which each individual occupied a structurally advantageous position, connecting otherwise unconnected others in the knowledge transfer network, we assessed betweenness centrality (Freeman, 2004). Betweenness centrality is an individual-level measure assessing 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 × 118) network matrix assessing knowledge transfer among both doctors and nurses was submitted to the betweenness procedure in the network program UCINET VI; the resulting score was used as a continuous measure for each respondent.

Control variables

Network size: Degree centrality is a measure of the number of co-workers with whom an individual is directly connected (see Scott, 1991). It provides a measure of each actor's network size, as it measures the number of direct connections that an individual has with other actors in the

acquaintance network (see Kilduff & Tsai, 2003). Network size may have ambiguous effects on individual rewards: a network including many contacts may allow individuals to access multiple sources of knowledge. As maintaining a large number of relationships involves costs, however, individuals who interact with numerous others risk of running short of time and other resources (see Mehra et al., 2001, p.131). We measured degree centrality on the (118 × 118) matrix through the degree centrality procedure in UCINET VI; the resulting score was used as a continuous measure for each respondent.

Organizational hierarchy: Differences in organizational rank are likely to influence patterns of interaction in organizations. Those in power in the formal structure, by virtue of their control over valuable resources and knowledge, can be better positioned to emerge in social networks (see Ibarra, 1992). In doctors' networks, we coded clinical directors as '1' and doctors without managerial responsibilities as '0'. Clinical directors differ from consultant physicians in that they combine clinical care activity with time devoted to manage their ward or unit. In nurses' networks, we coded nurse managers as '1' and nurses without managerial roles as '0'. Nurse managers have responsibility for overseeing the development and activity of nursing staff and delivering service improvements (see Fitzgerald et al., 2013).

Organizational unit: Network effects could be contingent on the specific status configuration and social structure of relationships within each organizational unit. The units have been therefore included in the regression models as dummy variables.

Professional group: In the overall departmental network, we controlled for the professional group, coding nurses '0' and doctors '1'.

Tenure: Individual tenure is a potential predictor of inclusion in social networks (see Kilduff & Tsai, 2003). Higher tenure may be related to higher centrality in the informal network structure and greater legitimacy to occupy brokerage positions. Using administrative records, we coded binary tenure as '1' for young doctors and nurses (below the median) and '0' for senior doctors and nurses (above the median).

Gender: As differences in gender may be related to network configuration and prominence (Ibarra, 1992), we controlled for gender in each analysis, coding '0' for women and '1' for men.

Analysis

To test the difference in average ease of knowledge transfer in nurses' interactions with other nurses rather than doctors (Hypothesis 1a), and the difference in ease of transfer between doctors and other doctors rather than nurses (Hypothesis 1b), we conducted a t-test. The t-test allows determining how much variation there is in the outcome variable between the two groups and then determining the ratio between the observed difference between groups (systematic variance) and the estimate of standard error of difference (unsystematic variance) (Hedeker & Gibbons, 2006).

To measure doctors' and nurses' ease of knowledge transfer, we took into account all the interactions displayed by doctors with other doctors and nurses, and all the nurses' interactions with other nurses and doctors. The (53 × 53) matrix of relationships among doctors generated 279 dyads in terms of observed confirmed knowledge transfer interactions in which doctors transferred knowledge to other doctors. The (65 × 65) matrix of nurses' interactions generated 452 dyads in terms of knowledge transfer ties between pairs of nurses. The (118 × 118) complete matrix representing the overall departmental network generated 1,036 observations, of which 121 with doctors providing knowledge to nurses and 184 with nurses providing knowledge to doctors. We assessed the t-test by comparing scores of ease of transfer between doctors and doctors versus

transfer between doctors and nurses, and ease of transfer between nurses and nurses versus transfer between nurses and doctors.

To assess the relationships between our predictors and our dependent variables (Hypotheses 2 and 3), we performed a linear regression model (see Hoechle, 2007) clustering the error terms around the ID of the knowledge giver (Hypothesis 3) or knowledge receiver (Hypotheses 4, 4a and 4b). We chose these particular models because we acknowledge that the observations may not be independent: a single person can provide knowledge to and receive knowledge from many colleagues.

To assess interaction effects (Hypotheses 4a and 4b), in each model interaction terms were entered in a separate step after the main terms were entered. If the addition of the interaction terms significantly improved the regression model including the main terms, this would suggest support for the interaction (see Aiken & West, 1991).

Results

The structure of doctors' and nurses' social networks

Because we investigate the effects of professional networks on knowledge transfer, we begin with a description of the communication networks of both doctors and nurses. Figure 2 shows patterns of knowledge transfer among doctors. Figure 3 shows patterns of interaction among nurses, whereas Figure 4 shows the overall network of interactions among doctors and nurses. Table 2 presents multiple network measures for each network. Although mainly descriptive, these measures help make sense of the structural properties of knowledge transfer relationships.

As displayed by both sociograms and network measures, nurses have on average more interactions than doctors (with an average degree centrality score of 6.95 interactions for each nurse with other nurses versus 5.26 interactions for each doctor with other doctors). That is, nurses tend to inhabit denser networks than do doctors. We assessed hierarchy in the network, in terms of difference in Bonacich power between actors with and without managerial roles. We found that nurses' networks are on average more hierarchically structured than doctors' networks. Hierarchy is often connected with network fragmentation and brokerage opportunities: looking at the average betweenness centrality, indeed, nurses have more room for brokerage than doctors.

Structure of professional networks and inter-professional knowledge transfer

Doctors and nurses display relevant differences in how they structure their social networks. Do differences in the structure of professional networks relate to patterns of knowledge transfer among professional groups? We answered this question with both survey and qualitative data. Table 3 reports mean values of ease of knowledge transfer within and between professional groups. As argued by Hypothesis 1, doctors tend to more easily transfer knowledge to other doctors than to nurses, and nurses to other nurses than to doctors. The t-test statistics in Table 3 confirm that the mean differences are statistically significant.

Qualitative data contribute to explain the network mechanisms underlying this argument (see data structure in Figure 1). Distinctive backgrounds and organizational roles lead members of occupational groups to develop different professional identities, which in turn make it difficult for professionals to transfer knowledge to other professional groups. A senior doctor in the nephrology unit said:

When I speak to 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 knowledge.

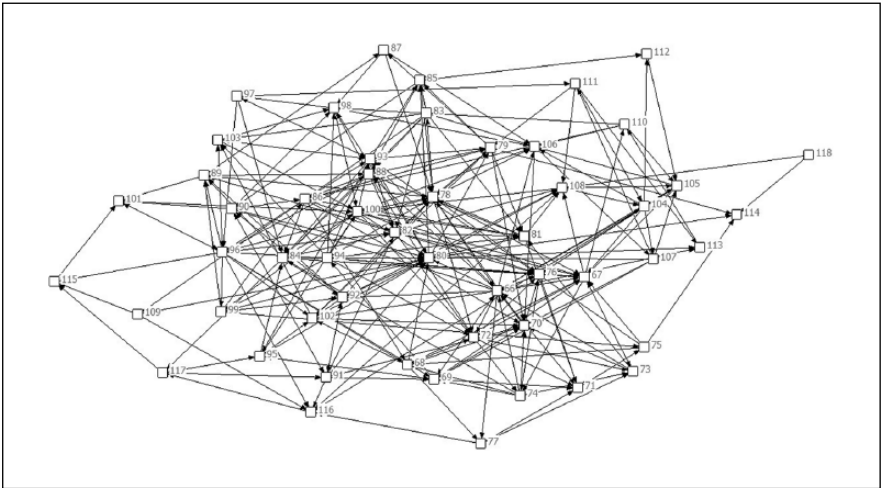


Figure 2. Communication network among doctors (N = 53).

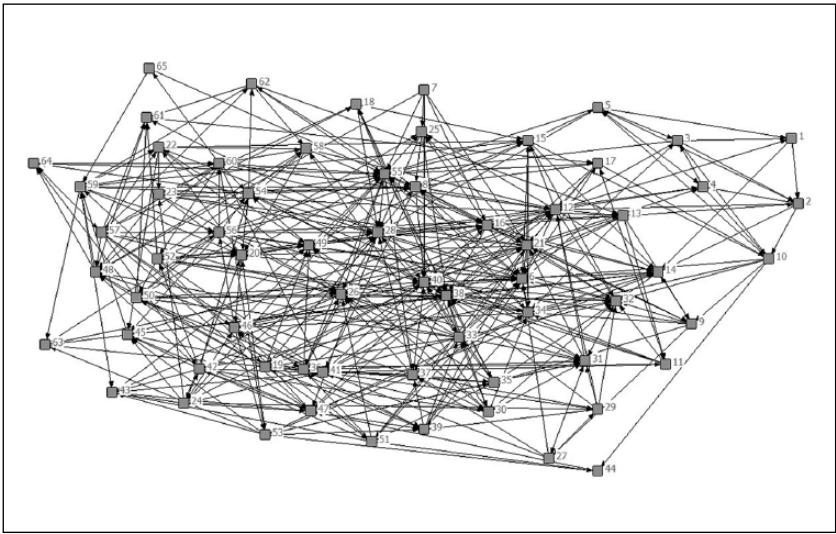


Figure 3. Communication network among nurses (N = 65).

Table 2. Multiple network measures.

Measures	Doctors	Nurses	Doctors and Nurses
Average degree centrality	5.26	6.95	8.78
Hierarchy (power distance)	33	364	218
Average betweenness centrality	1.17	1.38	1.29

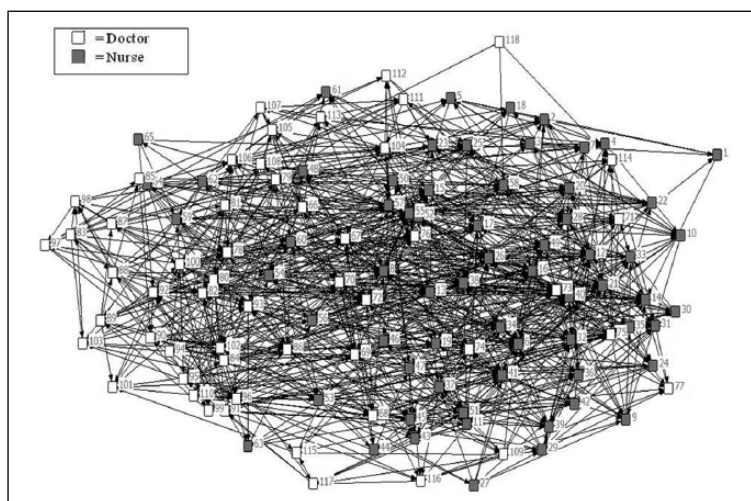


Figure 4. Overall communication network among doctors and nurses (N = 118).

Table 3. T-test predicting differences in ease of knowledge transfer between doctors and nurses.

Source of knowledge	Recipient of knowledge	N	Mean	Standard Deviation	t-Statistics
Doctors	Doctors	279	3.82	.49	11.40**
Doctors	Nurses	121	3.24	.43	
Nurses	Nurses	452	3.63	.62	14.73**
Nurses	Doctors	184	2.85	.57	

* $p < .05$; ** $p < .01$.

Moreover, inter-professional knowledge transfer is hampered by status gaps between doctors and nurses, which lead individuals to embed their social interactions within closed professional networks. This point is well exemplified by a nurse in the nutrition unit, who said:

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

Focusing on the structure of professional cliques, the analysis of nurses' and doctors' networks deserves further attention. Structural measures painted nurses' network as more connected than doctors' networks. However, our qualitative data show that the higher density of nurses' networks can come at the cost of a more pronounced separation from other professions. Specifically, the structure of nurses' work tasks tends to create boundaries between professions, with nurses mainly interacting with other nurses rather than with doctors. A nurse in the nephrology unit we interviewed said:

Often we feel we are working in isolation from the doctors. In pursuing our tasks, we mainly speak with other nurses, and we barely communicate with the doctors... I believe that this lack of communication substantially depends on how work tasks are designed.

Table 4. Regression models predicting ease of knowledge transfer.†

Variable	Model 1	Model 2	Model 3
Profession	.24** (.05)	.32** (.06)	.32** (.07)
Unit B	.10 (.08)	.09 (.08)	.09 (.08)
Unit C	.14 (.07)	.15* (.07)	.15* (.07)
Organisational hierarchy	-.01 (.08)	-.01 (.07)	-.01 (.07)
Gender	-.01 (.06)	.00 (.06)	.00 (.05)
Tenure	-.02 (.06)	-.05 (.06)	-.05 (.06)
Closeness centrality		2.20** (.75)	2.22* (1.07)
Betweenness centrality			-.00 (.03)
Model F	4.28	4.68	4.14
R ²	.04**	.06**	.06**

* $p < .05$; ** $p < .01$; $n = 1,036$.

† Entries represent un-standardized parameter estimates; standard errors are in parentheses. The intercept and dispersion parameters were included in the regression models but are not reported here.

Doctors instead tend to rely on peer-to-peer knowledge transfer. Thus the structure of communication ties entails horizontal knowledge transfer among doctors, but separates the network of doctors from those of nurses and other professionals. This point is well exemplified by a junior doctor in the nephrology unit, who said:

My professional development is fostered by continuous interaction with my peers. They provide me with advice and I feel stimulated to reciprocate it. It is through knowledge and advice coming from peer interactions that I legitimate day by day my work as a doctor.

Network centrality and inter-professional knowledge transfer

Knowledge tends to be more easily transferred within than across professional boundaries. But does the structure of intra-organizational networks relate to knowledge transfer above and beyond professional boundaries? We argued in our theory that professionals occupying central positions in closed networks can be more likely to facilitate knowledge transfer to other professionals within the organization.

Hypothesis 2 predicted a positive relationship between closeness centrality and ease of knowledge transfer. The results of linear regression models clustering the standard errors for the ID of the knowledge givers with ease of knowledge transfer as the dependent variable support this hypothesis (Table 4). The results of model 2 indicate that closeness centrality was positively related to ease of knowledge transfer ($p < .01$). Including closeness centrality improved the degree of variance explained by the model ($R^2 = .06$; $p < .01$) compared to model 1 including only the control variables ($R^2 = .04$; $p < .01$). Adding betweenness centrality (model 3) did not explain additional variance compared to model 2.

Qualitative findings help make sense of the mechanisms by which professionals' social networks influence patterns of knowledge transfer. In particular, qualitative evidence highlights the role of clinical directors as actors who consolidate the intra-organizational network by spending time and effort in joining doctors and nurses. Consistent with Simmel's metaphor of the 'mediator' – or the actor who joins others and facilitates the transfer of knowledge between social groups – we found that by occupying a central position in intra-organizational networks, clinical directors tend to facilitate inter-professional knowledge transfer. First, they are more willing and able to reduce

Table 5. Regression models predicting perceived receipt of useful knowledge.†

Variable	Model 1	Model 2
Profession	.03 (.14)	.11 (.12)
Unit B	.19 (.19)	.24 (.17)
Unit C	.04 (.17)	.16 (.17)
Organisational hierarchy	.23 (.18)	.27 (.15)
Gender	-.14 (.14)	-.08 (.12)
Tenure	.13 (.14)	.09 (.14)
Network size	.09** (.02)	.03 (.02)
Betweenness centrality		.34** (.11)
Model F	5.33	5.01
R ²	.08**	.13**

* $p < .05$; ** $p < .01$; $n = 1,036$.

† Entries represent un-standardized parameter estimates; standard errors are in parentheses. The intercept and dispersion parameters were included in the regression models but are not reported here.

tensions and facilitate opportunities of interaction between doctors and nurses. The clinical director in the medical unit illustrated this point well:

Communication between us – the doctors – and nurses is a big issue in the department... To deal with this issue, I try to enhance the opportunities for both parties to share ideas, insights and experiences. These opportunities are often spontaneous, and in this case, I only incentivize them. But when people barely speak with each other, I actively spend my efforts in fostering the dialogue.

Second, clinical directors tend to ease inter-professional knowledge transfer when they exert efforts in mentoring others and thus reducing the risk of misunderstanding between parties. The clinical director in the nutrition unit said:

When I work close to other doctors and nurses, knowledge circulates more easily... This is because I try to speak not only my own language, as a doctor and as a manager, but also the language of others.

Brokerage and receipt of useful knowledge

In hypothesis 3, we considered receipt of useful knowledge as the dependent variable, and stated that professionals occupying bridging positions are more likely to gain access to valuable knowledge. We ran linear regression models clustering the standard errors for the ID of the knowledge receivers. In model 1 of Table 5, which includes control variables, network size was positively associated with receipt of useful knowledge, whereas differences in rank and gender did not matter. Model 2 offers support for our hypothesis: controlling for tenure, gender, unit, profession, rank and network size, the more individuals were occupying brokerage positions connecting otherwise unconnected others, the more they were likely to receive useful knowledge ($B = .34$; $p < .01$). Compared to the baseline model including only control variables (model 1), adding brokerage to the baseline regression significantly predicted an additional 5% in variance ($R^2 = .13$; $p < .01$).

Structure of professional networks and brokerage

To assess the links between the structure of professional networks and inter-professional brokerage, we tested interaction effects. For what concerns doctors' networks, model 3 of table 6, which

Table 6. Regression models predicting perceived receipt of useful knowledge by doctors and interaction effects.†

Variable	Model 1	Model 2	Model 3
Unit B	-.19 (.28)	.08 (.28)	.19 (.25)
Unit C	-.50 (.28)	-.04 (.31)	-.02 (.29)
Organizational hierarchy	-.09 (.26)	-.04 (.23)	.08 (.19)
Gender	-.48* (.20)	-.45* (.17)	-.38* (.16)
Network size	.10** (.03)	.02 (.03)	.02 (.03)
Tenure		.14 (.19)	-.47 (.25)
Betweenness centrality		.46** (.13)	.16 (.12)
Betweenness centrality x Tenure			.45** (.14)
Model F	3.95	11.78	11.51
R ²	.13**	.20**	.22**

* $p < .05$; ** $p < .01$; $n = 463$.

† Entries represent un-standardized parameter estimates; standard errors are in parentheses. The intercept and dispersion parameters were included in the regression models but are not reported here.

includes 463 observations of knowledge transfer dyads of doctors receiving knowledge from others doctors and nurses, supports our hypothesis showing that the interaction effect of doctors' betweenness centrality by doctors' tenure was significant ($B = .45$; $p < .01$). To determine whether the direction of interaction patterns was consistent with our predictions, we used Aiken and West's approach (1991) and plotted the predicted values of receipt of useful knowledge from minus one to plus one standard deviation in betweenness centrality. Consistent with our hypothesis, simple slopes show that the positive relationship between receipt of useful knowledge and betweenness centrality was stronger among junior doctors compared to senior doctors (Figure 5).

Looking at the nurses' network, the regression models in Table 7 include 573 observations of knowledge transfer dyads with nurses receiving knowledge from nurses and doctors. When including the interaction effects for nurses' betweenness centrality by nurses' organizational rank, the interaction term was significant ($B = .37$; $p < .05$; model 3 of Table 7), supporting our hypothesis. As confirmed by the ordinal interaction effect showed by the simple slopes of Figure 6, the positive relationship between brokerage and receipt of useful knowledge was stronger among nurse managers.

We used qualitative data to understand the micro-processes through which the structure of professional networks relates to the likelihood of specific actors to broker useful knowledge between distinct professional groups. First we found that it is through gaining legitimacy in the professional network that actors are entitled to broker valuable knowledge. Thus it is by virtue of the hierarchical position in nurses' networks provided by their organizational rank that nurse managers are allowed to actively control knowledge transfer between other nurses and the doctors; whereas in the relatively less centralized networks of doctors, in which the role of internal professional hierarchy in controlling knowledge transfer tends to be less pervasive, junior doctors are more willing and able to act as inter-professional brokers by borrowing social capital from their senior peers. A senior doctor we interviewed in the medical unit said:

Junior doctors have good technical competence and are great in dealing with technology. Moreover, they search for the contact of their more experienced colleagues... And because senior doctors rarely strive to be directly responsible for regulating the communication flow between others, junior colleagues are often allowed to become the 'custodians' of most of the knowledge passing within the department.

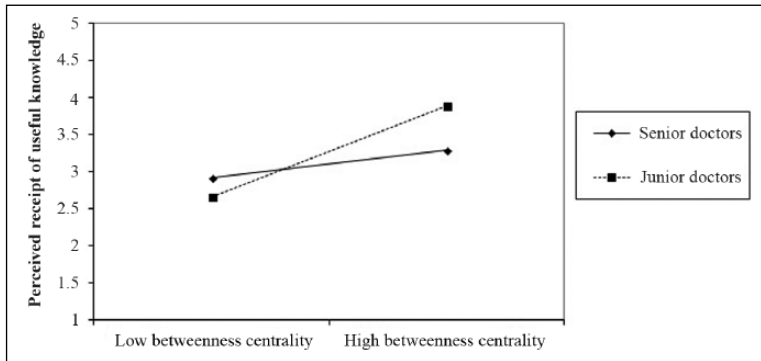


Figure 5. Simple slopes for betweenness centrality and receipt of useful knowledge by junior and senior doctors.

Table 7. Regression models predicting perceived receipt of useful knowledge by nurses and interaction effects.[†]

Variable	Model 1	Model 2	Model 3
Unit B	.26 (.22)	.35* (.16)	.24 (.16)
Unit C	.32 (.22)	.43* (.18)	.40* (.16)
Tenure	.08 (.17)	.17 (.15)	.13 (.14)
Gender	.08 (.19)	.16 (.12)	.02 (.12)
Network size	.08** (.02)	.02 (.02)	.02 (.02)
Organisational hierarchy		.58** (.16)	-.07 (.29)
Betweenness centrality		.27** (.11)	.21* (.10)
Betweenness centrality x Organisational hierarchy			.37* (.14)
Model F	6.78	11.40	13.80
R ²	.08**	.15**	.16**

* $p < .05$; ** $p < .01$; $n = 573$.

[†] Entries represent un-standardized parameter estimates; standard errors are in parentheses. The intercept and dispersion parameters were included in the regression models but are not reported here.

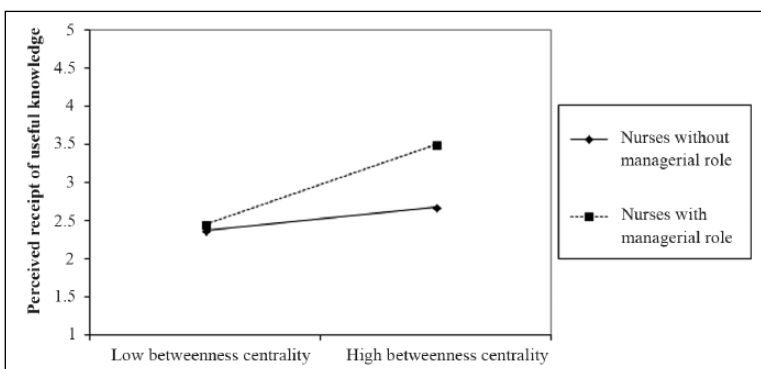


Figure 6. Simple slopes for betweenness centrality and receipt of useful knowledge by nurse managers and nurses without managerial role.

Second, we found that opportunities for inter-professional knowledge brokerage are more likely to accrue to actors exposed to inter-professional interaction ties providing access to knowledge from different sources. Regarding nurse managers, they exert an active role in regulating and controlling the interactions between other nurses and the doctors. By occupying positions that allow active management of the transfer of knowledge between distinct professionals, nurse managers are more likely to access valuable knowledge. This point is well exemplified by a nurse in the medical unit, who described the behaviour of the nurse manager:

Our nurse manager tends to work as a 'drawbridge' in regulating the contacts between other nurses and the doctors. She leverages this separation to maintain the control over what other nurses know, and over the knowledge they share with doctors.

For what concerns doctors, instead, it is worthwhile to evidence that junior doctors are more likely to gain access to non-redundant knowledge because they tend to rotate quickly through different wards within the department: in doing so, they can easily understand from whom to borrow social capital, and to whom to go to access valuable professional advice. This point is well expressed by a junior doctor in the nutrition unit, who said:

In my first three years in this department, I worked in several wards. This was for me a valuable experience. Indeed it boosted my professional competence and gave me the chance to meet new people to whom I can go for advice.

Discussion

In this study, we examined the relationships between the structure of professional networks and processes of inter-professional knowledge transfer in a hospital setting. We found that the composition of professional cliques and the development of distinctive professional identities built upon status gaps and organizational roles tend to inhibit effective knowledge transfer between doctors and nurses: professionals are thus more likely to transfer knowledge within rather than outside their occupational group. But social structures not only constrain patterns of knowledge transfer; they can also enable specific actors to facilitate the transfer of knowledge between professions. Thus inter-professional knowledge transfer is favoured by the network role of clinical directors, as subjects who act as mediators between doctors and nurses by occupying central positions in closely connected networks. And individuals who are motivated and legitimated, both intra-professionally and inter-professionally, to act as inter-professional knowledge brokers – namely, junior doctors and nurse managers – are more likely to gain access to valuable knowledge. The overall picture painted by these results is one of network structure interplaying with individual traits in shaping the dynamics of professional interactions.

Implications for theory and research

The evidence produced by our study offers important contributions to research on the sociology of professions and social networks in healthcare. First we fuelled the exploration of the links between the structure of professional networks of doctors and nurses and patterns of inter-professional knowledge transfer. Organizational researchers traditionally relied on sociological arguments to claim that frontiers built on status gaps and distinctive backgrounds can hamper the patterns through which knowledge is transferred between occupational groups (e.g. Addicott & Ferlie, 2007). However, we found that these patterns can be explained more persuasively when considering the internal structure of professional networks. In the relatively decentralized network of doctors, forms of horizontal

social control highlight the relevance of peer-to-peer helping and advice-sharing behaviours, which in turn make doctors less prone to expend effort in moving knowledge outside the boundaries of their professional group. In the more connected but also more centralized network of nurses, internal hierarchies and professional boundaries lead to intra-professional embeddedness, with knowledge transfer controlled by nurse managers and with limited opportunities of inter-professional interactions for other nurses (see Allen, 1998; Dingwall & Allen, 2001).

This evidence thus far could be read as though knowledge outcomes spring directly from the network structure of professional cliques. Although professional cliques represent powerful constraints for individual action, individuals can run counter to such constraints by virtue of their dispositions and their social positions in both intra-professional and intra-organizational structure (e.g. Kilduff & Tsai, 2003). Thus clinical directors, who are relatively less central in the internal structure of doctors' networks compared to nurse managers, tend to position themselves at the centre of closely knit inter-professional networks: these positions reflect their status in the network and make them more likely to bring doctors closer to nurses and facilitate the transfer of knowledge between different professions.

Further research is needed to longitudinally assess whether the action of clinical directors affects in turn the structure of intra-organizational networks (see Barley, 1990): that is, whether the overall network including nurses and doctors in the department becomes more connected over time following the efforts of clinical directors as actors who bring distinct professions together by occupying central positions in the network; or whether the embeddedness of professional cliques in hampering knowledge transfer tends to prevail in the long term over the efforts of joining distinct professionals.

Additional evidence is also needed to understand whether and how the role of clinical directors as inter-professional mediators between doctors and nurses over time affects status gaps and organizational roles. Network studies show that the proximity of actors in closed networks can be associated with the occurrence of processes of social influence between actors (Friedkin, 2001). Thus, it is of interest to assess whether knowledge transfer in closely knit networks can contribute to shift the meaning of doctors' social influence over other professions from use of formal authority and persuasion to more unconscious processes, including social comparison (see West et al., 1999, p. 635). Moreover, it is relevant to investigate whether closed ties to other doctors and nurses can help clinical directors maintain the existing status configuration when threatened in their role by other categories of professionals following, for example, organizational change (see Currie, Finn, & Martin, 2009).

Although we show that central positions help professionals transfer knowledge between cliques, it is remarkable to note that network positions bridging across inter-professional divides tend to provide individuals with the opportunity of accessing non-redundant knowledge (see Burt, 2007). Indeed, brokers tend to occupy positions that allow them to sit at the crossroads where knowledge and other resources flow. It is through the analysis of brokerage mechanisms that our study unveils the nuanced links between network structure and characteristics of individual actors in explaining knowledge transfer patterns: individual characteristics combine with social positions – both in the professional and organizational network – in allowing actors to span across inter-professional divides and reap the advantages of brokering knowledge (see Burgess & Currie, 2013). This is the case for junior doctors, who are more disposed toward brokering knowledge and benefit both from the legitimacy of their professional status and from their position in the relatively less centralized structure of doctors' networks, in which the internal control of senior members over knowledge tends to be less pervasive than in the networks of other professions. This is also the case of nurse managers, who are hampered by their belonging to a lower-status professional group (see Battilana,

2011), but gain the necessary legitimacy to act as knowledge brokers from their managerial role in the organization and from their hierarchical position in the nurses' network.

At the heart of this study is therefore the irreducible tension between social structure and the characteristics of individual actors in explaining outcomes of importance for individuals and groups. We show that there is a clear link between the micro activities of individuals and the social positions that achieve an apparently objective facticity. But we also acknowledge that individual dispositions are not enough to enable people to achieve positive outcomes when they either lack the ability to pursue these outcomes or occupy less advantageous positions in the structure of informal networks (see Lockett, Currie, Finn, Martin, & Waring, 2014). Thus we need to know more about how people are complicit in the creation of network arrangements within which their actions become embedded. And, given our interest in the dynamics of organizational networks, we suggest that it is time to reconsider whether it is the network that governs individuals' actions or, rather, do the individuals, with all their personal characteristics, actually govern and make up their network (Burt et al., 2013). Future research, therefore, is particularly essential concerning how individuals' attributes, in terms for example of people's demography, psychology and motivation, help people shape the structural features of those social networks that affect in turn their action (see Kilduff & Tsai, 2003).

Zooming out from the individual, future research is also needed to take into account the role of higher-level, inter-organizational dimensions of social position in affecting the actors' access to organizational resources (see Battilana, 2006). The traditional model of role division among organizations leads tertiary hospital centres, which provide specialist care and are often academic centres at the regional or national level, to enjoy higher status compared to other centres. They are followed by secondary care hospitals, which provide mainstream care locally, and by primary care organizations, which focus on preventive care and tend to offer community care services (Currie et al., 2012; Peckham & Exworthy, 2003). It would be of interest to assess whether the status gap between organizations with different social positions can hamper inter-organizational knowledge transfer, and what actors in the distinct organizations are socially legitimated to occupy brokerage roles aimed at facilitating inter-organizational communication processes.

An important issue concerns the transferability of our study in relation to contexts with a different configuration of healthcare services provision. On the one hand, we might perceive our setting as rather distinctive. For example, the investigated hospital is operating in a Beveridge-style system, in which central organization and centralized decision-making could affect the structure of professionals' social networks (Dent, 2003). On the other hand, the evidence arising from our focal case has wider resonance to different types of settings. Regarding the structure of professionals' networks, the evidence that doctors' social networks are more fragmented and less hierarchical in comparison to the networks of other professions is mirrored both in a study conducted in a country with a Beveridge model, such as the British NHS (West et al., 1999), and in research analysing hospital network data in a Bismarck system, such as the Netherlands (Sasovova et al., 2010). Although Bismarck systems, unlike Beveridge models, are based on decentralized decision-making and negotiation of consensus at the local level (Kümpers, Van Raak, Hardy, & Mur, 2002), the similarity of those findings seems to suggest that beneath the distinct institutional architecture of systems of healthcare provision (see Dent, 2003) there are relatively stable structural patterns that characterize the composition of inter-professional social networks at work.

An additional issue entails the transferability of our study beyond the healthcare setting. The analysis of closed ties within cliques and of spare bridges between cliques has been successfully adopted to explain the structure of interactions between partners, and their teams, in lawyers' firms (e.g. Lazega, 2001), and between top managers, and their companies, in a cluster of publicly held firms (Galaskiewicz, 1985). Moreover, the micro-processes through which network ties relate to knowledge transfer can shed light on the understanding of the mechanisms leading to important

organizational outcomes, including the development of innovation: inhabiting social structures rich in bridging ties was associated with the likelihood of generating new ideas in analysis conducted in the informal networks of bankers, entrepreneurs and professional consultants (e.g. Burt, 2004).

A potential limitation of our study is the focus on self-reported measures of ease of knowledge transfer and receipt of useful knowledge. Following previous research, because knowledge transfer represents a cost to the source of knowledge – in terms of time and effort spent helping others to understand the source's knowledge – the source of knowledge is supposed to be in the best position to evaluate these costs (see Reagans & McEvily, 2003). Therefore we measured the source's assessment of ease of knowledge transfer.

In conclusion, organizations are changing in ways that demand renewed attention to theorizing about inter-professional interactions. In particular in healthcare, an open challenge concerns facilitating interaction among different professional groups and rendering these groups more willing and able to transfer knowledge and share ideas with each other. As shown by our research, studying the interplay between the social structure of professional networks and individual traits may help explain the processes through which knowledge either remains stuck or is transferred between professional boundaries.

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Appendix. Structure of the survey instrument

Part 1: General information

- 1 A.** Family name and given name: _____
- 1 B.** Gender: [] F; [] M
- 1 C.** Age (in years): _____
- 1 D.** Tenure (years in the hospital): _____
- 1 E.** Profession: [] Doctor; [] Nurse
- 1 F.** Educational background: _____
- 1 G.** Organizational rank: [] Clinical Director (or Director of Nursing); [] Other

Part 2: Communicating with co-workers searching for information and knowledge

- 2 A.** Focusing on all the colleagues within the department (both doctors and nurses) listed in alphabetical order below, please indicate with whom you communicate - specifically, to whom you generally go for knowledge or information on work-related topics.

(The roster with the names of all the professionals working in the department is provided)

- 2 B.** Think about your knowledge transfer relationship with #Person1#. To what extent does the knowledge received from #Person1# allow you to:

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

better perform my clinical activity	1	2	3	4	5	6	7
achieve higher performance in the clinical activity of my ward	1	2	3	4	5	6	7
enhance the appropriateness of the clinical activity of my ward	1	2	3	4	5	6	7
give my co-workers more accurate information	1	2	3	4	5	6	7
reduce potential errors in the daily activity of my ward	1	2	3	4	5	6	7
be able to focus my efforts in the most important activities in my ward	1	2	3	4	5	6	7
better understand how to perform my job	1	2	3	4	5	6	7

This question is repeated for each person listed by the respondent in 2A.

Part 3: Communicating with co-workers transferring information or knowledge

- 3 A.** Focusing on all the colleagues within the department (both doctors and nurses) listed in alphabetical order below, please indicate who generally comes to you for knowledge or information on work-related topics – only if you provide knowledge or to this person.

(The roster with the names of all the professionals working in the department is provided)

- 3 B.** Think about the knowledge that you provided to #Person1#. The statements on the following table concern your perceived assessment of the ease of knowledge transfer from you to #Person1# (1: strongly disagree to 5: strongly agree).

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

This question is repeated for each person listed by the respondent in 3A.