State of IS Integration in the Context of Patient-Centered Care: A Network Analysis and Research Directions

Ali Reza Montazemi, McMaster University, Canada
Jeff J. Pittaway, McMaster University, Canada
Karim Keshavjee, InfoClin Inc., Canada

ABSTRACT

For more than a decade, healthcare reform has emphasized coordinated “patient-centered care”. To that end, policymakers have invested in integration of healthcare providers’ information flows. Research has studied healthcare providers’ information needs but overlooked communicative exchanges among participants in coordinating treatment plan decisions. Consequently, although medical literature asserts that patients should depend on information exchange with healthcare providers to enable participation in treatment plan decisions, the assertion has not been tested. In this paper, the authors conduct an empirical study to elucidate the structure of actors’ communications in support of their information dependencies. The findings illustrate that although patients are well connected through personal contact with healthcare providers, patients are disenfranchised from integrated healthcare information systems (IS) and the potential of IS to support patients’ participation in coordinated “patient-centered care” decisions. Furthermore, knowledge asymmetry between patients and healthcare providers should be considered in the selection and design of healthcare IS.

Keywords: Communication, Coordination, Information Integration, Knowledge Asymmetry, Network Analysis, Patient-Centered Care

INTRODUCTION

Medical literature asserts that patients should depend on information flows with healthcare providers to enable patients’ participation in treatment plan decisions, and that integrated information systems (IS) should support the coordination of essential information from all pertinent actors. However, we found that the assertion has not been systematically assessed in prior research. Therefore, we undertook a systematic empirical study to develop and substantiate a conceptual framework of information dependencies and patterns of information

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flows in the context of patient-centered care for diabetics in one healthcare system. We develop the initial conceptual framework based on a review of the literature and refined through expert informants. We then substantiate the conceptual framework through face-to-face interviews with primary care physicians, clinical diabetes educators, and diabetes specialists in context. The findings shed new light on the state of IS integration in the context of patient-centered care, and highlights implications of providing patients with access to electronic medical records that should be considered in the selection and design of healthcare IS.

The basic premise of our study is that a mantra of healthcare reform for more than a decade has been “patient-centered care” in which patient-specific treatment plan decisions should be coordinated among all of the pertinent actors – patients and healthcare providers – over the course of patients’ lifecycles (ACP, 2007; Bergeson & Dean, 2006; Porter & Teisberg, 2007; Wagner et al., 1996). A central tenet of patient-centered care is that integrated IS should support the coordination of essential information from all pertinent actors. Integrated information flows are essential to coordinating treatment plan decisions over the course of patients’ lifecycles. The process of enacting patient-centered care involves diagnosing symptoms, identifying potential treatments, projecting possible health outcomes and deciding on plans of action (D’Cruz, 2008). In the process, healthcare providers and patients often face uncertainty for two reasons (Charles et al., 1997; Whitney et al., 2004). Firstly, symptoms are often indicative of numerous and potentially interacting medical conditions that are difficult to distinguish with certainty. Secondly, several alternative treatment options often exist with different possible impacts on patients’ physical and psychological wellbeing and no certain right or wrong answer. Providers and patients seek information, therefore, to help them to overcome uncertainty and decide on plans of action (Charles et al., 1997; Whitney et al., 2004; Daft & Lengel, 1986; Goodhue et al., 1992; Wybo & Goodhue, 1995). However, “while the healthcare provider possesses better knowledge regarding the expected effectiveness of health care in improving health status, the individual [patient] knows best how improvements in health status affect his or her wellbeing” (Hurley et al., 1992, p. 4). Therefore, to make coordinated patient-centered treatment plan decisions requires the integration of healthcare providers’ technical knowledge and patients’ intimate knowledge of their wellbeing (Charles et al., 1997; Flynn et al., 2006; Gafni et al., 1998; Hurley et al., 1992; Von Korff et al., 1997). To that end, “information exchange between patients and health professionals is fundamental to achieving patient participation in decision-making...[which] requires the exchange of all information relevant to decision-making” (Bugge et al., 2006, p. 2065). Because they depend on each other for information essential to treatment plan decisions, patients and healthcare providers can be viewed as a network of interdependent actors.

Prior studies have conceptualized the healthcare system as a network of actors, each of which possesses specialized knowledge in support of treatment plan decisions (e.g., Ellingsen & Obstfelder, 2007; Hanseth et al., 2006; McGrath, 2002; Ramiller, 2007; Timpka et al., 2007). Specialization is necessary because individual actors are unable to acquire, store and process information in all areas of knowledge (Grant, 1996). Actors lacking resources, such as information related to specialized knowledge, on which they depend to achieve objectives, such as deciding a treatment plan, coalesce into social networks (Borgatti & Cross 2003; Gasson, 2006; Tillquist et al., 2002). Social networks consist of interdependent human actors with links or ties that facilitate coordination, i.e., the exchange of resources, such as information, through actor-to-actor interactions. The structure of a knowledge-intensive social network such as a healthcare system is constituted in the patterns of actors’ dependencies and the communicative exchanges they enact to coordinate the flow of information. Communicative exchanges and information flows between actors in the social network...
can occur through (1) personal contact, such as face-to-face and telephone communication (e.g., Coiera, 2000), and/or (2) IS-supported contact, such as email communication, and Internet applications and mobile devices that facilitate the recording, transmission and analysis of biological information such as blood sugar and blood pressure levels between patients and their healthcare providers (e.g., Korhonen & Bardram, 2004; Steinbrook, 2008). The literature suggests that provider-to-provider communication in support of clinical practice is typically enacted through both personal contact and IS-supported contact (e.g., Coiera, 2000). Other studies advocate for both personal contact and IS-supported communication between patients and healthcare providers in support of patient-centered care (e.g., Bergeson & Dean, 2006). An understanding of the structure of networks constituted in the information flows between actors is considered essential to informing design and selection of IS that can support actors’ information requirements, and assessing “whether the systems we build will work the way we want them to in context” (Tillquist et al., 2002, p. 92). However, prior literature has analyzed the information requirements of healthcare organizations and individual actors without taking into account information exchange constituted through communicative interaction among all actors pertinent to care decisions (e.g., Clarke et al., 2003; Grimson et al., 2000; Huq & Martin, 2006; Keshavjee et al., 2006; Khoubati et al., 2006; Shakir & Viehland, 2005; van Merode et al., 2004; Xu et al., 2000). Therefore, notwithstanding the “patient-centered care” mantra of healthcare reform, we still do not understand the structure of the network in support of patient-centered care as constituted in information flows among all pertinent actors.

To ameliorate this gap, we undertook an empirical study in Ontario, Canada to elucidate the nature of actors’ communications in support of their information dependencies and the consequent structure of the patient-centered healthcare social network. The context of healthcare for Canadians with diabetes provides a poignant example of patient-centered care that relies on the active participation of patients and numerous healthcare providers in treatment plan decisions. As discussed in this paper, scholars find that active participation of diabetic and pre-diabetic (i.e., at risk) persons can substantially mitigate escalating medical complications and associated treatment costs (Homer et al., 2004; Testa & Simonson, 1998; Wagner et al., 2001) – costs that amounted to CAD $6 billion of the $54 billion Canada spent on all public healthcare in 2000 (PTMH, 2000). However, patients’ active involvement in treatment plan decisions must be informed through communication with healthcare specialists. Such a flow of information among actors within a patient-centered healthcare system has been advocated (e.g., Bergeson & Dean, 2006; Porter & Teisberg, 2007; Wagner et al., 1996) but has not been systematically assessed.

This paper proceeds as follows. First, we elaborate on the nature of patient-centered healthcare information flow among actors within the context of the chronic condition diabetes mellitus. This provides the basis to draw on social network theory to postulate hypotheses regarding how actors communicate in support of coordinated treatment plan decisions. We then outline the conceptual framework and methodology adopted to test the stated hypothesis, and follow with an analysis and discussion of findings. The paper concludes with implications for researchers and practitioners in the quest to improve information flows in support of patient-centered care.

THEORETICAL FOUNDATION

The context of patient-centered care can be conceptualized as a knowledge-intensive social network in which information essential to deciding treatment plans is distributed among actors with specialized knowledge, and effective patient-centered care depends on coordinating the exchange of information among all pertinent actors. As depicted in Figure 1, Abidi (2008) asserts that an understanding of information
coordination in support of healthcare delivery requires analysis of the stakeholders, the activities they undertake to achieve their healthcare goals (i.e., workflow), the knowledge sets that are the source of information required for care decisions, and the communications and technologies that support information flows. Patient-centered care decisions depend on the exchange of information about these dimensions and held within each dimension. The exchange of information through communicative interactions is a dynamic process.

Factors influencing the dynamic process of information exchange are depicted in the Borgatti and Cross (2003) dynamic model of learning, as depicted in Figure 2. The model states that the success of information exchange is a function of the dynamic process of asking for the information and of relational conditions between the actors. The process of asking for information and providing information links actors in the network. The nature of actors’ information requirements (i.e., dependencies) provides an impetus for a relationship or tie between actors. Relational ties, in turn, affect the success of the information exchange.

We use the case of healthcare for diabetics to highlight the significance of information flow among actors in support of coordinated treatment plan decisions. Diabetes mellitus is a chronic condition that tends to amplify medical complications over patients’ lifecycles (D'Cruz, 2008). Patients diagnosed as pre-diabetic (i.e., “at-risk”) bring their risk factors under control through dietary changes, exercise and periodic monitoring of their condition. Undiagnosed diabetics in the population are at severe risk of escalating medical complications because they are unaware of their need to control their blood glucose, blood pressure and cholesterol, for example, to mitigate escalation of diabetes. The diagnostic process involves physicians, nurses and medical lab tests among others. Patients diagnosed with diabetes require regular monitoring, pharmaceuticals such as insulin, and consultations with physicians in an effort to prevent the onset of diabetes-related medical complications such as stroke, heart attack, vision problems and foot disorders (O’Reilly et al., 2007). Patients with escalated diabetes experience diabetes-related organ damage that can lead to escalated medical complications, disabilities and death. Patients’ overarching objective is to manage their diabetic risks and conditions in order to mitigate escalation of medical complications over time.

Escalation of diabetes-related conditions can be substantially mitigated provided that patients implement dietary changes, regular blood glucose monitoring and insulin treatment, for example (ADA, 2003; Homer et al., 2004; Testa & Simonson, 1998; Wagner et al., 2001). Management of diabetes is necessarily patient-centered because substantial segments of the management — diet, exercise, self-monitoring and medication use, for example

Figure 1. Healthcare Knowledge Management dimensions (adapted from Abidi, 2008)
— rely on the actions of patients over their lifetimes (Bodenheimer et al., 2002; Porter & Teisberg, 2007; Wagner et al., 1996). However, numerous healthcare providers with specialized knowledge (e.g., physicians, nurses, dieticians, medical laboratory technicians, pharmacists) play a role in informing treatment plan decisions (D’Cruz, 2008). Thus, patient-centered care depends on knowledge held by patients, providers, organizations, the medical community and knowledge about medical resources, processes, metrics used to assess healthcare delivery, and the network of actor relationships (Abidi, 2008).

Actors involved in patient-centered healthcare (i.e., patient and healthcare providers) share their information towards coordinated treatment plans for a specific patient. Within this context, actors communicate with each other to reduce uncertainty, thereby making their decision environments more predictable (Te’eni, 2001). Communication among networked actors supplements information exchange by providing opportunities for clarification and sense-making regarding the potential impacts of alternative treatment strategies for a specific patient (Grabowski & Roberts, 1999).

An important aspect of social network theory is the presence or absence of ties that support communication among actors, measured by means of network density and connectivity, and the structure of ties has a direct link with how information is exchanged (Borgatti & Cross, 2003; Marsden, 1990). Communication and information exchange among the actors benefits from network closure, referring to a dense network in which all actors are cohesively connected to each other (Coleman, 1988). Here, information exchange is leveraged when actors tend to “close” the network by creating and maintaining a dense network of relationships. The closure of the network structure encourages every individual to play an active role in the network and to add to its richness by exchanging his or her information (Akgun et al., 2005; Lee & Choi, 2003).

Information exchange between actors in the social network can occur through personal contact and through IS-supported contact. The literature suggests that healthcare providers typically exchange information with each other in support of clinical practice by means of both personal contact and IS-supported contact (e.g., Coiera, 2000). Other studies advocate for both personal contact and IS-supported information exchange between patients and healthcare providers. For example, the typical patient’s physician office visit involves face-to-face communication (i.e., personal contact) but “can only address a portion of patients’ needs” (Johnson & Ambrose, 2006, p. 109). Physicians may not have time, for instance, to explain that an antibiotic prescribed to be taken three times a day must be taken every eight hours in order to maintain the desired blood levels of the medication. Hence, “a major cause of noncompliance is lack of comprehension of the treatment, fueled by lack of information” (Johnson & Ambrose, 2006, p. 110). To complement information exchange in face-to-face physician office visits, the literature advocates the use of ubiquitous healthcare information systems (UHIS) (e.g., Bonato, 2003; Dishman, 2004; Korhonen & Bardram, 2004; Steinbrook, 2008). UHIS refer...
to pervasive and ubiquitous consumer technologies such as email, Internet, mobile phones and PDAs (personal digital assistants) that facilitate information flows between patients and their healthcare providers in support of prevention, diagnosis, and treatment. For example, Internet applications such as Microsoft HealthVault and Google Health enable patients to record information about their medical indications (e.g., weight and blood pressure) over time and aggregate data from healthcare providers in order to provide up-to-date information to physicians, specialists and other healthcare providers in support of diagnosis and treatment (Steinbrook, 2008). PDAs and mobile phones offer a mobile platform for logging biological information (e.g., blood glucose, pressure) and subsequently providing real-time guidance to the patient in support of compliance (e.g., alerting the patient that he/she needs insulin) and/or submitting the information wirelessly to healthcare providers in support of diagnoses and treatment plan decisions (Korhonen & Bardram, 2004). Email enables patients to follow-up their physician office visits with a quick question (Practice Solutions, 2009). Based on the preceding theoretical foundation, within the context of patient-centered health care, we can state the following hypotheses:

Hypothesis 1: Healthcare providers in a patient-centered context maintain direct ties with each other through (a) personal contact and (b) IS-supported contact in order to exchange information in support of coordinated treatment plan decisions.

Hypothesis 2: Patients and healthcare providers in a patient-centered context maintain direct ties with each other through (a) personal contact and (b) IS-supported contact in order to exchange information in support of coordinated treatment plan decisions.

In order to assess our hypotheses, we undertook an interpretive field study (Klein & Meyers, 1999) in the context of healthcare for diabetics in Ontario, Canada.

METHODOLOGY

The purpose of an interpretive field study is to develop researchers’ understanding within subjects’ context (Klein & Meyers, 1999). It enables us to develop a rich understanding of the context of information exchange among actors in support of patient-centered care for diabetics. Interpretive study is guided by and couched within a theoretical framework that informs researchers’ initial conceptualization. To that end, we developed an initial conceptual framework of the actors involved in patient-centered care for diabetics, their information dependencies and their pattern of interactions to satisfy their dependencies through both literature survey and expert informants. We subsequently refined and substantiated the conceptual framework through face-to-face interviews with primary healthcare providers in an iterative process that continued until consensus emerged among the interview subjects. The resulting conceptual framework, in the form of a dependency network diagram, emerged from interviews with seven expert healthcare providers: two primary care physicians, a clinical pharmacist, two certified diabetes educators, and two diabetes specialists. All of the informants were experts that had both clinical and research experience in the context of information flows in support of patient-centered care for diabetics. The protocol employed in our research is elaborated as follows.

Interpretive Field Study: Conceptual Framework

Tillquist et al. (2002) draw upon a rich history of engineering data flow diagrams, process models, entity-relationship diagrams, and state transition diagrams to specify a representation methodology, dependency network diagramming (DND), which enables detailed qualitative analysis of actors’ information dependencies and interactions that constitute the structure of a network. Therefore, we adopted the protocol of dependency network diagramming to develop our conceptual framework. In the DND protocol, researchers identify roles and actions
that collectively refer to the nature of actors’ purposeful participation in the actor network. A role, encapsulates a set of actions performed by an actor or actors to achieve a goal. An action is the means or procedure for the manipulation of resources to achieve a desirable or suitable goal. A resource is anything perceived as valuable by actors in support of performing their roles, such as information, specialized skills, materials, tools or equipment. When actors are unable to achieve their goals without relying on the outputs, resources or skills of another role, a dependency exits between the roles. A dependency forms the impetus for actors to establish network ties. Coordination refers to how actors interact and exchange information (i.e., communicate) to satisfy dependencies, thereby forming ties between actors. DND arranges these constructs – roles (actors, activities, goals), dependencies and coordination – diagrammatically to depict the structure of a network.

We followed the protocol specified by Tillquist et al. (2002) for developing a DND that is parsimonious yet sufficiently detailed to facilitate analysis, as follows.

1. **Scope:** The scope of the diagram should encompass the roles involving communication to satisfy actors’ patient-specific information dependencies.

2. **Activities:** Concentrate on the essential units of activities for the purpose of analyzing dependencies and communications. Thus, we modeled a composite of activities as a single activity when they produced a single goal within the same role. Otherwise, we modeled activities separately.

3. **Goals:** Combine like goals that utilize the same supporting activities within a role.

4. **Dependencies:** Depict only one dependency from one role to another unless the dependencies are unrelated.

In order to identify the components of DND – specifically the actors, their roles, actions, goals and information exchanges – we developed and refined the initial DND diagram in four phases. First, we conducted a detailed search of the medical literature (e.g., including but not limited to *Annals of Internal Medicine, Diabetes Care, Journal of the American Medical Association*) and medical informatics literature (e.g., including but not limited to *International Journal of Medical Informatics, Journal of the American Medical Informatics Association, Journal of Biomedical Informatics*). Second, two rounds of semi-structured face-to-face interviews were conducted with a primary care physician who has been involved in design and development of medical information systems. Third, we walked through the DND with a medical specialist in chronic diseases during a one-hour face-to-face interview. Fourth, the DND was sent to an independent expert – a clinical pharmacist experienced in care for patients with diabetes – for review and comments. We concluded the process of developing the DND when no further changes were identified (Miles and Huberman 1994). With our initial conceptualization informed by the literature and by expert informants, we undertook the next phase of interpretative field study.

**Interpretive Field Study:**
**Face-to-Face Interviews**

Following the methodology of interpretive field study, we next sought to enhance and refine our initial conceptualization within subjects’ context (Klein & Meyers, 1999). To that end, we refined and substantiated the DND through in-context face-to-face interviews with each of the primary healthcare providers involved in advising patients: a primary care physician, two certified diabetes educators, and two diabetes specialists. Our first interview subject was a primary care physician because the primary care physician is considered the most significant actor in patient-centered care for diabetics (Charles et al., 1997; Porter & Teisberg, 2007), and it is the primary care physician that typically refers patients to diabetes educators and specialists, and provides prescriptions that are filled by pharmacists. Through face-to-face
interviews of 60 to 120 minutes duration conducted within healthcare providers’ context, we obtained data to elaborate, amend and refine our initial conceptualization (i.e., DND conceptual framework). Interview subjects were provided a copy of the emerging DND diagram and asked to confirm, disconfirm, amend or refine the diagram to best represent the information dependencies and information flows among all pertinent actors in patient-centered care for diabetics. We asked all interview subjects to enhance and refine our understanding of all of the roles and information flows that typically support patient-centered care for diabetics. We further substantiated the data by interviewing actors in each of the primary roles involved in advising patients, as previously discussed. In accordance with the process of interpretive study, we concluded the process of refining the conceptual framework when the data converged; that is no further changes were identified (Miles & Huberman, 1994). Convergence occurred after five interviews, and our subjects included a primary care physician, two certified diabetes educators, and two diabetes specialists. All of the participants were experts that had both clinical and research experience in the context of information flows in support of patient-centered care for diabetics.

**Analytical Procedures**

The process of developing a DND is analytical in nature (Tillquist et al., 2002). In the process of developing the DND, described above, a general conceptualization of the network structure emerges based on the pattern of actor-to-actor information exchange. However, to assess our hypotheses we sought to further evaluate the extent to which the pertinent actors maintain direct ties with each other in order to exchange information in support of coordinated treatment plan decisions, and the pattern of communicative exchange through personal contact and IS-supported contact. To that end, we used the final DND to inform a structural approach to social network analysis (SNA) (Borgatti et al., 2002; Gabbay & Leenders, 2001). Whereas the “tie approach” to SNA focuses on the dyadic relationship between a given ego and alter (i.e., subject and object actors) in order to assess the strength of ties, the “structural approach” to SNA focuses on the structure of relationships in which the ego is embedded in order to identify holes (or conversely, closure) in the network structure (Borgatti et al., 2002). Following the Borgatti et al. (2002) procedure for structural analysis, we arranged all seven actor roles identified in the DND (i.e., patients, primary care physicians, clinical professionals including diabetes educators, specialists, pharmacists, and the medical labs and insurers that provide technical and operational support) in a 7x7 matrix and coded a “1” in each cell of the matrix for which information flowed from one actor (i.e., rows) to another (i.e., columns), a “1” in each cell of the matrix for information flowed in the reciprocal direction (i.e., from actors in columns to actors in rows), and a zero in the remaining cells of the matrix. The matrix was then subjected to network density and centrality (i.e., geodesic distance) analysis and to visual analysis using UCINET software (Borgatti et al., 2002). Network density and centrality measures enabled us to evaluate the extent to which actors are cohesively connected to each other. The visual analysis enabled us to differentiate ties (i.e., patterns of actor-to-actor information flows) based on actors’ use of personal contact and/or integrated IS-supported contact. Supporting “integrated IS” include available systems to coordinate and integrate all actors’ participation, and exclude systems available to only a subset of pertinent actors (e.g., interactive pharmacy websites that are not available to patients from all pharmacies). The DND and the SNA analyses enabled us to assess our hypotheses as elaborated next.

**ANALYSIS**

**Emergent Conceptual Framework: Dependency Network Diagram**

The conceptual framework, the dependency network diagram (DND), that emerged from
literature review and interpretive field study is depicted in Figure 3. Actors’ typical information dependencies and communicative exchanges are labeled from (1) to (6) in Figure 3 and elaborated as follows.

1. Patients exhibit risks or conditions they do not recognize as related to a diabetic condition and consult with a primary care physician (PCP) to reach an understanding of their symptoms. During consultations, physicians gather information from patients (e.g., family history, weight, diet and exercise habits). If physicians interpret patients’ risks and/or symptoms as indicative of diabetes they generate an assessment action plan to confirm diagnosis. Physicians integrate their knowledge of alternative medications and interventions to project potential impacts of alternative treatment plans, decide treatment plans specific to the patient, decide which other healthcare providers to engage, and communicate risks and treatment options to patients in terms that patients can understand. Thus, patients cannot complete their action-goals of recognizing their needs and articulating an objective (i.e., Patient-AG1 and Patient-AG2 respectively in Figure 3) until they can engage a physician. Exchanges between patients and physicians in support of coordinated treatment plan decisions are usually enacted through personal communications.

2. Under the supervision of physician(s), clinical diabetes educators such as nurses, dieticians and other certified diabetes educators gather information from patients and communicate risks, treatment options and skills to patients in terms that patients can understand. Standardized forms, medical language and protocols are used to record and exchange technical information among healthcare providers. Patients have the legal right to request their medical records but usually do not maintain their own records. Not all physicians and clinicians provide IS support for patients to access medical records and communicate with professionals. Instead, exchanges between patients and clinical professionals in support of coordinated treatment plan decisions are usually enacted through personal communications.

3. Patients with diabetes have a substantially amplified risk of diabetes-related medical complications such as foot, eye and heart disorders. Therefore, patients depend on podiatrists/chiropodists, ophthalmologists, optometrists and cardiac specialists, for example, who have the knowledge to interpret symptoms, set objectives, and plan actions (i.e., to satisfy patient action-goals AG1, AG2, AG3) for a narrow set of specialized conditions. However, patients are usually not aware of who alternative specialists are, their capabilities, and how to engage them. Thus, patients rely on PCPs’ knowledge of specialists and protocols of engagement; a reliance that is enforced by a requirement for official patient referrals from PCPs to physicians that specialize in diabetes-related medical complications. Exchanges between patients and physician specialists are usually enacted through personal communication such as face-to-face physician office visits. Physician specialists also depend on information from the PCP and other healthcare providers. Providers usually exchange standardized medical records via paper and via inter-organizational information networks linking clinical information systems. Standardized forms, medical language and protocols are used to record and exchange information. Providers also communicate with other providers directly by phone, email or face-to-face when they require specialized information to inform treatment plans. Providers establish their knowledge of other providers’ specialties and establish the ability to
communicate with them through similar medical education, experience, medical conferences, and by building a history of rich interactions. Usually, patients do not have similar education and experience and are not privy to providers’ communications and information systems.

Patients are directed to medical laboratories for specialized diagnostic tests. Medical technicians perform HbA1c, LDL, HDL, and urine albumin tests using specialized laboratory instruments and techniques, and they record their findings in standardized medical language and forms. This information is usually communicated back to the provider that requisitioned the test for interpretation and action planning in a subsequent patient consultation. Until this information is interpreted, patients cannot accurately interpret symptoms, set objectives and plan actions (i.e., complete action-goals Patient -AG1, -AG2 and -AG3).

Patients diagnosed with diabetes depend on medications such as insulin and blood thinners, medical supplies and consumer medical devices to plan and perform purposeful action (i.e., satisfy patient action-goals AG3 and AG4). Only physicians can prescribe controlled medications, but pharmacists communicate self-administration instructions and the skills to use medical devices to patients in terms they can understand. Some pharmacies also use information systems to identify potential negative interactions of a new prescription with patients’ other medications. If a negative interaction is
detected, the information is relayed back to the physician to modify the treatment plan and prescription. Not all pharmacies provide IS support for patients to access medical records and communicate with pharmacists, and pharmacies do not actively share customers’ prescription records with competing pharmacies. Instead, exchanges between patients and pharmacists to coordinate patients’ treatment plan decisions over their lifecycles are usually enacted through personal communication.

Regulators and insurers influence healthcare providers’ actions and decision-making. Regulators, such as physicians’ College of Physicians and Surgeons of Ontario, specify the “appropriateness” and the boundaries of medical practices that different providers are licensed to perform. For example, physicians are licensed to interpret patients’ conditions, decide patients’ medication regime and write prescriptions, whereas pharmacists are not. The boundaries and appropriateness of practices are communicated to healthcare providers through intensive education, publications, seminars, conferences and specialized knowledge bases. Patients are usually not aware of the boundaries of providers’ practice that influence providers’ actions and decision-making. Furthermore, patients’ insurers, both public and private, specify the medical treatments they will fund and how much they will pay for them. By law in Ontario, providers cannot extra-bill patients for most services covered by government insurance. Therefore, providers’ treatment recommendations to patients may be influenced by their knowledge of the rates and coverage of specific patients’ insurance providers. Patients can choose private insurance programs but cannot usually access information about how much insurers pay for services and how providers perceive patients’ insurance coverage.

Hypothesis Testing: Social Network Analysis

We used information from the preceding DND analysis to construct a matrix of ties between actors. The matrix was used to assess the network density and patient centrality through UCINET software (Borgatti et al., 2002). Actors’ network density computations show that all of the actors – both healthcare providers and patients – are cohesively connected to each other (Network density = 0.9286 and Geodesic distance of 1.071). Furthermore, as can be noted from the graphical depiction of network ties in Figure 4, direct ties exist between the patient and all healthcare providers.

For visual analysis, ties (i.e., actor-to-actor information flows) that typically use both personal and IS-supported contact were distinguished with bold lines, and ties that typically use personal contact but not IS-supported contact were distinguished with thin lines, as depicted in Figure 4. Based on the analysis, we find that healthcare providers maintain direct ties with each other through both personal contact and IS-supported contact, and therefore both Hypothesis 1a and 1b are supported. In addition, patients and healthcare providers maintain direct ties with each other through personal contact, and therefore Hypothesis 2a is supported. However, Hypothesis 2b is not supported: patients and healthcare providers do not typically maintain direct ties with each other through integrated IS-supported contact. Integrated information systems support coordination among healthcare providers but patients are disenfranchised from potential benefits afforded by access to these systems. It is noteworthy to realize that even if patients had access to these information systems, they may not benefit from them because the content is highly technical. We elaborate on this issue next.
DISCUSSION

Diabetes mellitus is a chronic condition that involves numerous risks and associated medical conditions that patients need to actively manage over their lifecycles. Accordingly, patients are central and active actors that are expected to learn how to manage diabetes risks and conditions. For example, pre-diabetic patients need to develop a basic awareness of diabetes whereas diabetic patients learn to test and interpret their own blood pressure and blood glucose levels instead of relying on physicians and medical labs as they do during initial diagnosis. Furthermore, patients cannot achieve their management goals until they receive information essential to informing care decisions in a form that they can understand and act upon. Our actor-network analyses show that patients have direct ties based on personal communication with healthcare providers but are disenfranchised from direct access to the integrated IS that benefit the other actors. This may constrain patients’ ability to communicate effectively with healthcare providers in support of a coordinated patient-centered treatment plan. For example, Johnson and Ambrose (2006) assert that “the typical patient’s physician office visit (POV) can only address a portion of patients’ needs... [and] there is little the POV can do to alter this scenario, given the economic, personnel, and time constraints on the existing system” (p. 109). Consequently, scholars such as Bergeson and Dean (2006) advocate for supplementing the traditional POV with IS-supported information exchange. Nonetheless, providing patients with direct access to integrated healthcare IS “as is” could be problematic due to their lack of shared knowledge with healthcare providers. Actors must possess cognitive proximity to communicate effectively.

Cognitive proximity refers to the presence of overlapping knowledge sets between actors that enables them to communicate with higher plausibility of mutual understanding (Montazemi & Chan, 1990; Te’eni, 2001). Healthcare providers develop close cognitive proximity through considerable investments in similar education, experience and organizational contexts. Patients, in general, do not develop the same close cognitive proximity with healthcare providers. Therefore, the plausibility is remote that patients can correctly understand technical information available in healthcare information systems to enable them to communicate effectively with healthcare specialists. Because of the knowledge asymmetry, direct access to healthcare providers’ IS “as is” will not likely enable patients to communicate more effectively with healthcare providers. Instead, patients require IS solutions that help them to engage actors who can help them to reach an understanding about a situation and their plans of action (Te’eni, 2001). Therefore, viewing the findings of our

Figure 4. Actors’ network ties for communication in support of patient-centered treatment plan decisions
study through the lens of cognitive proximity elucidates important implications for practice, policy and research as follows.

**IMPLICATIONS FOR PRACTICE, POLICY AND RESEARCH**

While the findings from this research show that healthcare providers have access to integrated IS, we found no evidence of integrated IS that support patients’ participation in coordinated treatment plan decision-making. Policymakers should realign their investments with their strategy of patient-centered care by directing resources at integrated IS that support patients’ communication requirements. For example, in February 2009, the US government passed a proposed budget of $17 billion in investments directed at making electronic health records (EHRs) available to patients (Mearian, 2009). The investments are intended to improve patient-centered care, in part, by integrating patients into healthcare information flows. However, simply providing patients with access to the same records that healthcare providers benefit from is insufficient due to knowledge asymmetry. Patients lack requisite knowledge that healthcare providers possess to interpret the available information in support of coordinated patient-centered treatment plan decisions. For example, physicians can draw upon their medical education and experience to accurately interpret the results of a blood test that patients without similar education and experience are unlikely to accurately interpret. Hence, the deployment of healthcare IS such as EHRs will not be sufficient to achieve healthcare reform without greater emphasis on providing cognitive support for patients and healthcare providers (Stead & Lin, 2009). Our study highlights, therefore, the need to incorporate knowledge asymmetry into IS design and IS research in order to identify how IS can help patients to access the interpretive support they need to understand and apply medical information as intended by experts. When actors lack information and processing skills and cannot access these resources when and as needed, they seek out other actors that can satisfy their needs to ameliorate the asymmetry (Gasson, 2006; Tillquist et al., 2002). This constitutes a compelling explanation for the rise in popularity of Internet-based online communities in healthcare.

The members of online communities voluntarily coalesce around “shared purposes, and they interact socially by adhering to tacit and explicit protocols, rituals, and roles using Internet technologies that support interaction” (Johnson & Ambrose, 2006, p. 108). Communities are known to promote learned individual competence through diffusion of the collective knowledge of the group via social interactions (Lave & Wenger, 1991; Wenger, 1998). Through the sharing of narratives and participation in discussions with actors that have a variety of expertise, members develop competence to engage experts in sense making and experts collaborate to guide the learning and activities of community members (Lave & Wenger, 1991; Wenger, 1998; Orlikowski, 2002). Therefore, patients may be able to access interpretive assistance when and as needed within online communities to develop enhanced competence to participate in patient-centered care decisions. In turn, providers may benefit when patients, through community participation, increase their competence to participate in patient-centered care and to communicate their intimate knowledge about how improvements in health status affect their wellbeing (Charles et al., 1997; Hurley et al., 1992). Furthermore, healthcare providers can coordinate their collective expert knowledge in support of patient-centered care plans through the enabling mechanism of an online community (Abidi, 2008). However, online communities are faced with a number of problems such as misinformation (Johnson & Ambrose, 2006). Therefore, further research is needed to assess the costs and benefits of online communities in the context of patient-centered care.

Costs associated with managing Internet-based communities arise from three important sources. First, communal network structures may be optimal for coordinating distributed
knowledge in support of highly complex problems, but prove inefficient for coordinating solutions to less complex problems (Nickerson & Zenger, 2004). Therefore, research is required to identify optimal design structures that can support the types of problems that actors address in online communities. Second, scholars studying communities find that governance mechanisms commonly employed in organizations, such as authority-based hierarchical management structures, can prove detrimental to the sustainability and performance of online communities (Brown & Duguid, 1991). Therefore, optimal governance mechanisms need to be identified for ensuring sustainable healthcare communities. Third, the literature asserts the vital importance of expert, leader and governing roles – for healthcare professionals in our case – to ensure responsible quality standards for community information, behaviors and activities (Brown & Duguid, 1991; Johnson & Ambrose, 2006; Lave & Wenger, 1991; Wenger, 1998). However, the optimal combination of design, governance and quality roles has not been empirically assessed. Therefore, further research is needed to identify community design, governance mechanisms and roles of healthcare providers that optimize the value of communities as an effective and efficient tool in support of patient-centered healthcare.

The findings reported in this paper are limited to patient-centered information flow within the context of the diabetes mellitus environment in Ontario. Future research could help us to understand the nature of patient-centered information flow within other healthcare contexts and/or jurisdictions. The findings are also limited to healthcare providers’ expert view. However, the conceptual framework (DND) that emerged from this study can provide a basis for assessing patients’ perspectives in future studies. Research eliciting patients’ perspective on information flows should provide rich new insights into the efficacy of personal contact and IS-supported contact in support of management of diabetes.

Finally, this study showed that DND can provide a useful analytical tool for depicting the overall pattern of information flows among actors (i.e., network structure). DND does not, however, tell us what knowledge actors exchange or fail to exchange by means of personal contact, such as patients’ physician office visits, or IS-supported contact, such as Internet access to medical records. Only with this understanding can we begin to assess how investments in IS, intended to integrate patients into healthcare information flows, work or do not work. As jurisdictions make substantial new investments intended to integrate patients into healthcare information systems (e.g., $17 billion in US, cf. Mearian, 2009), the need is ever more urgent for research that elucidates how these systems work or do not work to complement information exchange between patients and healthcare providers.

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Ali Reza Montazemi is a Professor of Information Systems at DeGroote School of Business, McMaster University. He has served on the editorial boards of Journals such as European Journal of Information Systems, Canadian Journal of Administrative Sciences, and several international conferences including conference co-chair of Americas Conference on Information Systems 2008. He has published over 80 papers, one textbook, three monographs, and three software packages. His publications have appeared in journals such as MIS Quarterly, Communications of the ACM, Journal of Management Information Systems, Decision Support Systems, Information & Management, OMEGA, and IEEE Transactions on Systems, Man, and Cybernetics.
Jeff J. Pittaway is a Doctoral candidate in Information Systems at DeGroote School of Business, McMaster University. Prior to the PhD program, he had 20 years of experience in implementation of information systems in public sector and private industry. His research interests are knowledge management and IT governance in the areas of eHealth, eGovernment and multinational corporations.

Karim Keshavjee is a family physician with a part-time practice. He is a primary care health informatics consultant and an Adjunct Associate Professor at the University of Victoria. He is an associate at the Centre for Evaluation of Medicines, a research institute at McMaster University. He has published several peer-reviewed articles and has spoken at numerous conferences on the topics of electronic medical records and clinical decision support. He is currently the Clinical Data Systems Architect for Canada’s chronic disease surveillance network which is amalgamating data on chronic disease from 140 physicians who use 7 different EMRs in several provinces in Canada.