

Exploring Health Information Technology Innovativeness and its Antecedents in Canadian Hospitals

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Keywords

Health information technology, innovativeness, hospitals, organizational characteristics, survey

Summary

Objectives: The primary aim of this study was to assess the antecedents of health information technology (HIT) innovativeness in public hospitals. To do so, we built upon our own previous work to relate the level of HIT innovativeness to organizational capacity characteristics.

Methods: We conducted a survey of chief information officers (CIOs) in public hospitals in the two largest Canadian provinces to identify the level of HIT innovativeness in these settings and test nine research hypotheses derived from the proposed research model.

Results: A total of 106 completed questionnaires were received, which represents a response rate of 52%. Our findings indicate strong support for the research model. Seven out of nine hypotheses were supported indicating a significant relationship between HIT innovativeness and structural, financial, leadership, and knowledge sharing capacity characteristics. Results also reveal a moderate level of HIT innovativeness in the surveyed hospitals, with more emphasis on administrative systems and their integration than on clinical systems and emerging technologies.

Conclusions: This study demonstrates that organizational characteristics are related to HIT innovativeness; this relationship holds irrespective of the public or private nature of hospitals.

tion of technologies that reduce medical errors and promote patient safety was ranked as top e-health priority for hospitals [16].

Despite recognizing the role of HIT as a critical enabler for patient safety and quality of care and the increasing efforts invested by hospitals to benefit from these resources, little is known about the organizational characteristics that influence the level of innovativeness with regard to HIT applications in hospitals. According to Hikmet et al. [17], prior adoption studies have mainly focused on single applications like computerized physician order entry (CPOE) and electronic medical record (EMR) systems, were conducted in less-generalizable settings such as academic medical centers, and used secondary datasets of uncertain quality, which present limitations in relation to the observed inferences. Importantly, previous studies that investigated the factors influencing the broader adoption of HIT applications were all conducted in U.S. hospitals, which might also limit the generalizability of the results to other nations such as Canada, Australia, and several European countries where the health care system is mainly public. This research presents a contribution in this area by examining HIT innovativeness in the context of Canadian hospitals and addressing the research question below. HIT innovativeness is used in the context of this study to refer to the extent to which administrative and clinical applications/technologies are deployed, used, and integrated in healthcare organizations.

What organizational characteristics are most likely to influence HIT innovativeness in public hospitals?

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Methods Inf Med 2010; 49: 28–36

doi: 10.3414/ME09-01-0027

received: April 17, 2009

accepted: August 2, 2009

prepublished: December 8, 2009

1. Introduction

It is widely accepted that the adoption of health information technology (HIT) in the healthcare sector offers great potential for improving the quality of services (e.g. [1, 2]) and the efficiency and effectiveness of personnel (e.g. [3–5]), as well as reducing organizational costs (e.g. [6, 7]). In recent years, HIT has become critical for achieving several health care organizational reform priorities, including home care, primary care, and integrated care networks (e.g. [8–11]).

Hospitals, which represent critical constituents of health care systems, are continuously exploring opportunities for investing in HIT to improve efficiency, promote patient safety, and better quality of care [12–14]. According to a recent survey by the American Hospital Association on hospital use of HIT, around 46% of hospitals reported moderate to high use of clinical information systems in 2006 [15], which represents an increase compared to previous years. In Canada, a recent survey of hospitals in the province of Ontario also showed that the implementa-

2. Background

Following Jaana et al. [18], we identified four categories of organizational characteristics as being salient to HIT innovativeness in hospital settings, namely: 1) structural capacity characteristics; 2) financial capacity characteristics; 3) leadership capacity characteristics; and 4) knowledge-sharing capacity characteristics. The characteristics considered under each domain as well as the theoretical rationale for choosing these specific factors are presented in the following paragraphs.

2.1 Structural Characteristics

Organization size has been one of the most widely investigated antecedents of HIT innovativeness in hospitals (e.g. [17, 19–21]). According to the resource-based theory^a, large organizations have the capacity to accommodate environmental pressures by making strategic choices and using the abundant internal resources and administrative skills that they possess. The diffusion of innovation theory^b also considers size as a positive predictor of organizational innovativeness. In the present context, it is likely that larger hospitals may be more innovative with regard to HIT adoption, use and integration than smaller hospitals since they are usually more geographically dispersed, deal with more complex tasks, and require greater coordination to perform administrative and clinical activities. Empirical evidence to this effect is obtained from several studies including

^a Resource-based theory [22, 23] argues that organizations possess resources, a subset of which enables them to achieve competitive advantage, and a subset of those that lead to superior long-term performance. Resources that are valuable and rare can lead to the creation of competitive advantage. That advantage can be sustained over longer time periods to the extent that the firm is able to protect against resource imitation, transfer, or substitution.

^b Diffusion of innovation theory [24] posits that organizational innovativeness is related to such variables as individual leader characteristics (e.g., attitude toward change), internal organizational structural characteristics (e.g., size, complexity), and external characteristics of the organization (e.g., system openness).

Burke et al. [19], Wang et al. [20], McCullough [21], and Furukawa et al. [25]. Hence, we posit that:

H1a: Larger hospitals have higher levels of HIT innovativeness than smaller hospitals

Past research has also observed that academic hospitals are more inclined to innovate than non-teaching institutions [e.g., 26–29]. In the particular context of HIT innovations, limited evidence to this effect was reported by Furukawa et al. [25] and McCullough [21]. Teaching hospitals tend to be associated with medical schools and, hence, are expected to adopt, use and integrate HIT to support their research and training activities in addition to the usual clinical and administrative processes. Therefore, we suggest that:

H1b: Teaching hospitals have higher levels of HIT innovativeness than their counterparts

2.2 Financial Characteristics

Financial resources represent another important factor recognized in the innovation literature [24, 30]. The decision to adopt HIT applications requires significant financial resources for which hospitals often have competing demands. In support of this view, Wang et al. [20] found that operating revenue is positively associated with HIT innovativeness in nonfederal U.S. hospitals. In the present study, two variables are used as indicators of available financial capacity in Canadian hospitals, namely, overall operating budget and the percent of the budget allocated to HIT operations and activities. We propose the following hypotheses with regard to the financial capacity of public hospitals:

H2a: Overall operating budget is positively related to the level of HIT innovativeness in hospitals

H2b: The proportion of the overall budget allocated to HIT activities is positively related to the level of HIT innovativeness in hospitals

2.3 Leadership Characteristics

Leadership resources represent the third conceptual domain examined in this study. The resource-based view emphasizes the managerial role and its importance in facing organizational challenges and environmental pressures [31]. In the case of hospitals, individuals who have the power to allocate resources can certainly affect decisions involving adoption, use and integration of innovative technologies [32]. It is argued that CIOs who have long IT tenure would have more legitimacy, knowledge, experience, and skills that would favor the adoption of innovations in organizations [33–36]. In the healthcare context, Jaana et al. [18] found a positive relationship between the CIO's level of IT tenure and the level of HIT innovativeness in a sample of Iowa hospitals. Hence, we posit that:

H3a: IT tenure of the CIO is positively related to the level of HIT innovativeness in hospitals

Another organizational mechanism that can enhance IT leadership in organizations is the presence of an IT steering committee [37, 38]. A steering committee is a high-level team of representatives from multiple divisions or functions who are entrusted with the task of linking IT strategy with organizational objectives and strategy by setting a strategic direction and matching organizational concerns with technological potential. IT steering committees are likely to enhance HIT innovativeness levels in hospital settings by providing strategic direction to IT operations, ensuring leadership in exploiting and managing IT, resolving resource allocation decisions, and supporting visibility of IT initiatives [39]. Hence, we propose the following hypothesis:

H3b: Hospitals with an IT steering committee have higher levels of HIT innovativeness than their counterparts

Table 1 Summary of research hypotheses and previous empirical support

Hypotheses	Independent variables	Capacity dimensions	Nature of hypotheses		Previously tested hypotheses		
			Newly developed hypotheses	Previously tested hypotheses	Full support	Partial support	Included as a control variable
H1a	Number of beds	Structural		✓	[19–21, 25]	[17, 18]	–
H1b	Teaching status	Structural		✓	[25]	[21]	–
H2a	Operating budget	Financial		✓	[20]	–	–
H2b	% budget allocated to HIT	Financial	✓				
H3a	CIO's IT tenure	Leadership		✓	[18]	–	–
H3b	IT steering committee	Leadership	✓				
H4a	Network affiliation	Knowledge sharing		✓	[17, 20, 21, 25]	[19]	–
H4b	Urban hospital	Knowledge sharing		✓	[19, 21]	–	[18, 20]
H4c	IT knowledge resources	Knowledge sharing		✓	[18]	–	–

2.4 Knowledge-sharing Characteristics

The fourth and last family of predictors falls under the knowledge-sharing domain. The diffusion of innovation theory discusses “interconnectedness” as a positive predictor of organizational innovativeness [24]. Through this connection, it is argued that the extent of transfer of new ideas increases and goes beyond organizational boundaries, which support innovations [40]. Thus, the chance to learn about new technologies and innovations increases, and the exchange of information and expertise is facilitated. Membership in a network is an example of communication channels that allow health care organizations to exchange and share information more easily. Past research has found a strong relationship between membership in a multihospital system and HIT innovativeness [e.g., 17, 19–21, 25, 41]. Hence, we posit that:

H4a: Hospitals that belong to a multihospital network have higher levels of HIT innovativeness than independent hospitals

Further, past research reveals that a hospital's geographic location also tends to have a significant impact on its HIT adoption pattern [19, 25]. Hospitals located in urban

areas usually have greater access to financial, infrastructural, and human resources, by virtue of their proximity to technology vendors, funding agencies, and support organizations (e.g., systems integrators) that also tend to be co-located in urban areas, than hospitals in rural areas [19,35]. Thus, we propose the following hypothesis:

H4b: Urban hospitals have higher levels of HIT innovativeness than rural hospitals

Finally, based on the resource-based theory, it is argued that the presence of specialized human IT resources allows organizations to access knowledge, new ideas, and technical expertise, which then facilitate the adoption, use, and integration of innovations in organizations [32, 36]. Dewar and Dutton [42] posit that “the greater the number of specialists, the more easily new technical ideas can be understood and procedures developed for implementing them” (p 1424). In this line of thought, we argue that:

H4c: The number of IT knowledge resources in hospitals is positively related to the level of HIT innovativeness in hospitals

► Table 1 synthesizes the empirical support in the literature for each hypothesis.

3. Methods

3.1 Data Collection

As a first step, pretesting of the questionnaire was performed with five HIT experts in Canada and two in the U.S. We sent them an electronic copy of the questionnaire and conducted interviews with them, during which participants provided their feedback regarding the question form, wording and order. Their feedback was integrated to improve the content and structure of the instrument (e.g., adding examples in the instrument, rewording items). Further, the measures assessing the implementation of Enterprise Resource Planning (ERP) systems and the modules deployed, and the items measuring the implementation of electronic medical records and the systems with which it is integrated were moved to the section assessing IT internal integration. These items were considered by respondents as reflective of internal clinical and administrative integration rather than computerized processes.

The revised version of the questionnaire, with a cover letter indicating the purpose of the study, was sent to all acute care hospitals in Québec and Ontario between June and September 2007. We first contacted CIOs by phone, excluding those who had participated in the pretest, to present

the study and solicit their participation (Québec: N = 92; Ontario: N = 129). CIOs were chosen as key respondents given their expertise in the area of IT in health care, and their ability to answer questions about a wide range of systems and technologies. Five CIOs in Québec and 12 in Ontario refused to participate due to reported time constraints; these were excluded from the survey. A hardcopy of the questionnaire was then sent with a return envelope to all remaining hospitals (N = 204). We sent a reminder letter to the health care organizations that had not yet responded four weeks following the initial mailing. In total, 60 and 46 responses were received in Québec and Ontario, respectively. The overall response rate was 52%.

3.2 Variables and Measures

As shown in ► Table 2, a total of eight dimensions provided the conceptual framework for the HIT innovativeness measurement instrument. The first four dimensions refer to the *functional vector*, the fifth dimension relates to the *technological vector*, and the last three dimensions refer to the *integration vector*. *Functional innovativeness* measures the extent to which processes are computerized in the following areas: administrative (e.g., accounting, disease costing, material management, staff scheduling), patient management (e.g., patient admission, discharge and transfer), patient care (e.g., emergency room, operating room, nursing care), and clinical support (e.g., pharmacy, laboratory, radiology). *Technological innovativeness* refers to the extent to which various technologies are used in each of the areas mentioned above. Lastly, *integration innovativeness* represents the extent to which information systems are internally and externally integrated with other systems inside or outside the hospital. With the exception of external integration that was measured on a (1–7) scale, respondents were asked to provide information for the seven dimensions, including internal integration, along a time frame that reflects “plans for” versus “current implementation” of IT. Respondents would choose along the four categories: 1) no plan for implementation; 2) planning

Table 2 Structure and components of the HIT innovativeness measure

Vectors	Dimensions		# of items in instrument
Functional innovativeness	D1	Administrative systems	8
	D2	Patient management systems	8
	D3	Clinical support systems	4
	D4	Clinical systems	10
Technological innovativeness	D5	Emerging technologies	13
Integration innovativeness	D6	Internal integration – administrative	1
	D7	Internal integration – clinical	1
	D8	External integration	4

to implement; 3) began installation; and 4) implemented. In case of current implementation, the extent of use of computerized processes and technologies was assessed on a 1–7 scale. A detailed description of the survey instrument and its validation is provided in Jaana et al. [43], and all items from the HIT innovativeness measurement instrument are presented in ► Appendix 1^c.

Survey respondents were also asked to provide information on: the number of inpatient beds in their hospital and whether their hospital is affiliated to a medical school (measures of structural capacity); the approximate annual operating budget of their organization (in CAN\$) and the percentage of the budget allocated to IT (measures of financial capacity); the number of years of experience in the IT field or domain (IT tenure) and whether there is a formal IT steering committee in their organization (measures of leadership capacity); the geographic location of their hospital (urban or rural), the number of permanent IT staff, and whether their hospital is affiliated with a network (as measures of knowledge-sharing capacity).

3.3 Scoring Approach

We developed a scoring approach that assigns weights to the questions in the survey instrument and allows the calculation of a score for each dimension, as well as an over-

all HIT innovativeness score [43]. First, items measuring the status of computerized applications and emerging technologies (dimensions D1 – D5) were assigned the following weights: 1) no plan for implementation = 0 point; 2) planning to implement = 1 point; 3) began installation = 3 points; 4) implemented with weak usage as indicated by answers within the 1–4 interval on the Likert scale = 4 points; and 5) implemented with strong usage as indicated by answers within the 5–7 interval on the Likert scale = 5 points. Second, the questions assessing internal integration (dimensions D6 and D7) were assigned similar weights as above: 1) no plan for implementation = 0 point; 2) planning to implement = 1 point; 3) began deployment = 3 points; 4) implementation completed with (1–3) ERP modules or 1–4 systems integrated with the EMR = 4 points; and 5) implementation completed with more than four ERP modules or more than five systems integrated with the EMR = 5 points. The resulting score (over 100) for the first seven dimensions (D1 to D7) equals the sum points for all items under a specific dimension, divided by the total number of items in that dimension multiplied by 5 (i.e. maximum number of points for an item), times 100.

Third, the questions measuring the external integration of systems (Dimension D8), which was assessed on a 1–7 scale, were assigned the following weights: 1) No external integration (i.e. 1 on the Likert scale) = 0 point; 2) Minimal external integration (i.e. 2 and 3 on the Likert scale) =

^c Appendix 1 is accessible on our website www.methods-online.com

Table 3 Profile of the surveyed hospitals (n = 106)

	Average	Stand. dev.	Minimum	Maximum
Structural capacity				
Number of beds	354	296	18	1,227
Number of physicians	216	334	14	2,500
Number of registered nurses	853	1,228	30	10,000
Financial capacity				
Operating budget (M\$)	155	180	4	1,200
% of budget allocated to HIT	2.0%	1.8%	0.5%	12.0%
Leadership capacity				
CIO's IT tenure (years)	17	9	1	37
Knowledge sharing capacity				
IT resources (FTEs)	19	29	0	180
Structural capacity				
Institutions affiliated to a university	Yes	48%		
	No	52%		
Leadership capacity				
Presence of an IT steering committee	Yes	73%		
	No	27%		
Knowledge sharing capacity				
Network affiliation	Yes	78%		
	No	22%		
Geographic location	Urban	62 %		
	Rural	38 %		

1 point; 3) Moderate level of integration (i.e. 4 on the Likert scale) = 3 points; 4) High level of external integration (i.e. 5 and 6 on the Likert scale) = 4 points; and 5) Very high level of external integration (i.e. 7 on the Likert scale) = 5 points. The score (over 100) for the external integration dimension D8 equals the sum of points for the four items measuring external integration, divided by the total number of items (i.e. four) multiplied by the maximum number of points for an item (i.e. five), times 100.

Based on the answers to the questions falling under the eight dimensions in the survey instrument, scores (over 100) representing functional innovativeness, technological innovativeness, integration innovativeness, and overall HIT innovativeness were computed as follows:

- functional innovativeness score = sum (D1 to D4)/4

- technological innovativeness score = D5
- integration innovativeness score = Sum (D6 to D8)/3
- overall HIT innovativeness score = Sum (D1 to D8)/8

A score of zero represents no current or plans for implementation of systems and technologies along the dimensions D1 to D7, and no external integration at all. A score of 100 is associated with strong utilization of technologies and systems, and very high systems integration. By using this formula, hospitals can assess their level of HIT innovativeness in various areas, examine the evolution of their scores over time, and compare themselves to other hospitals.

3.4 Data Analyses

Descriptive data analysis was conducted to provide an overview of the respondents and surveyed organizations. HIT innovativeness scores were calculated according to the weights assigned to the survey items, which reflect the time frame presented above. In order to test the hypotheses, hospitals were divided into two groups, which represent low/high HIT innovativeness on a given vector. A hospital that is regarded as having low innovativeness on a given vector has a score ranking in the lower one third of the total sample. A hospital regarded as highly innovative on a given vector has a score ranking in the upper one third of the total sample. Hypotheses H1a, H2a, H2b, H3a, and H4c were tested using t-test and hypotheses H1b, H3b, H4a, and H4b were tested using chi-square test, for each of the functional, technological, and integration vectors as well as the overall HIT innovativeness score.

4. Results

4.1 Description of the Sample

As shown in ►Table 3, the profile of the sample reveals that surveyed hospitals were relatively large in size (average of 354 beds) with a considerable number of health professionals (average number of physicians and nurses was 216 and 853, respectively). Almost half of the sample consisted of teaching hospitals that are affiliated to a medical school. With respect to financial resources, the average operating budget of these hospitals was 155M CAN\$, of which an average of 2.0% was allocated to IT investments and operations. Assessment of leadership resources at the managerial level indicates that CIOs working in these hospitals had spent approximately 17 years in IT-related positions. Interestingly, a vast majority of the surveyed hospitals had an IT steering committee. Finally, the majorities of hospitals were members with a larger hospital network (78%) and located in urban areas (62%); the average number of permanent IT staff in these settings was 19.

4.2 Extent of HIT Innovativeness

As explained in Jaana et al. [43], we computed HIT innovativeness scores for all hospitals, which revealed information about their HIT capacities (overall and along the eight dimensions). As indicated in ► Table 4, the overall HIT innovativeness score for the sample was 56%. A closer examination of the results shows that the functional innovativeness score was moderate to high (66%), the technological innovativeness score was low (30%) and the integration innovativeness score was moderate (51%). Detailed information about HIT adoption rates along each of the HIT dimension considered and its respective items is presented in ► Appendix 2^d.

With respect to functional innovativeness, hospitals reported moderate to high levels of implementation of administrative systems (e.g., financial, human resources), patient management systems (e.g., ambulatory care scheduling, admission/discharge/transfer), and clinical support systems (e.g., laboratory, pharmacy) (► Table 4). However, computerized clinical systems (e.g., nursing and clinical documentation, CPOE, and clinical decision support systems) are still not widely adopted among the surveyed hospitals although a high percent of hospitals reported plans to implement these systems.

The technological innovativeness score reveals a significant gap in relation to the implementation of emerging technologies (e.g., bar coding for patient identification and materials management, bedside terminals, single sign-on, RFID, biometry). Surprisingly, most of the surveyed hospitals did not report plans for implementing several of these technologies (e.g., RFID, biometry, and bedside terminals), which underscores a greater emphasis on implementing computerized processes rather than adopting emerging technologies.

Finally, the level of systems integration was relatively low in our sample, with the exception of the internal integration of administrative systems as highlighted by the wide implementation of enterprise resource planning (ERP) systems. From a

Table 4 HIT innovativeness scores in hospitals (n = 106)

		HIT innovativeness score	Vectors	Overall HIT innovativeness score
Functional vector	Administrative systems	65%	66%	56%
	Patient management systems	64%		
	Clinical support systems	84%		
	Clinical systems	52%		
Technological vector	Emerging technologies	30%	30%	
Integration vector	Internal integration: administrative applications	74%	51%	
	Internal integration: clinical applications	45%		
	External integration	34%		

clinical perspective, hospitals in Ontario had significantly higher level of implementation of EMR, and more external systems integration with other organizations than hospitals in Québec (not shown here), which might be explained by the creation of Local Health Integration Networks by the Ontario government in 2006 supporting the integration of services in the province.

4.3 Antecedents of HIT Innovativeness

► Table 5 reports the results of t-test and χ^2 analyses that assess the relationship between HIT innovativeness and organizational capacity characteristics. Structural, financial, leadership, and knowledge sharing characteristics showed significant relationships with HIT innovativeness among the surveyed hospitals. As in Burke et al. [19], Wang et al. [20], McCullough [21], and Furukawa et al. [25], hospital size was found to be one of the strongest predictors of HIT innovativeness (H1a). Highly innovative hospitals have more than twice as many beds as less innovative hospitals. However, size was not associated with one of the three vectors, namely, integration innovativeness.

Both hypotheses related to the financial capacity of hospitals were also supported.

Highly innovative hospitals had four times more financial resources than their counterparts (H2a) and they allocated 2.5% of their budget to HIT investments and operations compared to only 1.5% for less innovative hospitals (H2b).

From a leadership capacity perspective, and as in Jaana et al. [18], our results show that CIOs in highly innovative medical centers had more experience in IT positions than those working in less innovative hospitals (H3a). IT steering committees were also more diffused in highly innovative hospitals than in less innovative institutions (H3b). However, while the presence of an IT steering committee was positively associated with functional and integration innovativeness scores, it was not a strong predictor of technological innovativeness.

Two of the three knowledge-sharing characteristics were also found to be associated with HIT innovativeness. First, consistent with prior research, hospitals in urban or metropolitan locations showed a higher level of HIT innovativeness compared to hospitals located in rural areas (H4b). It is important to note that while geographic location played a significant role in terms of functional innovativeness, it was not associated with the technological and integration dimensions. Second,

^d Appendix 2 is accessible on our website www.methods-online.com

Table 5 Antecedents of HIT innovativeness

Independent variables	Functional vector			Technological vector			Integration vector			Overall HIT innovativeness		
	Low	High	p	Low	High	p	Low	High	p	Low	High	p
Structural capacity												
H1a : Number of beds	219	524	***	221	483	**	279	390	ns	231	480	***
H1b: Teaching institutions	40%	57%	ns	33%	63%	*	33%	53%	ns	35%	53%	ns
Financial capacity												
H2a: Operating budget	55M	273M	***	75M	233M	**	95M	221M	**	65M	269M	***
H2b: % budget allocated to IT	1.6%	2.6%	*	1.7%	2.4%	**	1.5%	2.4%	*	1.5%	2.5%	***
Leadership capacity												
H3a: CIO's IT tenure	14.9y	20.5y	*	15.2y	19.0y	ns	15.5y	16.1y	ns	14.7y	19.5y	*
H3b: IT steering committee	61%	88%	*	63%	88%	*	69%	67%	ns	64%	84%	*
Knowledge sharing capacity												
H4a: Network affiliation (yes)	82%	77%	ns	82%	80%	ns	75%	85%	ns	78%	75%	ns
H4b: Urban hospitals	25%	54%	**	26%	41%	ns	31%	44%	ns	22%	44%	*
H4c: IT resources (FTEs)	7.7	37.2	***	9.0	30.0	***	8.5	27.5	***	6.6	37.1	***

*** $p < .001$; ** $p < .005$; * $p < .05$; ns = non significant.

"Low" on the vectors as well as the overall HIT innovativeness refers to the group of hospitals that fall in the bottom one third scores for the respective category (i.e. functional, technological, integration, overall HIT innovativeness).

"High" on the vectors as well as the overall HIT innovativeness refers to the group of hospitals that fall in the top one third scores for the respective category (i.e. functional, technological, integration, overall HIT innovativeness).

highly innovative hospitals counted 37 internal IT specialists (average) compared to only seven in less innovative institutions, providing strong support for H4c.

Only two hypotheses in our research model were not supported. First, while teaching status was associated with the adoption of emerging technologies (technological vector), it was not associated with the overall HIT innovativeness index (H1b). Highly innovative hospitals counted a larger proportion of institutions affiliated to a medical school than less innovative hospitals (53% versus 35%); this difference however was not statistically significant. Second, contrary to our expectations, multihospital network members were not more innovative than independent hospitals; the absence of a significant relationship between network affiliation and HIT innovativeness was consistent for the functional, technological, and integration vectors.

5. Discussion

This study examines HIT innovativeness in the context of Canadian hospitals and assesses the organizational factors that are most likely to influence public hospitals' innovativeness in relation to HIT adoption, usage and integration. We adapted a previously developed research model [18] and conducted a survey of hospitals in the two largest provinces in Canada (Ontario and Quebec) to assess the relationship between organizational capacity factors and HIT innovativeness. Unlike previous studies, which relied on proxy measures, this research used a comprehensive and validated survey instrument [43], which included items that reflect eight dimensions of HIT innovativeness along the functional, technological, and integration vectors. Measures of various organizational factors (structural, financial, leadership, and knowledge-sharing capacity) were also included in the survey.

Our results indicate that the surveyed hospitals have a moderate level of func-

tional and integration innovativeness as reflected by the scores on these two vectors (66% and 51%, respectively). However, a closer examination of the results shows that HIT innovativeness with respect to the implementation of computerized systems and internal integration of systems in administrative areas exceeds the level of innovativeness in clinical areas. The implementation of clinical systems is lagging behind administrative, patient management, and clinical support systems. Specifically, clinical systems (e.g., nursing and clinical documentation, computerized physician order entry, and clinical decision support systems), which have the potential to reduce errors and support clinical decision making, are still not widely adopted in the surveyed hospitals. Although a high percent of hospitals reported plans for implementing these clinical systems, financial barriers remain as important challenges, especially with the competing priorities and minimal available resources. The aging of the population, the burden of chronic diseases, and

the increasing demand on the health care system for reduced wait time and improved patient safety are a few examples. The level of internal integration of clinical systems and external integration with other facilities/organizations also appears to be limited in these settings. It is expected however that the federal initiative led by Canada Health Infoway, an independent not-for-profit organization that support the development and adoption of IT in health care, would move forward the efforts for implementation of clinical systems and external integration given its mandate to ensure an interoperable electronic health record for Canadians.

The lowest score on HIT innovativeness was observed in the case of implementation of emerging technologies. The technological innovativeness score reveals a significant gap in relation to the implementation of emerging technologies (e.g., bar coding for patient identification, bedside terminals, single sign-on, biometry) that have the potential of reducing errors, improving efficiency, and addressing security issues. This reveals a greater emphasis among Canadian hospitals on the implementation of computerized processes rather than technologies, which reflects their priorities in relation to the investments in HIT. This might be explained by the public nature of the health care system in Canada that necessitates the existence of computerized systems for supporting the exchange of information between providers and government institutions.

The results of the survey demonstrate strong support for the research model. Seven out of nine hypotheses were supported indicating a significant relationship between HIT innovativeness and structural, financial, leadership, and knowledge-sharing capacity. As in previous research [e.g., 19–21], hospital size appears to play a major role in the implementation of HIT in Canadian hospitals; larger hospitals have more capacity and resources to acquire and maintain new systems and technologies. Financial resources are also very important factors in determining HIT innovativeness (all three levels – functional, technological, and integration) in these settings, which is in line with previous research that highlights the significance of these factors in af-

fecting HIT implementation in health care settings (e.g. [20, 44]). Leadership capacity, as measured by the CIO's IT tenure and the presence of an IT steering committee, seem to play a significant role in the implementation of new systems and technologies, but not HIT integration innovativeness. Finally, the availability of IT personnel is a variable that showed relationship with all three levels of HIT innovativeness, which is in line with previous findings observed in U.S. hospitals [18].

It is important to highlight that network affiliation was not significantly associated with HIT innovativeness. In the context of Canadian hospitals, network affiliation refers to close relationships between hospitals; it is equivalent to the concept of system membership observed in the context of U.S. hospitals. Unlike prior research in the U.S. that reported significant relationship between system membership and IT [20, 21, 25], network affiliation was not significantly associated with the implementation of new systems and technologies, or the integration of systems. This might be explained by the difference in the nature of the health care system between the two countries. In Canada, the health care system is very structured and organized, and hospitals in each province may be considered as permanently belonging to a large network. Hospitals receive funds from the government based on the allocated budget each year, and are expected to function within these resources. As such, even if a hospital has access to IT personnel or other resources from a sister hospital in a network, it will not be able to implement new systems or technologies unless it has the financial resources to do so.

Teaching affiliation was also not significantly related to HIT innovativeness, with the exception of technological innovativeness. This might be explained by the learning environment in teaching hospitals, which tends to be open to the use of new technologies. However, teaching hospitals do not seem to have more implementation of computerized systems, nor higher levels of system integration, than their counterparts. We suggest that future research investigates this issue further.

In short, it is important to note that despite the satisfactory response rate in this

study, we did not have data available on non-responding hospitals that would allow a comparison with the surveyed hospitals to confirm the representativeness of our sample. Given the fact that the sample had a relatively large sample size and considerable resources (average budget and number of health professionals), we expect that the average level of HIT innovativeness might be slightly lower than what was observed in this study. This is a clear indication that more efforts are still needed, especially in the area of the implementation of clinical systems and technologies as well as clinical systems integration, which can play an important role in supporting clinical decision making, reducing errors, and integrating patient care. Finally, and as highlighted by previous research (e.g. [18, 20, 44]), this study confirms that there are important organizational variables (including bed size, technical resources, financial resources, and leadership variables) that continue to play a significant role in the implementation of HIT in health care settings. Unless carefully considered, these variables may turn into barriers that prevent hospitals from benefiting from available and rich IT solutions in the field.

As a final remark, we must recognize that the familywise error rate (FWER) was not applied in this study. The FWER is a concern when performing multiple pairwise tests. In the present context, FWER represents the probability of making one or more false discoveries or type I errors among all nine hypotheses. If we apply the Bonferroni correction [45, 46], we observe in the last column of Table 5 that four out of the seven significant findings are unlikely to have occurred by chance (significance level for the family of tests = $0.05/9 = .006$). Therefore, the results associated with financial capacity characteristics (H3a and H3b) and geographic location (H4b) would deserve further investigation.

6. Conclusion

This study makes a contribution in the field of medical informatics by exploring the relationship between organizational capacity characteristics and HIT innovativeness in the particular context of public hospitals.

By using primary data to test the relationships presented in the research model, this study demonstrates that the organizational characteristics that play a significant role in the implementation of HIT hold, irrespective of the public or private nature of the hospital. The survey of hospitals in Canada revealed a moderate level of HIT innovativeness, with more emphasis on administrative systems and their integration than on clinical systems and technologies in these settings. Future efforts are necessary to move the agenda forward in this direction and benefit from available solutions in the market with the potential of supporting patient care.

Acknowledgements

The Canada Research Chairs Program is gratefully acknowledged for its financial support for this research project. We also thank Jean-Nicolas Malek and George Balouzakis for their precious assistance during the data collection process.

References

- Mullett CJ, et al. Development and Impact of a Computerized Pediatric Antiinfective Decision Support Program. *Pediatrics* 2001; 108 (4): e75.
- Cordero L, Kuehn L, Kumar R et al. Impact of Computerized Physician Order Entry on Clinical Practice in a Newborn Intensive Care Unit. *Journal of Perinatology* 2004; 24 (2): 88–93.
- Krall MA. Acceptance and Performance by Clinicians Using an Ambulatory Electronic Medical Record in an HMO. *Proc Annu Symp Comput Appl Med Care*; 1995. pp 708–711.
- Daly JM, Buckwalter K, Maas M. Written and Computerized Care Plans. Organizational Processes and Effect on Patient Outcomes. *Journal of Gerontology and Nursing* 2002; 28 (9): 14–23.
- Paré G, et al. A Pre-Post Evaluation of a Telehomecare Program in Oncology and Palliative Care. *Telemedicine and e-Health* 2009; 15 (2): 154–159.
- Menachemi N, et al. Hospital Information Technology and Positive Financial Performance: A Different Approach to Finding an ROI. *Journal of Healthcare Management* 2006; 51 (1): 40–58.
- PricewaterhouseCoopers. The Economics of IT & Hospital Performance: A Population Study Reveals Challenges and Opportunities 2007. Available from: <http://www.pwc.com/extweb/pwcpublishations.nsf/docid/B0EEE7757105F368525727D006BF770> (consulted on May 26, 2009).
- Sicotte C, Paré G, Moreault MP, Paccioni A. A Risk Assessment of Two Interorganizational Clinical Information Systems. *JAMIA* 2006; 13 (5): 557–566.
- Paré G, Jaana M, Sicotte C. Systematic Review of Home Telemonitoring for Chronic Diseases: The Evidence Base. *JAMIA* 2007; 14 (3): 269–277.
- Jha AK, Doolan D, Grandt D, Scott T, Bates DW. The Use of Health Information Technology in Seven Nations. *Int J Med Inform* 2008; 77: 848–854.
- Grossman JM, Kushner KL, November EA. Creating Sustainable Local Health Information Exchanges: Can Barriers to Stakeholder Participation be Overcome? *Research Briefs* 2008; 2: 1–12.
- Ball MJ. Hospital Information Systems: Perspectives on Problems and Prospects, 1979 and 2002. *Int J Med Inform* 2003; 69: 83–89.
- Bates DW, Gawande AA. Improving Safety with Information Technology. *New England Journal of Medicine* 2003; 348: 2526–34.
- Chaudhry BJ, et al. Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care. *Annals of Internal Medicine* 2006; 144: E12–22.
- American Hospital Association (AHA). Continued Progress: Hospital Use of Information Technology. American Hospital Association (AHA); Chicago; 2007.
- Ontario Hospital Association (OHA). Ontario Hospital e-Health Adoption Survey: 2007 Survey Top Line Report. Toronto: Ontario Hospital Association. Available from <http://www.oha.com>.
- Hikmet N, et al. The Role of Organizational Factors in the Adoption of Healthcare Information Technology in Florida Hospitals. *Health Care Management Science* 2008; 11: 1–9.
- Jaana M, et al. Antecedents of Clinical Information Technology Sophistication in Hospitals. *Health Care Management Review* 2006; 31 (4): 289–299.
- Burke DE, et al. Exploring Hospitals' Adoption of Information Technology. *Journal of Medical Systems* 2002; 26 (4): 349–355.
- Wang BB, Factors Influencing Health Information System Adoption in American Hospitals. *Health Care Management Review* 2005; 30 (1): 44–51.
- McCullough JS. The Adoption of Hospital Information Systems. *Health Economics* 2008; 17: 649–664.
- Wernerfelt B. A Resource-based View of the Firm. *Strategic Management Journal* 1984; 5: 171–180.
- Grant RM. The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation. *California Management Review* 1991; 33 (1): 114–135.
- Rogers EM. *Diffusion of Innovations*, 5th edition. NY: Free Press; 2003.
- Furukawa MF, et al. Adoption of Health Information Technology for Medication Safety in U.S. Hospitals, 2006. *Health Affairs* 2008; 27 (3): 865–875.
- Sloan FA, et al. Diffusion of Surgical Technology. *Journal of Health Economics* 1986; 5: 31–61.
- Fendrick AM, et al. Hospital Adoption of Laparoscopic Cholecystectomy. *Medical Care* 1994; 32: 1058–1063.
- McDonald RE, Srinivasan N. Technological Innovations in Hospitals: What Kind of Competitive Advantage does Adoption Lead To? *International Journal of Technology Management* 2004; 28 (1): 103–117.
- Tsai Y. A Survey of Hospital Innovation in Taiwan. *Journal of the American Academy of Business* 2008; 13 (1): 116–120.
- Ramamurthy K, et al. Organizational and Inter-Organizational Determinants of EDI Diffusion and Organizational Performance: A Causal Model. *Journal of Organizational Computing and Electronic Commerce* 1999; 9 (4): 253–285.
- Dorgan SJ, Dowdy JJ. How Good Management Raises Productivity. *The McKinsey Quarterly* 2002; 4: 14–16.
- Khatri N. Building IT Capability in Healthcare Organizations. *Health Services Management Research* 2006; 19 (2): 73–79.
- Damanpour F. Organizational Innovation: A Meta-Analysis of Effects of Determinants and Moderators. *Academy of Management Journal* 1991; 34 (3): 555–590.
- Kimberly JR, Evanisko MJ. Organizational Innovation: The Influence of Individual, Organizational, and Contextual Factors on Hospital Adoption of Technological and Administrative Innovations. *Academy of Management Journal* 1981; 24 (4): 689–713.
- Meyer AD, Goes JB. Organizational Assimilation of Innovations: A Multilevel Contextual Analysis. *Academy of Management Journal* 1988; 31 (4): 897–923.
- Bharadwaj AS. A Resource-Based Perspective on Information Technology Capability and Firm Performance: An Empirical Investigation. *MIS Quarterly* 2000; 24: 169–196.
- Karimi J, et al. The Effects of MIS Steering Committees on Information Technology Management Sophistication. *Journal of Management Information Systems* 2000; 17 (2): 207–230.
- Pai JC. An Empirical Study of the Relationship between Knowledge Sharing and IS/IT Strategic Planning (ISSP). *Management Decision* 2006; 44 (1): 105–122.
- Earl MJ. *Management Strategies for Information Technology*. Englewood Cliffs, New York, NY: Prentice-Hall; 1989.
- Robertson M, et al. The Role of Networks in the Diffusion of Technological Innovation. *Journal of Management Studies* 1996; 33 (3): 333–359.
- Li P, Bahensky JA, Jaana M, Ward M. Role of Multihospital System Membership in Electronic Medical Record Adoption. *Health Care Management Review* 2008; 33 (2): 169–177.
- Dewar RD, Dutton JE. The Adoption of Radical and Incremental Innovations: An Empirical Analysis. *Management Science* 1986; 32 (11): 1422–1433.
- Jaana M, et al. IT Capacities Assessment Tool in Hospitals: Instrument Development and Validation. *International Journal of Technology Assessment in Health Care* 2009; 25 (1): 97–106.
- Bahensky JA, et al. Health Care Information Technology in Rural America: Electronic Medical Record Adoption Status in Meeting the National Agenda. *The Journal of Rural Health* 2008; 24 (2): 101–105.
- Benjamini Y, Hochberg Y. Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. *Journal of the Royal Statistical Society* 1995; 57 (1): 289–300.
- Abdi H. Bonferroni and Sidak Corrections for Multiple Comparisons. In: Salkind NJ (ed). *Encyclopedia of Measurement and Statistics*. Thousand Oaks, CA: Sage; 2007.