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Information Technology Sophistication in Hospitals: A Field Study in Quebec

Guy Paré, Claude Sicotte

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Information Technology Sophistication in Hospitals: A Field Study in Quebec[*]

Guy Paré[†], Claude Sicotte[‡]

Résumé / Abstract

Le secteur de la santé au Québec vit à l'heure des grands bouleversements. Plusieurs s'entendent à dire que les hôpitaux n'ont d'autre alternative que de faire appel aux technologies de pointe afin d'assurer un niveau de qualité des soins adéquat tout en minimisant les coûts associés à ces mêmes soins. Or, si l'on veut identifier les effets de la TI sur la performance des hôpitaux, il faut être capable de définir cette TI en tant que construit et caractériser cette dernière dans un but d'opérationalisation en tant que variable indépendante, dépendante ou modératrice dans un cadre conceptuel de recherche. Cette étude vise deux objectifs particuliers. Le premier consiste à développer un questionnaire mesurant le degré de sophistication des TI en milieu hospitalier et à le valider auprès de la population des hôpitaux québécois. Notre second objectif est de présenter, de façon sommaire, le profil des hôpitaux du Québec en matière de sophistication des TI.

The Quebec health sector has been experiencing a period of great turmoil over the last five years. Among other institutions, hospitals are faced with huge pressures from government funding cuts. Several empirical studies in the information systems field have shown that the use of computer-based information systems could have positive impacts on organizational performance. Many agree to say that health care institutions are no exceptions. But if one wishes to identify the effects of IT on the delivery of care, one must be able to characterize IT for operationalization purposes. The objective of this research project is twofold. Our first aim consists in developing and validating a measurement instrument of IT sophistication in hospitals. Such instrument should provide hospital managers with a diagnostic tool capable of indicating the profile of their respective institutions in regard to IT use and comparing this profile to those of other similar health institutions. In this line of thought, our second objective consists in presenting the IT sophistication profile of Quebec hospitals.

Mots Clés : Sophistication des TI, instrument de mesure, SI en milieu hospitalier

Keywords: IT sophistication, measurement instrument, hospital information systems

[*] Corresponding Author: Guy Paré, CIRANO, 2020 University Street, 25th floor, Montréal, Qc, Canada H3A 2A5
Tel.: (514) 985-4000 Fax: (514) 985-4039 email: guy.pare@hec.ca

[†] École des Hautes Études Commerciales and CIRANO

[‡] Université de Montréal

1. Introduction

The Quebec health system offers a broad range of services and is organized to ensure that services are universal, free of charge and continuous. The system, which is governed by the Act Respecting Health Services and Social Services, is intended to maintain and enhance the physical, psychic and social well-being of over seven millions Quebecers. The health and social services system encompasses over 480 public and private establishments, several hundred medical clinics and over 2 000 community agencies. It employs nearly 10% of the Quebec labor force. The Quebec government has adopted a management model centered on regionalization (the system counts 18 regional boards) and the complementarity of establishments.

The health sector in Quebec has been experiencing a period of great turmoil since the early 1990s and healthcare institutions are faced with huge pressures from government funding cuts. The process for restructuring the Quebec health network, which was initiated in the mid-1990s, aims at making the system more dynamic, enabling it to seize opportunities for improvement, and for progressively implementing changes in attitudes. The various measures put forward for reorganizing physical-health services target two objectives : offering quality ambulatory-care services and installing effective interactive service networks. In March 2000, Quebec counted 115 hospitals. This population includes the very small institutions, the long-term care hospitals as well as some multi-vocational establishments.

Recent empirical studies in the information systems field have shown that the use of computer-based information systems could have positive impacts on organizational performance (Chan and Huff, 1990; Raymond et al. 1995). Many agree to say that health care institutions are no exceptions (Lorenzi and Riley, 1995; Hatcher, 1998) and Quebec hospitals are starting to embrace this concept. Managers and clinicians are realizing that they have no other alternatives but to heavily invest in information technologies in order to deliver higher quality care to patients while at the same time holding down costs. For instance, a province-wide telecommunication network is being deployed to allow fast, real-time access to clinical data and administrative information and greater expertise sharing among clinicians. Several computer-based applications such as intranet, extranet, EDI, telemedicine and videoconferencing will be progressively implemented throughout the network along with the deployment and increasing use of smart cards (medical records).

A fundamental problem facing medical informatics and information systems researchers wishing to identify the effects of information technology (IT) on health care institutions is the necessity of characterizing IT for operationalization purposes as an independent, dependent or moderating variable within a conceptual framework. As of today, there exists no recognized characterization of IT in terms of its level of sophistication in health care organizations, and thus no validated instrument for use in empirical research and practice. Such an instrument should identify IT's fundamental dimensions and position health care institutions on each of these dimensions, thus establishing an IT sophistication profile and allowing comparison between institutions. The objective of this research project is twofold. Our first aim consists in developing and validating a measurement instrument of IT sophistication in hospitals. Such instrument should provide hospital managers with a diagnostic tool capable of indicating the profile of their respective

institutions in regard to IT sophistication and comparing this profile to those of other similar health institutions. In this line of thought, our second objective consists in presenting the IT sophistication profile of Quebec hospitals.

The next section introduces the conceptual framework for our characterization of IT sophistication in health care and describes the various dimensions of the construct. The methodology used in the research is detailed in section 3. The results are presented in section 4 in terms of the reliability and validity of the instrument, and in terms of the IT sophistication profile of the sampled hospitals. Finally, section 5 presents the methodological limitations of this study, proposes recommendations for future research, and highlights some implications for health care managers and health informatics specialists.

2. Conceptual Framework

One of the first attempts at characterizing information technology was made by Nolan (1973, 1979) with his "stages of EDP growth" model. In the context of IT adoption by organizations, the evolution concept is used in identifying and planning the different stages of systems growth. One of Nolan's objectives was to explain the relationship between a stage and the preceding or following stage. While the empirical validity of this model has been contested (Benbasat et al., 1984; King and Kraemer, 1984), and while it pertains to the evolution of organizational information systems, a fundamental concept was introduced in regard to the characterization of IS, i.e., the concept of the organization's "IS maturity." In Nolan's model, the notion of IS maturity is closely related to IS evolution, maturity being defined as the ultimate stage of computing growth in organizations. IS maturity thus refers to a state where information resources are fully developed and computer-based systems are fully integrated.

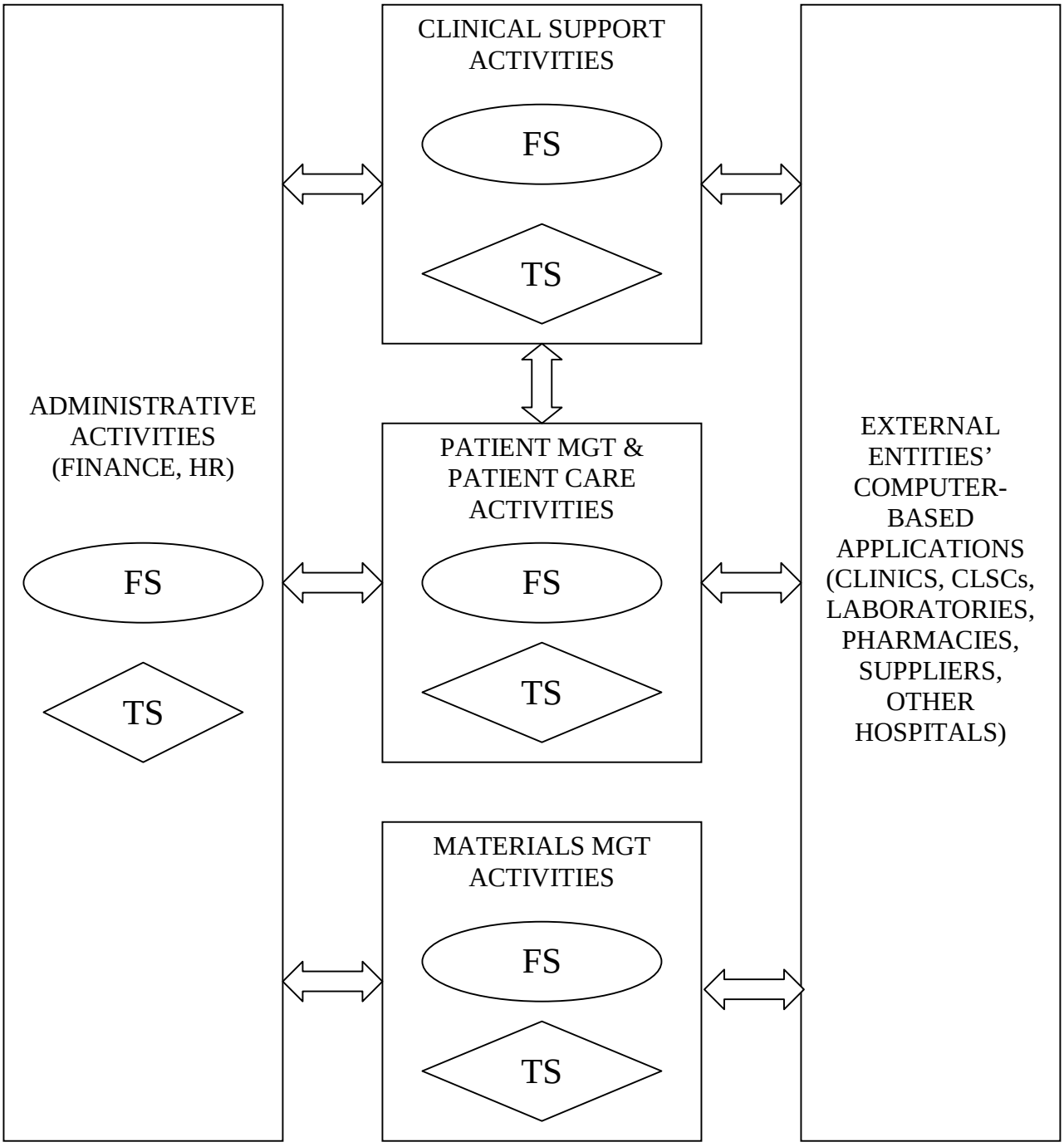
Following this, a number of researchers became interested in characterizing organizational information systems, and particularly in identifying different criteria of systems "maturity" or "sophistication" (Cheney and Dickson, 1982; Saunders and Keller, 1983; Gremillion, 1984; Mahmood and Becker, 1985; Raymond, 1988; Raymond and Paré, 1992). Much of these studies have used Nolan's model as a theoretical foundation. Among others, Cheney and Dickson (1982) investigated the relationship between what they defined as "technological sophistication" (hardware and software system, nature of application systems), "organizational sophistication" (information resources management activities) and system performance. One of their most important results was that user performance appeared to be very much influenced by organizational sophistication, but very little by technological sophistication. Also, within the IS usage perspective, Saunders and Keller (1983) referred to IS maturity as the "sophistication of the mix of applications provided by the IS function", focusing more on the nature, content and structure of the information provided. More recently, Raymond and Paré (1992) defined IT sophistication as a multi-dimensional construct which includes aspects related to technological support, information content, functional support, and IT management practices.

Following Raymond and Paré (1992), we initiated this study by performing an in-depth review of the different models and variables proposed in the information systems, health management

and medical informatics literatures as characterizing explicitly or implicitly the concept of IT sophistication (Sneider, 1987; Austin, 1992; Sicotte et al., 1991; Singh, 1997; Hatcher, 1998). From this review, we defined IT sophistication as a construct which refers to the diversity of technological devices and software applications used to support patient management & patient care, clinical support, materials & facility management, and administrative activities. Our conceptualization also considers the extent to which computer-based applications are integrated (electronic and automatic transfer of information). This key dimension refers to the extent of systems integration. The general framework for our classification of IT sophistication is presented in Figure 1 on next page.

Functional sophistication represents the proportion and diversity of *processes or activities* (e.g., vital sign recording, medication administration, staff scheduling, post-operative report dictation) being supported by computer-based applications. Technological sophistication basically reflects the diversity of the *hardware devices* used by health care institutions, referring to various domains such as the newest ones including medical imaging, bar coding devices, data warehousing, wireless networks and PACS equipment. Finally, informational *integration* sophistication refers to the degree to which computer-based applications are integrated both internally via a common database and externally via electronic communication links. These three dimensions shall be assessed for each of the health care institutions' four core domains, namely, patient management & patient care activities, clinical support activities (e.g., laboratory, pharmacy, radiology), materials & facility management activities, and administrative activities (Bourke, 1994; Austin, 1992).

After defining the building blocks of the concept of IT sophistication in the specific context of heath care institutions, we moved on to the operationalization of the various dimensions. Again, the work of Singh (1997), Austin (1992), Hatcher (1998) and Sicotte et al. (1991) were instrumental during this phase as they helped us in elaborating a thorough classification of technologies, processes and integration applications in this particular context. First, **hospital information technologies and devices** (technological sophistication) can be regrouped under five distinct categories: 1) office automation systems; 2) human-computer interaction devices; 3) storage and compression devices; 4) data distillation systems; and 5) connectivity devices. Office automation systems include appropriate technologies which help people manage information such as word processors, spreadsheets, electronic agendas, and project management systems. Human-computer interaction devices are those which facilitate data entry and data retrieval to and from computerized information systems. These technologies include, among others, light pen input devices, hand-held computers, bar coding systems, touch screens as well as handwriting and speech recognition devices. Storage and compression regroups technologies such as optical storage devices, videodisk technologies, PACS systems, smart cards, badge readers, medical imaging and digital signal processors. Data distillation refers to technologies employed to automate or support rapid, skilled human judgment. It encompasses artificial intelligence neural networks, decision support systems, expert systems, executive information systems and simulation tools. Last, connectivity devices regroup the different technologies that facilitate communication between applications. It includes EDI, all types of networks such as



Legend:

FS = Functional Sophistication;

TS = Technological Sophistication

⟺ = Informational Integration Sophistication

Figure 1. IT sophistication framework in hospitals

LANs, WANs, fiber optic networks, wireless networks, and infrared connections. It also takes into consideration Internet technologies and the different types of conferencing technologies.

It is important to mention that each of these technologies can support one or several core activities in a medical center. For instance, bar coding can be used to track medical records throughout the hospital (patient management), to track the use of tools during operations (patient care), and to track films for radiologists (clinical support). As another example, electronic requisitions can be used for tests by radiologists and medication by pharmacists (clinical support) and for materials by hospital units (materials management).

Second, it was clear from our literature review that a measure solely based on the identification of a hospital's list of computerized applications was not going to inform us about its level of functional sophistication. The same application, for instance a pharmacy information system, can support **activities or processes** varying from one institution to another. In this study, patient management processes include, among others, inpatient pre-admission and admission, outpatient admission, waiting list management, bed availability estimation, and inpatient discharge and transfer. Examples of patient care activities include order entry/results reporting, physician order transcription, historical record keeping, care planning, vital sign recording, anesthetic notes recording and operations' booking, to name a few. Clinical support processes include, among others, recurring tests management, specimen pick-up rounds scheduling, and blood bank management (laboratories); label generation and results capturing (radiology); and medication purchasing and administration, patient drug profile lookup, IV admixtures management, and drug interaction checking (pharmacy). Purchasing, receiving, distribution and inventory control are examples of materials management processes which can be supported by computer-based applications. Finally, administrative processes include budget planning, case costing, cash management, case-mix analysis, billing, staff scheduling and payroll, to name a few.

Third, another key aspect or dimension of a sophisticated technological infrastructure is related to the extent to which computer-based systems can exchange information with each other internally and with external applications (integration dimension of IT sophistication). For each of the four core activities identified above, we ask if supporting applications were **integrated** (electronic and automatic transfer of information) with other computerized systems in the hospital and with external entities' computer-based applications. For instance, we ask to indicate the extent to which laboratory systems are integrated with other computerized systems (ER systems, OR systems, nursing systems) in the hospital and with external entities' (e.g., other hospitals, clinics) computerized information systems. We also asked respondents to indicate whether the hospital had implemented (or was implementing) modules of an Enterprise Resource Planning (ERP) system such as SAP R/3. Last, we described a five-stage model of systems integration (from discreet manual systems to fully integrated computer-based systems) and asked respondents to indicate which level represented best the current IT architecture in their own hospital.

In short, the items included in our measurement instrument were chosen on the basis of their fundamental nature as descriptors of IT use, their relevance to the specific context of medical centers and their having previously been examined in empirical research.

3. Methodology

Measurement of research constructs is neither simple nor straightforward. In order to ensure content validity of our instrument, we decided to conduct interviews with health care and IT specialists at the Montreal Jewish Hospital (MJH). MJH is a 637-bed acute care teaching hospital affiliated with McGill University. There are over 550 doctors affiliated with the medical center. The hospital has also 2,700 employees including over 1,000 registered nurses. With an average of 23,000 inpatient admissions and 50,000 visits to the ER annually, MJH is one of the three busiest medical centers in the province of Quebec making it an ideal site for data collection.

A total of 20 in-depth interviews were conducted. An interview guide was developed and used during each interview. Respondents were first required to identify the technologies and computer-based applications that were in use in their department or hospital-wide and discuss their particularities while focusing on the processes or activities being supported by these systems. Secondly, participants were asked to assess the degree of integration of the various applications in used in their department with other applications both within and outside their department. Finally, they were invited to share their knowledge about any other technologies and/or computer applications, possibly more recent ones, used in other institutions. Seventeen out of the 20 interviews were taped and notes were taken for the other three. The conclusions extracted from all the interviews were later used to bring modifications to the initial version of the instrument. As expected, the initial content of the questionnaire appeared to be measuring well the reality of IT sophistication in the hospital context. However, the interviews have brought an undeniably important pool of information that once incorporated into the questionnaire made it even more valid and representative of the reality. As a first example, we learned that fingerprint recognition systems were used in some medical centers in Quebec to control the logging in and out of hourly employees and that these systems may have a direct interface to time sheets applications. Such systems are used instead of stripe cards that are more prone to sabotage and misuse. We were also told that some Quebec hospitals, including MJH, have adopted scanning technologies as a short-term solution to fight the ever increasing volume of paper-based medical records. As a final example, we were informed that results capturing from analyzers is computerized in several hospitals and that analyzers usually have quality assurance capabilities.

In order to refine further our questionnaire instrument, it was decided to perform a pre-test with a relatively small sample of individuals. The primary objective was is to have additional feedback on the relevance and reliability of the measurement instrument before it is sent to the potential respondents. Hence, the revised questionnaire was sent to three representatives of the targeted population, namely, hospital information systems (HIS) directors. Following the mailing, we conducted an in-depth interview with each of the directors. The reviewers were very thorough in their comments which helped change the total feel of the questionnaire to make it more appealing. The major criticism that was made concerns the size of the questionnaire which was thought to be too long. The order of the sections was also criticized and suggestions were made to reshuffle their sequence. Moreover, some comments were made about the use of the scales (wording) and suggestions were offered to improve them. In fact, most of the changes made

specifically affected the format of the instrument without affecting its substance. Examples of questions from the questionnaire are presented in Appendix. Note that the last section of the questionnaire elicited general information about the respondent and the hospital. Questions about the respondent focused on the field of specialization, highest education degree, job title, organizational and position tenure, and number of years of experience in the IT field. Demographic information about the hospital concerns the annual total budget, annual IT budget, number of internal and external IT staff, and variety of outsourced IT activities. Last, we asked respondents to indicate the extent to which they thought clinical and administrative applications meet current needs in their hospital. The final version of the measurement instrument is available from the authors.

Next, using a government list of the names, mailing addresses and phone numbers of each medical center in the province of Quebec, we contacted all 115 HIS directors by phone to request their participation in this study. Only 5 of those contacted refused to participate. The final version of the questionnaire, with a cover letter indicating the purpose and the importance of the study, was then sent in May 2000 to those having accepted to participate in our study. Six weeks following the initial mailing, a follow-up letter was sent to the participants. This letter stressed the importance of their responses and provided a number to call if they had any questions or required a new copy of the survey. A total of seventy-eight questionnaires (response rate of 70.9%) were returned to the researchers within a 15-week period. This response rate appears to be highly satisfactory in comparison with most of mail surveys (Pinsonneault and Kraemer 1993). Table 1 on next page presents characteristics of the respondents and of the medical centers.

As in the population from which they were sampled, respondents were predominately male (80.3%). Their average work experience in the current IT position is approximately 6 years and they have been involved in IT development and management activities for approximately 14 years. Over three quarter of the respondents have a university degree and the most represented fields of specialization are, in decreasing order, computer science, MIS, accounting & finance, business, health management, and nursing. Our sample is constituted of acute-care hospitals (n=24), specialty hospitals (n=30), university hospitals (n=10), and long-term care institutions (n=14). The sampled hospitals have an annual budget varying between 4.2M$ and 440M$. The IT budget represents on average approximately 1.6% of the total annual budget. Last, these hospitals have an average of 8 full-time-equivalent (FTE) IT positions and contract the equivalent of one external consultant.

4. Results

The results are presented in terms of the reliability and validity of the instrument, and in terms of the IT sophistication profile of the sampled medical centers. The institutional scores on each scale were averaged to obtain a composite sophistication score on all three dimensions.

Profile of the respondents

Gender : Male : 80.3% Female : 19.7%

	Mean	Minimum	Maximum
Experience in the current function (years):	6.3	<1	29
Experience in the current hospital (years):	10.5	<1	30
Experience in the IT (years):	13.9	<1	40

Field of specialization :	Computer science	60.0%
	MIS	10.8%
	Accounting / Finance	10.8%
	Business administration	10.8%
	Health Management	7.7%
Highest education degree :	College	21.5%
	University certificate	26.2%
	Undergraduate degree	38.5%
	Graduate degree	13.8%

Profile of the medical centers

	n	Annual budget (min–max-mean)
Acute-care hospitals	24	10M$ - 47M$ - 26M$
Specialty hospitals	30	10M$ - 170M$ - 56M$
University hospitals	10	60M$ - 440M$ - 180M$
Long-term care hospitals	14	4.2M$ - 28M$ - 14M$

	Mean	Minimum	Maximum
Number of internal IT personnel	7.8	1	110
Number of external consultants	1.3	1	10

Annual IT budget :	< 150K$	15.5%
	Between 150K$ and 300K$	25.9%
	Between 300K$ and 500K$	20.7%
	Between 500K$ and 1M$	12.0%
	>1M$	25.9%

Table 1. Profile of respondents and medical centers

4.1 Reliability and Validity

The reliability of the instrument was tested by calculating Cronbach's alpha for the functional, technological and integration dimensions of each of the four core activities, and for overall dimensions. Table 2 presents the reliability results, which generally establish the correctness of the proposed measurement structure, with only two exceptions. Indeed, items pertaining to the technological and integration dimensions of materials management activities were removed from the measurement instrument because of their respective low reliability score. The overall Cronbach's alpha for the three dimensions and the overall IT sophistication measure are all superior or equal to 0.85, which is very satisfactory.

	Patient Care	Clinical Support	Materials Management	Administrative Activities	Overall Dimension
Functional Sophistication	.84 (33)†	.83 (21)	.85 (14)	.75 (16)	.91 (84)
Technological Sophistication	.77 (24)	.78 (13)	.44 (3)	.67 (11)	.88 (51)
Integration Sophistication	.81 (10)	.80 (6)	.42 (3)	.73 (4)	.85 (23)
Overall Sophistication					.93 (158)

† number of items

Table 2. Reliability results (Cronbach alpha)

Following Raymond and Paré (1992), construct validity was tested by calculating inter-dimensions correlations and by correlating each dimension with an adjusted overall dimension score obtained by removing the scales related to the particular dimension. Tables 3 through 5 present the construct validity results which establish the correctness of the proposed measurement structure. These results thus give evidence for the construct validity of the measurement instrument.

	Patient Care	Clinical Support	Materials Management	Administrative Activities
Clinical Support	.617 ***			
Materials Management	.572 ***	.474 ***		
Administrative Activities	.438 ***	.409 ***	.429 ***	
Adjusted Overall Measure	.695 ***	.614 ***	.602 ***	.507 ***

*** p<.001

Table 3. Construct validity of the functional dimension of IT sophistication

	Patient Care	Clinical Support	Administrative Activities
Clinical Support	.695 ***		
Administrative Activities	.402 ***	.402 **	
Adjusted Overall Measure	.674 ***	.634 ***	.435 ***

*** p<.001 ** p<.005

Table 4. Construct validity of the technological dimension of IT sophistication

	Patient Care	Clinical Support	Administrative Activities
Clinical Support	.677 ***		
Administrative Activities	.357 **	.143 ns	
Adjusted Overall Measure	.667 ***	.457 ***	.268 *

*** p<.001 ** p<.005 * p<.05

Table 5. Construct validity of the integration dimension of IT sophistication

To test for the predictive validity of the instrument, the three dimensional measures and the overall sophistication measure were correlated with six other variables, the hospital's present stage of IT maturity in terms of a five-stage model inspired from Nolan (1979), its annual budget and IT budget, its number of internal IT staff as well as the educational level and IT management experience of the respondent (i.e. the person having the greatest responsibilities for IT within the hospital). The first of these variables was measured by succinctly describing each of the five stages and asking the respondent to indicate which description best fitted the hospital's present state. One thus expects that the higher the stage of IT maturity, the higher the level of IT sophistication. One also expects larger hospitals with larger IT departments and budget to be more sophisticated. Finally, the person having the highest responsibilities for IT in the hospital is expected to play a key role in an hospital's IT adoption process. On the basis of the results presented in Table 6 on next page, the predictive validity of the instrument is confirmed, the only exceptions being the absence of a significant relationship between the integration dimension and three of the predictive variables, namely, level of education, size of IT department, and IT budget.

	Functional dimension	Technological dimension	Integration dimension	Overall sophistication
IT maturity	.509 ***	.413 ***	.521 ***	.527 ***
Annual budget	.397 **	.400 **	.268 *	.366 **
Annual IT budget	.333 **	.378 **	.279 *	.353 **
Number of IT staff	.234 *	.362 **	.218 ns	.311 **
Education level	.232 *	.303 *	.169 ns	.257 *
IT tenure	.461 ***	.417 ***	.424 ***	.468 ***

*** p<.001 ** p<.005 * p<.05

Table 6. Predictive validity results

4.2 IT Sophistication Profile

The IT sophistication profile of the sampled medical centers (n=78) is based on the three dimensional construct previously defined. This profile, as described below, indicates how the medical centers studied fit into the construct. Looking first at the **functional dimension** of IT sophistication, patient management processes including inpatient pre-admissions and ADT, outpatient admissions, bed availability estimation and patient-index are supported by computer-based applications in a large proportion of Quebec hospitals (80%). However, more sophisticated systems that allow physicians to electronically sign documents from the medical chart including operative reports, discharge summary and face sheet are not widely diffused among medical centers in Quebec (30%). We also note that order entry & results reporting is computerized in about half of the sampled institutions only. Medication administration, staff scheduling, historical record keeping and physician orders transcription are among the most computerized nursing activities (50%) while vital signs recording, patient acuity/condition recording, quality assurance and nursing flowsheet figure among the least computerized processes (20%). In the ER, only registrations & admissions and patient inflow, waiting time and crowding are being supported by a reasonable number of medical centers (67% and 41% respectively). Clinical applications in the ER such as those supporting patient data collection, physician's orders transcriptions and results reporting are not available in a majority of hospitals (less than 20%). About half of the sampled hospitals have computerized their OR operations' booking and one fourth have implemented OR staff scheduling systems. Again, more complex OR processes including case costing, materials (tools) management and anesthetic notes recording have been computerized in a very small proportion of institutions (10%). As to the clinical support departments, a sizable percentage of hospitals have implemented systems to support the following processes: results capturing and validation as well as specimen tests management and

archiving (laboratory); label generation and results capturing (radiology); patient drug profile lookup, medication purchasing and administration, wards stock management, IV mixtures management, making out refill reports, drug interaction checking, historical information storing, and duplicate orders checking (pharmacy). Most materials management processes (e.g., purchasing orders, POs-receipts matching, receiving, inventory control, reorder point estimation, and distribution) have been computerized in a large number of medical centers in Quebec (80%). Last, from an administrative perspective, a significant proportion of hospitals have started to use more diverse systems in support of functions other than accounting and payroll, such as key finance (e.g., budget planning and control) (90%) and more sophisticated human resources activities (e.g., staff scheduling, time/attendance recording) (80%).

Second, the results clearly indicate that most hospitals in Quebec still exhibit a somewhat low level of **technological sophistication**. For instance, telemedicine, expert systems, voice recognition systems and connection to external clinical databases such as Medline are not available to support clinicians' work in most hospitals. Further, we note that only a handful number of hospitals (4%) have installed PCs or workstations in the hallways or at the bedside and an even smaller proportion (1%) have implemented portable computing devices such as hand-held computers and wireless computers to support work of physicians, nurses and other health professionals in the ER. In the OR, technologies such as bar coding to track the use of tools during operations, real time monitoring and reporting of operations' stages, voice recognition system for notes transcription during operations, and portable devices for data input have yet to be implemented. In the clinical support departments, bar coding and electronic reporting of test results to medical units are moderately diffused in laboratories (50% and 40% respectively). However, more sophisticated technologies such as PACS, voice recognition systems, telemedicine, EDI, and extranet links to medication suppliers are far from being widely diffused in radiology and pharmacy departments (less than 20%). On the administrative side, sophisticated tools such as centralized scheduling system crossing departmental boundaries, direct entry of timesheets by employees, automatic time capture without manual data entry (swiping cards) have yet to be implemented. However, the use of word processor and spreadsheet software as well as database and groupware technology is common place in most Quebec hospitals and such applications are integrated through a Local Area Network (LAN). Fax machines, modems, fiber optics and Wide Area Networks (WAN) figure among the most widely diffused connectivity technologies. On the other hand, only a handful of hospitals have yet adopted emerging technologies such as microwave connections (3%), satellite connections (2%), infrared connections (9%) and wireless networks (17%). It is quite interesting to note that while electronic mail is available to health professionals in most hospitals, only one third of the sampled medical centers have an on-line Web site.

Third, the results reveal a significantly low level of sophistication in regard to **systems integration**. Indeed, while patient management systems (e.g., inpatient ADT, scheduling, resources availability) appear to be sizably integrated to each other and to other computerized systems (e.g., laboratory, pharmacy, human resources) in the hospital, patient care systems, nursing systems as well as computer-based applications used in the ER and OR are at best

slightly integrated to each other. The situation is far from being brighter in clinical support departments (laboratories, radiology and pharmacy) where most information systems are depicted as stand-alone. From an administrative perspective, findings show that financial systems are moderately integrated to each other but that medical units have slight or no on-line access to financial information in most hospitals. Another interesting observation is that emerging integrated ERP systems developed by firms such as SAP, Oracle and Peoplesoft have been implemented in less than 10% of Quebec hospitals. Even more revealing is the fact that where these integrated systems can be found, only administrative applications (Finance, Purchasing, HR) have been implemented. As a final observation, we note that less than 20% of the sampled hospitals have developed extranet applications which support external integration. These descriptive statistics provide a clear sign of the great lack of integration between computer-based applications, both internally and externally.

In short, from the results of this study, we can paint an interesting and revealing portrait of the extent of IT penetration and sophistication in hospitals. Because we attained a high response rate, we believe that our results accurately reflect the actual situation in the health care environment in Quebec. As shown in Table 7, findings suggest a high-moderate level of functional sophistication, a somewhat low level of technological sophistication, and an even lower level of integration sophistication. Hence, we agree with members of the IT Council of the Quebec Hospital Association (AHQ, 2000), that future deployment efforts and investments shall be directed towards the integration of clinical and administrative applications and the acquisition of more advanced and emerging technological devices, more specifically those which allow direct capture of clinical data at the bedside or elsewhere. Such push on clinical systems and technologies is supported by results presented in Table 8 which reveal that IT sophistication and perceived usefulness of clinical applications (which are fairly new compared to administrative applications) are related. As expected, we did not found a relationship between the level of sophistication and perceived usefulness of administrative applications. A plausible explanation might be that the perceived usefulness of administrative applications, which have been around since the early 1970s, is now "taken for granted" and further improvements or refinements (sophistication) of these applications do no longer influence their perceived usefulness.

	Patient Care	Clinical Support	Materials Management	Administrative Activities	Overall Assessment
Functional Sophistication	Moderate	Moderate	High	High	High Moderate
Technological Sophistication	Low	Low	[a]	Moderate	Low
Integration Sophistication	Very Low	Very Low	[a]	Low	Very Low

[a] No assessment due to low reliability score.

Table 7. Overall assessment of IT sophistication in Quebec hospitals

	Perceived usefulness of clinical applications	Perceived usefulness of administrative applications
Functional Sophistication	.494 ***	.047 ns
Technological sophistication	.472 ***	.010 ns
Integration Sophistication	.487 ***	.063 ns
Overall Sophistication	.536 ***	.043 ns

*** p<.001

Table 8. IT sophistication and perceived usefulness of applications

5. Conclusion

This field study has some limitations that must be acknowledged. For one thing, a more reliable test of construct validity, using factor analysis, would be desirable but would also require a larger population. In this regard, we are in the process of contacting hospital IT directors from other Canadian provinces to invite them to participate in our study. Our hope is to be able to receive enough data to paint an interesting, exhaustive, and up-to-date portrait of Canadian hospitals in regard to IT sophistication. We also intend to seek participation from other countries for comparison purposes. However, further analysis of the IT sophistication construct and further validation of the measure presented here, most particularly with regard to materials and facility management, are pre-requisite to an eventual utilization by researchers. Notwithstanding, the findings reported in this study support the theoretically appealing breakdown of IT sophistication into functional, technological and integration dimensions. This framework can be used for further study and extension of the IT sophistication construct to health care institutions other than hospitals.

Our measurement instrument can also be used as a diagnostic tool by hospital managers interested in better situating their institution in terms of its adoption and use of information technologies. Of most importance, it can be useful in investigating the link between IT sophistication and hospitals' performance measures such as the Data Envelopment Analysis (DEA) method. For instance, an inadequate level of performance might be diagnosed when a high level of functional sophistication is not matched by sufficiently high levels of technological and integration sophistication. Our instrument might then help in pointing out where this mismatch occurs and provide guidance as to the type of solution that is needed.

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Appendix. Examples of questions from the measurement instrument

Please check (✔) which of the following patient management processes are computerized

☐ Inpatient pre-admission
☐ Inpatient admissions
☐ Outpatient admissions
☐ Waiting list management
☐ Bed availability estimation
☐ Inpatient discharges
☐ Inpatient transfers
☐ Patient-Index

Please circle the answer that best indicates the extent of use of each of the following technologies in support to patient care activities in your hospital

	N/A	Barely used						Extensively used
Dictation (audio) system for physicians' notes into medical records	0	1	2	3	4	5	6	7
Voice recognition system for physicians' notes transcription	0	1	2	3	4	5	6	7
Connection to external clinical databases (e.g., Medline)	0	1	2	3	4	5	6	7
Artificial intelligence / expert systems used by clinicians	0	1	2	3	4	5	6	7
Expert systems that patients use to enter their personal medical history by answering a set of questions	0	1	2	3	4	5	6	7
Telemedicine for evaluation of patients, triage decisions and pre-transfer arrangements	0	1	2	3	4	5	6	7
Telemedicine for transmission of diagnostic images and/or consultations and second opinions	0	1	2	3	4	5	6	7

Please circle the answer that best indicates the extent to which nursing information systems are integrated (electronic and automatic transfer of information) to each other in your hospital

Not at all						Very much
1	2	3	4	5	6	7

Please circle the answer that best indicates the extent to which nursing information systems are integrated to other computerized systems (ADT, pharmacy, dietary, etc.) in your hospital

Not at all						Very much
1	2	3	4	5	6	7

Please check (✔) which of the following processes are computerized in the laboratories

☐ Patients registration and admission
☐ Staff workload management
☐ Specimen pick-up rounds scheduling
☐ Recurring tests management
☐ Specimen archiving
☐ Blood bank management
☐ Results capturing (from analyzers)
☐ Results validation (abnormalities…)

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