IT Capacities Assessment Tool: A Survey of Hospitals in Canada

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Abstract

This study presents an IT assessment tool that aims at capturing the level of IT sophistication in hospitals. In order to develop a measure that reflects IT capacities in hospitals, an IT scoring approach was proposed that incorporates eight IT dimensions related to the implementation of computerized processes and emerging technologies, and the level of internal and external systems integration. The instrument was validated through a survey of hospitals in two provinces in Canada (Québec and Ontario), and the psychometric properties revealed a good level of validity and reliability. Based on the results of the survey and the IT scores obtained, hospitals in both provinces seem to have a moderate to high level of implementation of various computerized processes; limited implementation of clinical systems was observed. Low IT scores were reported in relation to the implementation of emerging technologies. The level of systems integration was moderate with significantly higher level of integration among hospitals in Ontario; limited clinical systems integration was observed.

1. Introduction

Since the release of the Institute of Medicine reports, “To Err is Human” [1] and “Crossing the Quality Chasm” [2], health information technologies (IT) have gained increasing attention and have been recognized as essential components for an improved health system. In a recent report presented by the national coordinator for health information technology in the U.S. [3], there was a clear emphasis on the value of IT in achieving consumer-centered care. Similarly, efforts in Canada that encourage fast deployment of technologies are underway, as demonstrated by the national funding of projects in various IT-related areas across provinces (e.g., electronic health records, telehealth, etc.) [4].

Hospitals, which represent essential components of health care systems, are continuously exploring opportunities for investing in IT to improve efficiency, promote patient safety, and better quality of care [5-7]. According to a recent survey by the American Hospital Association (AHA) on hospital use of IT, around 46% of hospitals reported moderate to high use of clinical IT in 2006 [8], which represents an increase compared to previous years. At present, IT priorities are mostly related to reducing medical errors, upgrading / replacing inpatient clinical systems, and implementing electronic medical records [9]. A recent survey of hospitals in Ontario also showed that the implementation of technologies that reduce medical errors and promote patient safety was ranked as top e-health priority for hospitals [10].

Despite recognizing the role of IT 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 level of IT capacities in these settings. Although scattered efforts have been made to develop measures that gauge IT in hospitals (e.g., [11-14]), no comprehensive tool exists that captures the level of IT sophistication and allows
the development of a valid IT score. Prior efforts in this area remain constrained by limitations associated with the measures and tools used. For instance, the crude nature of the indicators, the absence of a consistent scale that reflects the extent of implementation of various applications and technologies in hospitals and the lack of a well-developed scoring approach to gauge IT capacities in hospitals are examples.

This research addresses these issues, proposes an instrument for assessing IT capacities in hospitals, and validates it through a survey of Canadian hospitals. For this purpose, a comprehensive literature review was conducted to build on existing evidence and identify prior efforts to assess IT in hospitals. The results were mapped using the original conceptual framework developed by Paré and Sicotte [15], which defined IT sophistication along three dimensions (functional, technological, and integration). The term “IT sophistication” is used to represent IT capacities in hospitals, including various applications and technologies as well as the integration among different systems. This paper focuses on the findings of the survey, and provides an overview of the IT scoring approach used to represent the level of IT sophistication in hospitals.

2. Description of the instrument

A comprehensive literature review was conducted on Medline until September 2006 to build on the existing evidence and identify prior efforts that attempted to assess IT in hospitals. A total of 17 studies that provide indicators of clinical and administrative IT capacities were found. Six varied in their approaches to address this issue (e.g., [16-18]), while 11 studies that represent two more recent streams of research in this field relied on two IT measurement instruments in hospitals (e.g., [12,13,19-21]). Although the recently developed instruments presented important contributions in this area, limitations remained in relation to the absence of instrument validation, the crude nature of the measures, and the absence of a valid scoring approach (e.g., [12,13]). The length of the instrument and lack of a consistent scale to reflect the implementation of various applications and technologies represent additional issues that must be addressed (e.g., [15,19,21]).

We mapped the results of these studies using the original conceptual framework proposed by Paré and Sicotte [15]. Subsequently, an IT assessment tool was developed that included 34 items exploring computerized processes in four areas (administrative, clinical, patient management, and clinical support activities), 13 items assessing the implementation of contemporary technologies, and 11 items investigating internal and external information sharing (Appendix A). We further incorporated a time frame in the tool to reflect current versus plans for implementation of IT; in the former, the extent of use of computerized processes and technologies was further assessed on a [1-7] scale. A general information section about the respondents and organizations was introduced at the end of the instrument.

3. Methodology

3.1 Sample and data collection

In order to apply the IT assessment tool and evaluate its psychometric properties, we conducted a survey of health care organizations in two Canadian provinces (Québec and Ontario) between June and September 2007. All hospitals in these two provinces, which represent the largest health jurisdictions in Canada in terms of population served and health infrastructures, were invited to participate in this study. As part of the pretest, seven respondents (three from Québec, two from Ontario and two from the United States) completed a first version of the questionnaire and provided feedback about the process (e.g., administration time, clarity of directions) and the measures. Following the pretest, a number of minor changes were incorporated in order to improve the measures and the questionnaire’s overall structure and clarity.

The revised version of the questionnaire, with a cover letter indicating the purpose and the importance of the study, was sent to all hospitals in Québec and Ontario. As a first step, we contacted IT directors / administrators by phone, excluding those who had participated in the pretest, to present the study and solicit their participation (Québec: N=92; Ontario: N=129). Five IT directors in Québec and 12 in Ontario refused to participate due to reported time constraints; they were excluded from the survey. A hard copy of the questionnaire was then sent with a return envelope to all remaining organizations. Four weeks following the initial mailing, a reminder letter was mailed to the organizations that had not responded. In total, 60 and 46 responses were received in Québec and Ontario, respectively, which represents an overall response rate of 52% (106 hospitals).
3.2 Measurement issues

As indicated in Figure 1, following Paré and Sicotte’s model for assessing IT sophistication [15], which was validated among hospitals in the U.S. and Canada [15,19], eight dimensions provided the conceptual framework for the survey instrument used in this study. The first four dimensions refer to Functional IT sophistication, the fifth dimension relates to Technological IT sophistication, and the last three dimensions refer to the Integration level:

- D1 = Administrative systems (9 items)
- D2 = Patient management systems (8 items)
- D3 = Clinical support systems (4 items)
- D4 = Clinical systems (13 items)
- D5 = Emerging technologies (13 items)
- D6 = Internal integration – Administrative (Enterprise Resource Planning system)
- D7 = Internal integration – Clinical (Electronic Medical Record system)
- D8 = External integration (9 items)

A total of 58 items were included in the questionnaire. For the first five dimensions, the respondents were asked to check the answers that best reflect the current status of various computerized processes and technologies in their organizations. They could choose between: 1) No plan for implementation; 2) Planning to implement; 3) Began installation; and 4) Implemented. If they chose “Implemented” for questions under D1-D5, then they were also asked to identify on a [1-7] scale the extent to which the systems or technologies are currently used (1 = “Barely Used” and 7 = “Extensively Used”).

For the internal integration dimensions (D6 and D7), respondents were asked to check the answers that best reflect the current status of Enterprise Resource Planning (ERP) and Electronic Medical Record systems (EMR). They could choose between: 1) No plan for implementation; 2) Planning to implement; 3) Began deployment; and 4) Implementation completed. If they selected “Began deployment” or “Implementation completed”, they were also asked to choose the modules that are being deployed in the case of ERP, or the systems that are fully integrated with the EMR; a list of modules and systems was provided to them.

Last, respondents were asked to identify the extent of information sharing with external entities (dimension D8) on a [1-7] Likert scale (1 = “Not at All” and 7 = “Very Much”). The last section of the instrument included questions that provide an overview about the respondents and their respective hospitals.

3.3 Scoring approach

We developed a scoring approach that assigns weights (points) to the questions in the survey and allows the calculation of an IT score for each dimension, as well as an overall IT score for hospitals.

First, items measuring the status of computerized processes and technologies within hospitals (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 utilization as indicated by answers within the [1-4] interval on the Likert scale = 4 points; and 5) Implemented with strong utilization as indicated by answers within the [5-7] interval on the Likert scale = 5 points. It is important the note however that four items assessing the implementation of advanced computerized processes (clinical & support staff workload management; remote monitoring applications; on-line consumer health information; on-line patient appointment) were excluded from the calculation of scores due to the absence of variability in our sample and the consistently very low implementation levels.
Second, the questions assessing internal integration (dimensions D6 and D7), which represent the extent of implementation of ERP and EMR systems, 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 4 ERP modules or more than 5 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:

$$\text{Score (Dx)} = \frac{\text{Sum of points for all items}}{(5 \times \text{No. items in Dx})} \times 100$$

Where Dx = D1 – D7

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) = 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. Five items, which did not present variability and showed consistently very low information sharing levels (with drug stores; with insurance companies; with external laboratories; with governmental agencies; with patients), were excluded. 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:

$$\text{Score (D8)} = \frac{\text{Sum of points for four items}}{20} \times 100$$

Based on the answers to the questions falling under the eight IT dimensions in the survey, IT scores representing functional IT capacities, technological IT capacities, internal and external integration, and an overall IT score (over 100) can be computed for hospitals as follows:

<table>
<thead>
<tr>
<th></th>
<th>Score Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional IT score</td>
<td>( \text{Sum (D1 to D4)} )</td>
</tr>
<tr>
<td>Technological IT score</td>
<td>D5</td>
</tr>
<tr>
<td>Integration score</td>
<td>( \text{Sum (D6 to D8)} )</td>
</tr>
<tr>
<td>Overall IT score</td>
<td>( \text{Sum (D1 to D8)} )</td>
</tr>
</tbody>
</table>

The overall IT scores can range from 0 to 100. 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 IT capacities in various areas, examine the evolution of their scores over time, and compare themselves to other hospitals. Scores falling in the following ranges are expected to represent different levels of IT capacities:

- **Scores between 0 and 25**: Very low level of IT sophistication with minimal computerized processes and technologies, and limited levels of integration.
- **Scores between 26 and 50**: Low to moderate level of IT sophistication; the level of IT capacities might vary according to the eight dimensions.
- **Scores between 51 and 75**: Moderate to high level of IT sophistication; the level of IT capacities may vary according to the eight dimensions.
- **Scores between 76 and 100**: High level of IT sophistication with implemented computerized processes and emergent technologies, and good levels of systems integration.

### 3.4 Data analysis

First, descriptive analysis was conducted to provide an overview of the respondents and their respective organizations, and present the findings of the survey on IT capacities in hospitals along the eight IT dimensions. Specifically, the percent of hospitals in each of the categories of implementation was determined. Second, Chronbach Alpha and correlation coefficients were computed to assess the reliability and validity of the IT sophistication measures used.
Third, IT scores were computed over 100 to reflect the level of IT sophistication along the eight dimensions, and the overall IT scores in hospitals.

Last, significant differences on the respondent and hospital characteristics, and the IT scores between hospitals in Québec and Ontario were assessed using Chi Square and t-tests.

4. Results

This section presents the survey findings and is divided into three parts: 1) Sample overview; 2) Psychometric properties of the instrument; and 3) IT capacities and overall IT scores.

4.1 Sample overview

As indicated in Table 1, most of the respondents in both provinces had either an undergraduate or master level education, and varied in backgrounds with the majority having an area of specialization in administration or information systems / technology. The managerial and IT tenure among the surveyed CIOs / IT directors was high; the average years of experience in IT was 17 years with more than 10 years experience in the current organization and 8 years in the current position.

The profile of the surveyed hospitals shows that more than half were not affiliated with a teaching university (52%) and were characterized as rural hospitals (62%). Yet, the average size of the hospitals was 354 beds, and the majority reported having emergency rooms (92%), operating rooms (85%), and intensive care units (75%) in place. Hospitals in Québec were significantly larger and had more intensive care units and operating rooms than hospitals in Ontario.

<table>
<thead>
<tr>
<th>Profile of Respondents</th>
<th>Quebec n=60</th>
<th>Ontario n=46</th>
<th>Total n=106</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest degree of education</td>
<td>High school / College 10% 24% 16%</td>
<td>Undergraduate 46% 36% 41%</td>
<td>Master level 44% 40% 42%</td>
</tr>
<tr>
<td>Main area of specialization</td>
<td>Administration 37% 22% 31%</td>
<td>Computer science 27% 17% 22%</td>
<td>Information systems 24% 39% 31%</td>
</tr>
<tr>
<td>Computer engineering</td>
<td>9% 2% 6%</td>
<td>Project management</td>
<td>2% 5% 3%</td>
</tr>
<tr>
<td>Medical informatics</td>
<td>1% 3% 2%</td>
<td>Others</td>
<td>1% 1% 1%</td>
</tr>
<tr>
<td>Years experience in current position</td>
<td>7 [1 - 30]</td>
<td>9 [1 - 31]</td>
<td>8 [1 - 31]</td>
</tr>
<tr>
<td>Years experience in the current healthcare organization</td>
<td>8 [1 - 31]</td>
<td>10 [1 - 33]</td>
<td>12 [1 - 33]</td>
</tr>
<tr>
<td>Years experience in IT</td>
<td>16 [1 - 35]</td>
<td>17 [1 - 37]</td>
<td>17 [1 - 37]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profile of Hospitals</th>
<th>N (%)</th>
<th>N (%)</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban healthcare organization</td>
<td>41%</td>
<td>33%</td>
<td>38%</td>
</tr>
<tr>
<td>Affiliation with a teaching university</td>
<td>55%</td>
<td>39%</td>
<td>48%</td>
</tr>
<tr>
<td>Organizations with emergency room</td>
<td>93%</td>
<td>91%</td>
<td>92%</td>
</tr>
<tr>
<td>Organizations with operating room</td>
<td>92%</td>
<td>76%</td>
<td>85%</td>
</tr>
<tr>
<td>Organizations with intensive care unit</td>
<td>88%</td>
<td>59%</td>
<td>75%</td>
</tr>
<tr>
<td>Annual budget</td>
<td>150 M$ [12 - 750M$]</td>
<td>160 M$ [4 - 1200M$]</td>
<td>155 M$ [4 - 1200M$]</td>
</tr>
<tr>
<td>Number of physicians</td>
<td>223 [14 - 1300]</td>
<td>207 [20 - 2500]</td>
<td>216 [14 - 2500]</td>
</tr>
<tr>
<td>Number of registered nurses</td>
<td>1,015 [60 - 10000]</td>
<td>624 [30 - 4000]</td>
<td>853 [30 - 10000]</td>
</tr>
</tbody>
</table>

Significant differences between Québec and Ontario: a : p<.05; b : p<.005

In order to assess the reliability of the measures used to assess IT capacities in hospitals, Cronbach alpha coefficients were computed, which are good indicators of internal consistency. With the exception of the measures falling under the clinical support applications dimension, which were associated with a coefficient of 0.65, all coefficients for the other dimensions varied between 0.70 and 0.85, which indicates a good level of reliability of the measures developed.

Construct validity, which refers to the ability of an instrument to measure specific constructs and traits [22], was also determined to examine whether the developed measures behave as expected. As Table 2 shows, the correlations on the leading diagonal (correlations between similar measures), which represent the square root of the variance shared by the dimensions and their measures, are larger than off diagonal correlations among dimensions. This is reflective of convergent and discriminant validity [22].
4.3 IT capacities and scores

4.3.1. Computerized processes

As indicated in Table 4, the implementation of patient management systems varied between hospitals in Québec and Ontario. Hospitals in Québec have more advanced capacities with respect to operating room systems, emergency room systems, and ambulatory care scheduling systems. An opposite trend is observed however with respect to the implementation of the Master Patient Index (MPI) with the majority of hospitals in Ontario (87%) having these systems in place. Interestingly, critical care systems were only implemented in a small number of hospitals in both provinces and only hospitals in Ontario reported considering future implementation of these systems.

Computerized clinical support processes including laboratory, pharmacy, and radiology information systems were widely implemented with more than 80% of hospitals in both provinces reporting these systems in place. The only difference between the two provinces was related to the implementation of Picture Archiving and Communication System (PACS) (76% in Ontario vs. 55% in Québec), although 31% of the hospitals in Québec had plans for implementing these systems.

Last, the implementation of the majority of computerized clinical processes was limited, with the exception of electronic discharge summary, online access to knowledge database, and continuous quality improvement / risk management systems (Table 5). Specifically, advanced systems (e.g.,

The extent of implementation of computerized processes varied according to the IT dimensions examined. The early administrative computerized systems (e.g., material management systems, accounting / financial information systems) were implemented in the majority of hospitals, with comparable levels in the two provinces. The new generation of administrative systems however (e.g., business intelligence applications, disease costing systems) is still not widely implemented, and hospitals in Québec seem to be ahead in introducing these systems as compared to hospitals in Ontario (Table 3).
computerized physician order entry, clinical decision support) were not available in the majority of the hospitals despite reported plans for their implementation. Telemedicine however was used in 78% of hospitals in Ontario, which represents a significant penetration of these processes as opposed to Québec (42%). Order entry / results reporting systems were implemented in around half of the sample, but these systems are expected to become more prevalent with a large number of hospitals planning to implement them.

### 4.3.2 Emerging technologies

As indicated in Table 6, the implementation of contemporary technologies (e.g., voice recognition, RFID technology, bar coding for patient identification, single sign-on technology, biometry) was minimal as compared to the implementation of computerized processes. Hospitals in Québec are leading on some of technologies (e.g., bar coding for material and medications management, robots for medication preparation and dispensing, biometry, administrative data warehouse). On the other hand, more hospitals in Ontario reported having technologies such as single sign-on, voice recognition, medical record scanning, bar coding for patient identification, and bedside terminals in place. Although most technologies were not widely used, a large number of hospitals reported plans for their implementation, with the exception of advanced technologies (e.g., RFID, biometry, voice recognition and bedside terminals).

#### Table 6: Distribution of hospitals for emerging technologies.

<table>
<thead>
<tr>
<th>Emerging technologies</th>
<th>No Plan for Implementation</th>
<th>Planning to Implement</th>
<th>Began Implementation</th>
<th>Implemented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical record scanning</td>
<td>QC 35%</td>
<td>ON 30%</td>
<td>QC 9%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>ON 26%</td>
<td>QC 18%</td>
<td>ON 10%</td>
<td></td>
</tr>
<tr>
<td>Biometry</td>
<td>QC 42%</td>
<td>ON 38%</td>
<td>QC 5%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>ON 26%</td>
<td>QC 20%</td>
<td>ON 9%</td>
<td></td>
</tr>
<tr>
<td>Single sign-on technology</td>
<td>QC 43%</td>
<td>ON 43%</td>
<td>QC 7%</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>ON 44%</td>
<td>QC 39%</td>
<td>ON 2%</td>
<td></td>
</tr>
<tr>
<td>Bar coding for supplies / material management</td>
<td>QC 27%</td>
<td>ON 28%</td>
<td>QC 7%</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>ON 33%</td>
<td>QC 28%</td>
<td>ON 6%</td>
<td></td>
</tr>
<tr>
<td>Bar coding for medications management</td>
<td>QC 32%</td>
<td>ON 32%</td>
<td>QC 5%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>ON 37%</td>
<td>QC 43%</td>
<td>ON 9%</td>
<td></td>
</tr>
<tr>
<td>Bar coding for patient identification</td>
<td>QC 47%</td>
<td>ON 40%</td>
<td>QC 3%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>ON 23%</td>
<td>QC 25%</td>
<td>ON 7%</td>
<td></td>
</tr>
<tr>
<td>Robots (medication preparation / dispensing)</td>
<td>QC 12%</td>
<td>ON 5%</td>
<td>QC 10%</td>
<td>43%</td>
</tr>
<tr>
<td></td>
<td>ON 7%</td>
<td>QC 8%</td>
<td>ON 2%</td>
<td></td>
</tr>
<tr>
<td>Voice recognition</td>
<td>QC 50%</td>
<td>ON 35%</td>
<td>QC 5%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>ON 26%</td>
<td>QC 17%</td>
<td>ON 9%</td>
<td></td>
</tr>
<tr>
<td>Portable computing / wireless devices</td>
<td>QC 25%</td>
<td>ON 23%</td>
<td>QC 12%</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>ON 19%</td>
<td>QC 15%</td>
<td>ON 9%</td>
<td></td>
</tr>
<tr>
<td>RFID technology</td>
<td>QC 67%</td>
<td>ON 63%</td>
<td>QC 3%</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>ON 62%</td>
<td>QC 55%</td>
<td>ON 11%</td>
<td></td>
</tr>
<tr>
<td>Administrative data warehouse</td>
<td>QC 10%</td>
<td>ON 18%</td>
<td>QC 17%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>ON 20%</td>
<td>QC 15%</td>
<td>ON 4%</td>
<td></td>
</tr>
<tr>
<td>Clinical data warehouse</td>
<td>QC 25%</td>
<td>ON 28%</td>
<td>QC 6%</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td>ON 46%</td>
<td>QC 18%</td>
<td>ON 2%</td>
<td></td>
</tr>
<tr>
<td>Bedside terminals or PCS</td>
<td>QC 82%</td>
<td>ON 44%</td>
<td>QC 2%</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>ON 55%</td>
<td>QC 18%</td>
<td>ON 2%</td>
<td></td>
</tr>
<tr>
<td>QC = Quebec; ON = Ontario</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Table 8: Hospitals IT scores.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Total Sample (n=106)</th>
<th>Quebec Hospitals (n=60)</th>
<th>Ontario Hospitals (n=46)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 Administrative systems</td>
<td>64.5</td>
<td>67.6</td>
<td>60.3</td>
</tr>
<tr>
<td>D2 Patient management systems</td>
<td>63.6</td>
<td>67.2</td>
<td>58.9</td>
</tr>
<tr>
<td>D3 Clinical support systems</td>
<td>83.5</td>
<td>82.5</td>
<td>85.1</td>
</tr>
<tr>
<td>D4 Clinical systems</td>
<td>52.1</td>
<td>51.0</td>
<td>53.6</td>
</tr>
<tr>
<td>D5 Emerging technologies</td>
<td>30.1</td>
<td>31.7</td>
<td>28.2</td>
</tr>
<tr>
<td>D6 Internal integration - Administrative</td>
<td>74.1</td>
<td>78.0</td>
<td>69.1</td>
</tr>
<tr>
<td>D7 Internal integration - Clinical</td>
<td>44.6</td>
<td>34.9</td>
<td>57.0</td>
</tr>
<tr>
<td>D8 External integration</td>
<td>33.7</td>
<td>25.5</td>
<td>44.3</td>
</tr>
<tr>
<td>Overall IT sophistication score</td>
<td>56.3</td>
<td>55.0</td>
<td>58.0</td>
</tr>
<tr>
<td>Functional IT sophistication score</td>
<td>66.2</td>
<td>67.0</td>
<td>65.4</td>
</tr>
<tr>
<td>Technological IT sophistication</td>
<td>30.1</td>
<td>31.7</td>
<td>28.2</td>
</tr>
<tr>
<td>Integration level</td>
<td>50.9</td>
<td>46.3</td>
<td>56.8</td>
</tr>
</tbody>
</table>

Significant differences between Quebec and Ontario: a: p<.05; b: p<.005

#### 4.3.3. Internal and external integration

The level of internal integration for administrative systems, as reflected by the implementation of ERP modules was high in both provinces. The majority of hospitals reported ERP in place (85% in Québec and 78% in Ontario). The
level of internal integration of clinical systems however was lower as indicated by the poor implementation of EMR and the internal systems integrated with them. In this case, more hospitals in Ontario had either implemented (37%) or began installation of EMR (30%), as compared to hospitals in Quebec (18% and 20%, respectively). Similarly, hospitals in Ontario had a higher level of external integration with outside facilities than in Quebec (Table 7).

Table 7: External systems integration.

<table>
<thead>
<tr>
<th>Extent of information sharing with…</th>
<th>Mean* [Range]</th>
</tr>
</thead>
<tbody>
<tr>
<td>QC</td>
<td>ON</td>
</tr>
<tr>
<td>Other acute care organizations</td>
<td>2.5 [1-7]</td>
</tr>
<tr>
<td>Long term care organizations</td>
<td>2.3 [1-7]</td>
</tr>
<tr>
<td>Primary care organizations</td>
<td>2.5 [1-7]</td>
</tr>
<tr>
<td>Medical clinics</td>
<td>2.6 [1-7]</td>
</tr>
</tbody>
</table>

* The extent of external systems integration was assessed on a [1-7] scale with 1 = “Not at all” and 7 = “Very much”.

QC = Quebec; ON = Ontario

4.3.4. IT scores

We further computed IT scores for hospitals, which revealed information about their IT capacities (overall and along the eight dimensions). As indicated in Table 8, hospitals in Quebec and Ontario did not differ significantly on their overall IT sophistication; the overall IT sophistication score for the sample was moderate (score = 56.3). A closer examination of the results shows that functional and technological IT sophistication were not significantly different between the two provinces. The overall functional IT score was moderate to high (score = 66.3) while the technological IT score that was low (score = 30.1). The two provinces differed significantly on the scores for the integration level (Ontario: 56.8; Quebec: 46.3), which was moderate in both cases.

In general, the lowest IT scores were observed for clinical systems, emerging technologies, and external integration, which indicate limited capacities with respect to these dimensions; the scores for emerging technologies were particularly low in both provinces. The highest scores however were observed for clinical support systems and internal integration of administrative systems, which were moderate to high.

Significant differences were observed between the two provinces for administrative and patient management systems; hospitals in Quebec had significantly higher scores on these two dimensions. On the other hand, significantly higher levels of internal integration of clinical systems were reported in Ontario (Table 8).

5. Discussion

Although progress has been made over the past years in relation to assessing IT capacities in hospitals (e.g., [13-15, 24-26]), prior measures have been constrained by conceptual and methodological issues, which precluded the development of an IT scoring approach that reflects the level of IT capacities in hospitals. This research addresses these issues and proposes an IT capacities assessment tool and a comprehensive IT scoring approach that captures various dimensions of IT sophistication in hospitals.

The instrument was validated through a survey of hospitals in two provinces in Canada, and the psychometric properties demonstrated a good level of validity and reliability of the measures. The findings show a moderate level of IT sophistication among hospitals in Quebec and Ontario.

With respect to functional IT sophistication, hospitals in Quebec and Ontario reported moderate to high levels of implementation of computerized processes, with the exception of computerized clinical systems that were not widely available in these settings. Although these systems have the potential to reduce errors and support clinical decision making (e.g., nursing and clinical documentation, CPOE, and clinical decision support systems), they were still not widely used among the surveyed hospitals. Nevertheless, the high percent of hospitals reporting plans to implement these systems highlights current efforts undergone to address this issue.

A closer examination of the other dimensions along functional IT sophistication reveals that hospitals in Quebec have a higher level of implementation of administrative and patient management systems (e.g., operating room and emergency room systems), which might be explained by the differences in hospitals’ characteristics; surveyed hospitals in Quebec were larger and had more intensive care units and operating rooms than hospitals in Ontario. In
addition, the organization of the health care delivery system in Québec, which is based on the Health and Social Service Centers that provide a range of specialized and general services, necessitates having certain administrative and patient management systems in place in order to function effectively. On the other hand, the province of Ontario is leading in terms of the implementation of MPI, PACS, and telemedicine. This is not surprising in light of the recent efforts toward integrating services in various geographic areas in Ontario, and the increasing support of the government for telemedicine initiatives through the creation of the Ontario Telemedicine Network in 2006.

Technological IT sophistication scores in both provinces revealed a significant gap in relation to the implementation of technologies that have the potential of reducing errors, improving efficiency, and addressing security issues (e.g., bar coding for patient identification and materials management, bedside terminals, single sign-on, RFID, biometry). And 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 the greater emphasis of hospitals on implementing computerized processes than technologies.

The IT integration level was relatively low in our sample, with the exception of the internal integration of administrative systems (ERP). Hospitals in Ontario had significantly higher level of implementation of EMR, and more external systems integration with other organizations. This might be explained by the creation of Local Health Integration Networks by the Ontario government in 2006, which support the integration of services in the province.

It is important to note that the exclusion of the 9 items, which showed no variability and had consistently low scores in our sample, does not undermine the importance and relevance of these computerized processes and external integration approaches. However, they seem too advanced at present and practically not available in hospitals. Thus, incorporating them in the calculation of IT scores will not differentiate between hospitals on these items. Nevertheless, we expect that as these processes and approaches gain more attention in the future, they can further be incorporated in the IT sophistication scores.

Although the response rate in this study appears to be highly satisfactory in comparison with most mail surveys [23], we acknowledge that the absence of data on non-responding hospitals precluded a comparison between responding and non-responding hospitals to confirm the representativeness of our sample. Finally, given the fact that the instrument was validated among hospitals in two specific provinces in Canada, replicating the survey in other settings outside Canada and in other provinces can further support the instrument generalizability.

Finally, the development of a valid and reliable tool for assessing the level of IT sophistication in hospitals, which can produce IT scores that reflect IT capacities in these settings, presents an important contribution to managers and researchers. This instrument can be a useful tool for hospitals to exercise benchmarking and assess their positions in the market in relation to IT capacities. In addition, it can also be used to further examine the relationship between IT and organizational / contextual variables, as well as the process and outcomes of care.

6. Conclusion

The development of IT scores is a critical step forward towards addressing important research questions involving the determinants of IT sophistication in hospitals and the relationship between IT capacities and outcomes measures. By developing and validating an IT capacities assessment tool in hospitals, we unified prior literature in this area and proposed an IT scoring approach along eight dimensions representing computerized processes and technologies in administrative and clinical areas, as well as internal and external systems integration.

The survey of hospitals in Québec and Ontario revealed a moderate level of IT sophistication. Nevertheless, the IT capacities varied between the two provinces, although limited implementation of emerging technologies and clinical systems, and minimal internal integration of clinical systems, was observed in both provinces. This might raise concerns in light of the increasing focus on patient safety, especially that many of these systems and technologies have potential of reducing errors. Future efforts are necessary to optimize on the available solutions on the market, and improve the level of systems integration, to ensure better continuity and integration of care.
7. References


### Appendix A: Overview of the items included in the proposed IT capacities assessment tool.

#### Functional IT Capacities

**Administrative Applications**
- Accounting / Financial IS
- E-commerce / B2B applications
- Material management systems
- Staff scheduling system
- Business intelligence system
- Financial / Clinical dashboards
- Disease costing
- Human resources

**Patient Management Applications**
- Operating room management system
- Emergency room system
- Critical care systems
- Patient chart tracking system
- Master patient index (MPI)
- ADT system

**Clinical Support Applications**
- Laboratory IS
- Radiology IS
- Pharmacy IS
- PACS

**Clinical Applications**
- Nursing documentation system
- Clinical documentation system
- Continuing quality improvement
- Clinical decision support systems
- Electronic discharge summary
- Order entry / Results reporting
- Computerized physician order entry
- On-line access to knowledge base
- E-learning
- Telemedicine
- Electronic dictation

#### Technological IT Capacities

**Contemporary Clinical and Administrative Technologies**
- Medical record scanning
- Biometry
- Bar coding – materials management
- Administrative data warehouse
- Portable computing / wireless devices
- Single sign-on technology
- Bar coding – medication management
- Clinical data warehouse
- Robots (medication preparation / dispensing)
- Bedside terminals
- Voice recognition
- RFID

#### Integration

**Internal**
- Enterprise resource planning
- Electronic medical record

**External**
- With acute care organizations
- With primary care organizations
- With long term care organizations
- With medical clinics