

# Sophistication of information technology in healthcare: a comparison among a sample of hospitals in Japan

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## Abstract

*This study examines the level of clinical sophistication of information technology (IT) in a sample of hospitals in Japan and benchmarks the extent of clinical sophistication in Japan with the findings from similar surveys conducted at different points in time in the State of Iowa in the US and two provinces in Canada. Data for the study were collected using a validated instrument assessing three dimensions of IT sophistication: functional, technological and integration levels. Clinical areas that were assessed include patient management, patient care activities and clinical support activities. The results show that the majority of processes and activities that have been computerised in Japan are the basic patient management processes, such as admission, registrations and order entry systems. Telemedicine, expert systems and voice recognition systems for notes transcriptions were only available in less than 5% of the sample hospitals. Overall, there were no differences between the small hospitals and large hospitals in terms of functional and integration sophistication. However, large hospitals had higher technological sophistications than small hospitals. Functional sophistication was higher in Japan than Canada and the US. Technological sophistication in Japan was somewhat better than that of Canada but lower than that of the US. The results demonstrated that there exists substantial room for expanding clinical IT systems in the hospitals in Japan.*

**Keywords: Hospital information systems, information technology, computerised medical records, system integration, medical informatics, medical technology**

## 1. Introduction

Evidence continues to show that information technology (IT) has significant potential to improve patient safety, organisational efficiency, patient satisfaction and quality of healthcare [1-3]. Despite such growing evidence, its adoption remains limited across many nations. In Japan, a survey conducted

by the Ministry of Health, Labour and Welfare (MHLW) in 2002 reported that only 1.3% of hospitals (from a total of 8,023 hospitals) had the electronic medical records (EMR) system and that only 15.3% had the physician order entry systems (POES) [4]. Other developed nations also report a low level of the adoption of Health Information Technologies (HIT)<sup>1</sup>. Apart from Swe-

den (90%) and the Netherlands (88%) where adoption of EMR system by general practitioners is high, it is low in the US (17%), Canada (14%) and Australia (25%) [5-6]. In New Zealand and Britain, over 50% of hospitals have EMR systems [5]. As the demand for safe, effective, timely, patient-centred, efficient and equitably distributed healthcare systems continues, HIT will

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<sup>1</sup> HIT is used broadly here to refer to all computing technologies that are used to support healthcare including but not limited to electronic medical records systems and physician order entry systems.

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remain critical to the survival and competitiveness of healthcare institutions.

In the recent past, the government of Japan has initiated several programs that have generated a renewed interest in the adoption of HIT and, particularly, clinical IT systems. One initiative is the government policy paper targeting at least 60% of hospitals with 400 beds or more to computerise their records by 2006 [7]. The policy is based on the resource-based theory which argues that larger organisations have the capacity and resources to innovate [8]. Currently, there is no official survey done in 2006 regarding whether the policy was achieved or not. However, a survey conducted in the month of October 2005 by the ministry of health and welfare, government of Japan, indicated that the target has not been met. Only 20% of the hospitals with 400 beds or more had computerized their medical records (<http://www.mhlw.go.jp/toukei/saikin/hw/iriyosd/05/kekka1-3.html> [in Japanese]). According to a new IT reform strategy released on 19<sup>th</sup> January 2006 by the government, it is expected that computerization in hospitals with 400 beds or more will be completed by 2008 and that all hospitals with less than 400 beds are expected to computerize their records by 2010 (<http://www.kantei.go.jp/foreign/policy/it/ITstrategy2006.pdf>). It must be noted, however, that government policy papers generally give directions, goals and visions which in most cases are too ideal to achieve. To what extent larger hospitals in Japan are more sophisticated in terms of clinical IT adoption remain unclear. Hence, it seems important to examine how the trends of adoption between small and large hospitals in Japan vary.

Another initiative is the introduction of a prospective payment system based on diagnosis procedure combination (DPC). In 2003, DPC was introduced into 80 hospitals in Japan to promote standardisation of healthcare and shorten hospital stay. DPC was expanded to other hospitals on a voluntary basis at the beginning of 2004 [9]. The DPC system is expected to make hospital services measurable, and provide valuable information for manag-

ing patient care based on evidence-based medicine (EBM). Though it is still on a trial basis, effective use of DPC will require patient information to be in electronic form to allow generation of useful indicators and faster filing of health insurance claims. These programs, together with several researches commissioned by the Government of Japan, are expected to spur wider adoption of clinical IT in the coming years.

In Japan, there is still no research outcome on the characterisation and operationalisation of the functions of the clinical IT systems and identification of the parts, which corresponds to the systems' units that would facilitate the utilisation of these systems [10]. One way to capture this baseline data is to examine the extent to which computerised processes/activities in each clinical area have been developed, the technologies to support them, and the extent to which the computer-based systems are fully integrated within and between healthcare institutions. In other words, there is a need to examine the degree to which information resources are fully developed and computer-based systems are fully integrated (clinical IT sophistication) in healthcare institutions.

In this paper, we analyse comprehensively the current state of clinical IT in a sample of hospitals in Japan. This study is different from the previous studies examining clinical IT adoption in healthcare in Japan, because we do not look at adoption as a binary variable (e.g., whether POE has been adopted or not [11]). We extensively examine processes and activities in each clinical section of a hospital to try to characterise adoption in a way that would help policy makers understand both the leverage available and the context required to achieve wider adoption objectives. We also make an attempt to compare the level of clinical IT sophistication in samples of hospitals in Japan, the US and Canada as a process of benchmarking the clinical IT sophistication in Japan. Benchmarking is important in measuring outcomes of policies, and monitoring progress in clinical IT diffusion. This will indicate how Japan is doing

compared to the US and Canada in terms of extent of clinical IT sophistication in healthcare.

In summary, the objectives of this study were to (1) describe the sophistication of current clinical IT in hospitals that have adopted these systems, (2) assess whether the larger hospitals are more sophisticated in terms of clinical IT than the smaller ones, and (3) to benchmark the level of clinical IT sophistication in Japan with the results of similar studies in the US and Canada.

## 2. Method

### 2.1 Research Design

A cross-sectional survey was conducted as part of an ongoing nationwide longitudinal study whose aim is to evaluate the improvement of the quality of healthcare services as a result of the introduction of EMR systems. The overall goal of the nationwide study is to propose guidelines and self-evaluation methods for many medical institutions that plan to implement EMR systems in the near future.

### 2.2 Sample

In this study, a convenient sample of hospitals that had implemented some form of clinical IT was drawn as a follow-up to an earlier survey conducted to assess the costs of computerisation (both initial investment and running) according to system types and vendor support. The intention of the earlier survey was to build a business model for EMR system adoption. In that survey, 350 healthcare institutions were randomly selected to participate. Only 71 (20.3%) healthcare institutions responded to that survey. The response rate was low but the results of the survey were very useful in meeting the intended analysis. Furthermore, the responding healthcare institutions did not significantly differ from the non-responding hospitals in terms of organisational characteristics such as ownership, hospital category (acute or long-term), bed size and bed

category (small or large hospitals) (data not shown). For this follow-up survey, only the 71 healthcare institutions that responded to the earlier survey and had implemented some form of computerised applications in patient care management were invited to participate. The idea was to use the evidence of “success stories” of the adopters to understand the effect of clinical IT on the delivery of healthcare and also to convince other hospitals, which are yet to implement computerised systems. And since this survey was meant to provide evidence as a basis for characterisation of the clinical IT functions already deployed in healthcare rather than to measure the amount of adoption of these functions, we were satisfied that this sample would provide a good insight for the intended analysis. Besides, the hospitals that responded to this survey cover the spectrum of hospitals in Japan (university-affiliated, governmental, semi-governmental and private hospitals and clinics).

### 2.3 Instruments

The instrument developed by Paré and Sicotte [13] was used to collect data for this study. The instrument is based on a strong theoretical framework, and extensively assesses the functional and technological sophistication and the level of integration of systems in three key areas of hospital operations: patient management, patient care activities and clinical support activities. In these key areas, the instrument measures several intersecting technologies and processes including but not limited to, tracking systems (bar codes and radio frequencies identifications), POES, decision support systems and the integration of these systems not only within the departments but also with other systems in the external facilities. Prior research had demonstrated that the survey instrument was a valid and reliable instrument for measuring the availability of IT applications in hospitals [13, 14].

The instrument<sup>2</sup> was translated into

Japanese. This was then followed by a series of meetings involving health informatics experts to check the appropriateness of terminology as used in the items of the survey. Some minor changes were made to the original survey instruments to reflect the practice in Japan. For example, DRG was replaced with DPC. Also, one item examining the HIT architecture was restructured to conform to the Japanese Association of Healthcare Information Systems’ (JAHIS) 5-level hierarchy of clinical IT [15]. One item examining transcription of orders by nurses was omitted because this is not a common practice in Japan. As far as possible, we tried to retain the originality of the instrument to allow the comparison of the results obtained in Japan and the results obtained in Canada [13] and the US [14]. A pilot test of the survey instrument in Japanese hospitals indicated that the IT applications were relevant for hospitals in Japan.

### 2.4 Data collection

All the chief information officers (CIO) of the 71 institutions (69 hospitals and 2 clinics) were contacted by telephone to request their participation in this study. None of the contacted CIO refused to participate. A letter, detailing the purpose of the study, along with a copy of the questionnaire, was then sent to the CIO. Data were collected over a period of six weeks starting in February 2006.

### 2.5 Analysis

Overall, 42 institutions (41 hospitals and 1 clinic) completed the survey questionnaire in Japan. For the purposes of this analysis, clinics were excluded, making the overall response rate to be 59.4%. Also, the data collected from hospitals in Canada and presented by Paré and Sicotte [13] and that collected from the hospitals in the US and presented by Jaana et al. [14] were used in the benchmarking process.

The responses from the completed

questionnaires were entered twice into a computer and the dataset compared to ensure accuracy. Data were ‘cleaned’ and then analysed using *Statistical Package for Social Sciences* (SPSS version 12). The same scoring procedure for the variables applied by Jaana et al. [14] was used to ensure consistency. In brief, functional sophistication was measured using binary questions where a score of ‘1’ was assigned for each computerised process/activity and a score of ‘0 (zero)’ otherwise. Technological sophistication was measured on a scale ranging from ‘0’ (not available), ‘1’ (barely used) to ‘7’ (extensively used). The percent of hospitals that reported these computerised activities as available was determined in each clinical subsection and used for comparison between small and large hospitals in Japan. Finally, integration level was measured on a 1-7 scale ranging from “not at all” to “very much”.

The organisational characteristics of the hospitals surveyed in Japan were compared to the non-responding hospitals using chi-square test for categorical variables and Kruskal-Wallis non-parametric test for non-normally distributed continuous variables. Reliability of the measures used in the Japanese survey was assessed using Cronbach alpha coefficients, and then compared to the same coefficients reported by Paré and Sicotte [13] and Jaana et al. [14]. The percent of hospitals that reported having specific computerised processes and technologies under investigation for functional sophistication and technological sophistication, and the means of the responses to questions assessing the integration level were computed. Only questions that were clearly identified in the study in Canada and the US were used in this analysis.

Significant findings on clinical IT variables between small and large hospitals in Japan were verified using chi-square and Cramer’s V ( $p = \text{value } 0.05$ ). The  $p$ -values of Cramer’s V test are reported. Benchmarking data was plotted as the percent of hospitals reporting each of the items listed in the

<sup>2</sup> A copy of the original instrument is available from the authors.

Variable	Responding hospitals n = 41 n (%)	Non-responding hospitals n = 28 n (%)	p-value
Ownership <sup>a</sup>			0.268
University-affiliated	3 (7.3)	2 (7.1)	
Governmental hospitals	5 (12.2)	8 (28.6)	
Semi-governmental	5 (12.2)	1 (3.6)	
Private hospital	28 (68.3)	17 (60.7)	
Number of beds			0.057
Median	452.0	246.0	
Range	1373.0	798.0	
Age of systems <sup>b</sup>			0.152
Median	3.0	4.0	
Range	7.0	9.0	
Bed category <sup>c</sup>			0.061
Small	20 (48.8)	20 (71.4)	
Large	21 (51.2)	8 (28.6)	
Hospital category <sup>a</sup>			0.085
Acute	36 (90)	28 (100)	
Long term (chronic)	4 (10)	0 (0)	

Table 1: Characteristics of responding and non-responding hospitals in Japan.

Sources: <sup>a</sup> from reference [12]; <sup>b</sup> from reference [16]; <sup>c</sup> We define small hospitals as hospitals with fewer than 400 beds and large hospitals as hospitals with 400 beds or more in line with government's policy requiring hospitals with 400 beds or more to computerise their patient records by 2006 [7]. Clinics were excluded from this analysis.

Variable	Responding institutions n = 42 n (%)	Non-responding institutions n = 308 n (%)	(p-value)
Ownership <sup>a</sup>			0.331
University-affiliated	3 (7.1)	19 (6.2)	
Governmental hospitals	5 (11.9)	81 (26.3)	
Semi-governmental hospitals	5 (11.9)	32 (10.4)	
Private hospital	28 (66.7)	175 (56.8)	
Clinics	1 (2.4)	1 (0.3)	
Number of beds			0.248
Median	452.0	283.0	
Range	1373.0	1483.0	
Bed category (hospitals only)			0.155
Small	20 (48.8)	209 (68.1)	
Large	21 (51.2)	98 (41.9)	
Hospital category <sup>a</sup>			0.146
Acute	36 (87.8)	259 (84.4)	
Long term (chronic)	5 (12.2)	48 (15.6)	

Table 2: Characteristics of 42 hospitals as compared with the original 350 hospitals.

Source: <sup>a</sup> from reference [12]

functional and technological sophistication as computerised for each of the three countries. For integration sophistication, the means of the items in each section was calculated and tabulated for the Japanese hospitals.

### 3. Results

#### 3.1 Organisational characteristics of the hospitals

A total of 41 hospitals responded to the survey, with a response rate of 59.4%. There were no significant differences between the responding hospi-

tals and the non-responding hospitals according to ownership, number of beds, age of systems, bed category and hospital category (Table 1). No other information was available on the characteristics of the non-responding hospitals.

When the responding hospitals were compared to the original random sample of 350 hospitals, no differences were observed on organisational characteristics (Table 2).

Responding hospitals included 3 (7.3%) university-affiliated; 5 (12.2%) governmental; 5 (12.2%) semi-governmental; and 28 (68.3%) private hospitals. Survey respondents were mainly computer scientists (48%), with IT management experience ranging from

0 years to 25 years and a median of 7.0 years. Comparison of small hospitals and large hospitals showed no significant differences except on the number of years the CIO has worked in the current hospital and the budget (both total hospital budget and IT budget) (Table 3). Respondents from large hospitals reported to have worked longer in their respective hospitals than the respondents from small hospitals.

#### 3.2 Instrument Properties

The reliability of the questionnaire was assessed and the results were compared to the findings reported by Paré and Sicotte [13] and Jaana et al. [14]. Reliability was measured using

Variable	Small hospitals (n = 20)	Large hospitals (n = 21)	p-values
Ownership			.267
University-affiliated	0 (0)	3 (14.3)	
Governmental	2 (10)	3 (14.3)	
Semi-governmental	2 (10)	3 (14.3)	
Private	16 (100)	12 (57.1)	
Hospital category (5 missing data)			.906
Acute	15 (88.2)	17 (89.5)	
Long-term (chronic)	2 (11.8)	2 (10.5)	
CIO's field of specialisation*			
Computer scientist	11 (45.8)	13 (50.0)	
Administrator	8 (33.3)	7 (26.9)	
MIS	1 (4.2)	4 (15.4)	
Health manager	1 (4.2)	1 (3.8)	
Others	3 (12.5)	1 (3.8)	
Experience in current function (years)			0.652
Median	3.0	3.0	
Range	8.0	11.2	
Experience in current hospital (years)			0.033
Median	6.0	10.5	
Range	29.0	31.0	
Experience in IT (years)			0.419
Median	9.0	7.0	
Range	22.0	25.0	
Annual hospital budget (M\$)			0.010
Median	170.0	1059.0	
Range	72.0	200.0	
Annual IT budget (M\$)			0.008
Median	1.2	23.0	
Range	0.2	1.7	

Table 3: General characteristics of the responding hospitals.

\* Multiple answers accepted.

Cronbach alpha coefficients of internal consistency of the measures. Table 4 presents the results obtained from the sample hospitals in Japan, State of Iowa in the US, and Canada, based on the questions included in the survey. “Patient care” combines the questions related to patient management and patient care activities from the original instrument [13]. The number of items in each cell, used for the calculation of the *alpha* coefficients, is different for the three samples since the instrument was modified

computerised. The most frequent clinical IT application process used in small hospitals was patient index, while the least frequent application processes used in small hospitals were materials (tools) management and case costing. On the other hand, outpatient admissions, patient-index, results capturing (from analysers) were the most frequent processes being used in large hospitals, while the least frequent application process used in large hospitals was case costing.

Overall, the data from our research

cal sophistication. The application and connectivity technology most used was electronic reporting of test results to medical units and local area networks (LAN), respectively. Of the 18 application technologies listed in the survey, only four technologies were available in more than 75% of the sample hospitals. Three application technologies were available in less than 10% of the sample hospitals. Of the connectivity technologies, none of the sample hospitals was using microwave connections and fewer than 10% use

	Patient care			Clinical support activities			Overall dimension		
	Japan	Iowa <sup>a</sup>	Canada <sup>b</sup>	Japan	Iowa <sup>a</sup>	Canada <sup>b</sup>	Japan	Iowa <sup>a</sup>	Canada <sup>b</sup>
Functional sophistication	0.87 (32) <sup>†</sup>	0.91 (35)	0.84 (33)	0.87 (21)	0.91 (21)	0.84 (21)	0.91 (53)	0.95 (56)	0.91 (54)
Technological sophistication	0.75 (24)	0.86 (24)	0.79 (24)	0.84 (13)	0.84 (13)	0.83 (13)	0.80 (37)	0.91 (37)	0.88 (37)
Integration sophistication	0.83 (10)	0.93 (10)	0.86 (10)	0.78 (6)	0.84 (6)	0.84 (6)	0.83 (16)	0.94 (16)	0.89 (16)
Overall sophistication							0.91 (106)	0.97 (109)	0.94 (107)

Table 4: Comparison of internal reliability (Cronbach’s Alpha) in Japan, Iowa USA and Canada hospitals.

<sup>†</sup> the values in parentheses are the number of items in the survey instrument for the corresponding clinical section. <sup>a</sup> From reference [14]; <sup>b</sup> From reference [13].

in some instances to reflect the practice in Japan without affecting the substance of the instrument. The *alphas* were all above 0.70 levels acceptable for social research.

### 3.3 Functional sophistication in Japan

Table 5 presents variables measuring the extent of functional sophistication in a hospital. Nearly three fourths of hospitals surveyed in Japan use computer systems in twelve of the listed variables for functional sophistication. The least computerised process among the hospitals surveyed was case costing in the operating room, with only one hospital indicating to have computerised this process. The data also show that the least computerised section was operating room (OR) where only one process (operations booking) was reported by more than half of the sample hospitals as

reveal that no significant differences exist between small and large hospitals in terms of *functional sophistication* ( $t = -1.891$ ;  $P = 0.066$ ). However, of the variables in the functional sophistication, significant differences between small and large hospitals were noted in five of these variables. These processes were: materials (tools) management (Cramer’s  $V = 0.513$ ;  $p$ -value 0.001), anaesthetic notes recording (Cramer’s  $V = 0.488$ ,  $p$ -value = 0.002), historical drug information storage (Cramer’s  $V = 0.513$ ,  $p$ -value = 0.001), making out refill reports (Cramer’s  $V = 0.350$ ,  $p$ -value = 0.025) and label generation (Cramer’s  $V = 0.516$ ,  $p$ -value 0.001), were more likely to be computerised in large hospitals than in small hospitals.

### 3.4 Technological sophistication in Japan

Table 6 presents variables measuring the extent of use of a wide range of technologies in a hospital, technologi-

satellite connections and infrared connections. None of the small hospitals were using telemedicine for evaluation and triage purposes, bar coding and voice recognition systems for notes transcription in operation room. On the other hand, none of the large hospitals were using expert systems.

Our analysis reveals that technological sophistication was higher in large hospitals than small hospitals ( $t = -2.080$ ;  $P = 0.044$ ). Out of the 18 variables, significant differences between small and large hospitals were noted in only three variables, namely connection to external databases (Cramer’s  $V = 0.336$ ,  $p$ -value 0.031); bar coding to track tools (Cramer’s  $V = 0.369$ ,  $p$ -value 0.023); and telemedicine for results capturing and interpretation (Cramer’s  $V = 0.327$ ,  $p$ -value 0.036). In all these technologies, large hospitals were more likely to report use of these technologies than small hospitals. In the connectivity technologies variables, only two variables showed significant dif-

Variable	Small (n = 20)	Large (n = 21)	Japan (n=41)	p-Value
<b>Patient management</b>				
Inpatient pre-admissions	60.0	57.1	58.5	.853
Outpatient admissions	90.0	100.0	95.1	.137
Bed availability estimation	55.0	66.7	61.0	.444
Patient-index	100.0	100.0	100.0	-
<b>Patient care (MD)</b>				
Discharge summary	85.0	81.0	82.9	.731
Face sheet	55.0	76.2	65.9	.153
<b>Patient care (RN)</b>				
Medication administration	60.0	42.9	51.2	.272
Historical record keeping	80.0	66.5	73.2	.335
Vital signs recording	25.0	33.3	29.3	.558
Quality assurance	30.0	9.5	19.5	.098
Nursing flowsheet	95.0	90.5	92.7	.578
<b>Patient care (ER)</b>				
Results reporting	89.5	85.7	87.5	.720
Registrations and admissions	84.2	85.7	85.0	.894
Patient inflow, waiting time, crowding	36.8	57.1	47.5	.199
Patient data collection (consultations, tests)	73.7	76.2	75.0	.855
Physician orders transcriptions	26.3	38.1	32.5	.427
<b>Patient care (OR)</b>				
Operations booking	63.2	81.1	72.5	.208
Staff scheduling	21.1	28.6	25.0	.583
Materials (tools) management	0.0	42.9	22.5	.001
Case costing	0.0	4.8	2.5	.335
Anesthetic notes recording	10.5	57.1	35.0	.002
<b>Clinical support (pharmacy)</b>				
Medication administration	75.0	76.2	75.6	.929
Patient drug profile lookup	25.0	38.1	31.7	.368
Historical drug information storage	30.0	81.0	56.1	.001
Making out refill reports	15.0	47.6	31.7	.025
Drug interaction checking	85.0	81.0	82.9	.731
<b>Clinical support (laboratories)</b>				
Recurring tests management	40.0	47.6	43.9	.623
Specimen archiving	75.0	90.5	82.9	.188
Blood bank management	25.0	47.6	36.6	.133
Results capturing (from analysers)	85.0	100.0	92.7	.065
<b>Clinical support (radiology)</b>				
Label generation	20.0	71.4	46.3	.001
Results capturing and validation	75.0	81.0	78.0	.645

Table 5: Comparison of functional IT sophistication in Japanese hospitals.

ferences between small and large hospitals. These were; use of modems (Cramer’s V=0.372, p-value 0.017) and use of fibre optics (Cramer’s V=0.337, p-value 0.031). Large hospitals were more likely to report use of these technologies than small hospitals.

### 3.5 Integration sophistication in Japan

Integration level is the extent to which internal and external systems/applications are integrated to each other in a hospital and is measured on 7-point Likert scale ranging from “not

at all” to “very much”. No statistical tests of significance were done for the sample of hospitals in Japan as was also the case in the studies in Canada [13] and the US [14] using the same instrument. However, as Table 7 shows, the level of integration was all above the midpoint (3.5) in all the four

Variable	Small (n = 20)	Large (n = 21)	Japan (n=41)	p-value
<b>Patient management</b>				
Telemedicine for transmission of diagnostics	20.0	19.0	19.5	.939
Telemedicine for evaluation and triage purposes	0.0	5.0	2.5	.311
Expert systems	5.0	0.0	2.4	.300
Voice recognition systems	15.0	23.8	19.5	.477
Connection to external databases	20.0	52.4	36.6	.031
<b>Patient care (RN &amp; ER)</b>				
PCs or workstations at the bedside	90.0	90.5	90.2	.959
<b>Patient care (OR)</b>				
Bar coding to track tools	0.0	25.0	13.2	.023
Real-time monitoring and reporting of operations' stages	22.2	40.0	31.6	.239
Voice recognition systems for notes transcription	0.0	4.8	2.6	.348
Portable devices for data input	11.1	15.0	13.2	.723
Dictation systems for post-operative reports	16.7	20.0	18.4	.791
<b>Clinical support (pharmacy)</b>				
EDI links to medication suppliers	36.8	33.3	35.0	.816
Electronic requisition for medications from clinical units	95.0	100.0	97.6	.300
<b>Clinical support (laboratories)</b>				
Bar coding to track specimen	80.0	95.2	87.8	.136
Electronic reporting of tests results to medical units	100.0	100.0	100.0	-
<b>Clinical support (radiology)</b>				
PACS	68.4	76.2	72.5	.586
Voice recognition system for results transcription	10.0	30.0	20.0	.114
Telemedicine for results capturing and interpretation	10.0	38.1	24.4	.036
<b>Connectivity technologies</b>				
Use of Fax	60.0	81.0	70.7	.141
Use of Modem	25.0	61.9	43.9	.017
Use of Fiber optics	55.0	85.7	70.1	.031
LAN	100.0	100.0	100.0	-
WAN	10.0	28.6	19.5	.134
Microwave connections	0.0	0.0	0.0	-
Satellite connections	0.0	4.8	2.4	.323
Infrared	0.0	4.8	2.4	.323
Wireless connections	75.0	81.0	78.0	.645
Website	100.0	95.2	97.6	.323

Table 6: Comparison of technological IT sophistication in Japanese hospitals.

variables measuring integration level, indicating higher integration sophistication of the clinical IT systems in the sample hospitals.

### 3.6 Benchmarking

The percent of hospitals within a country that reported each of the listed variables to be available was charted for each of the functional and technological sophistication. Figure 1 dem-

onstrates the variability in the clinical IT sophistication between the three countries. In Japan, 19 of the 32 variables measuring functional sophistication were available in at least 50% of the sample hospitals in Japan, compared to 17 and 12 variables which were available in at least 50% the sample hospitals in Canada and State of Iowa in the US, respectively. On the hand, 10 of the 28 variables measuring technological sophistication were being

used in at least 50% of the sample hospitals in Japan compared to 8 and 12 in at least 50% of sample hospitals in Canada and State of Iowa in the US respectively.

## 4. Discussion

This report presents clinical IT sophistications across a sample of hospitals in Japan. The study was part



Variable	Mean of integration level		
	Small (n=20)	Large (n=21)	Japan (n=41)
[Patient management]			
Integration among patient management applications	5.5	5.8	5.6
Integration of patient management systems to other applications	5.1	5.8	5.5
[Patient care]			
Integration between patient care systems and external entities' computerised systems (clinics, other hospitals)	4.0	3.6	3.8
Integration of ER applications	5.1	5.2	5.2

Table 7: Comparison of IT integration level in Japanese hospitals. Scale 1-7, "not at all" to "very much".

of an ongoing nationwide longitudinal study whose aim is to evaluate the improvement of the quality of the healthcare services as a result of the introduction of EMR systems. In order to understand the effect of the in-

roduction of clinical IT systems (including EMR systems), it is important that one is able to characterise clinical IT and identify parts which corresponds to the systems' units that would facilitate the utilisation of these

systems. Therefore this study was intended to characterise clinical IT sophistication among the Japanese hospitals and to evaluate whether the IT sophistication varies significantly among the small and large hospitals

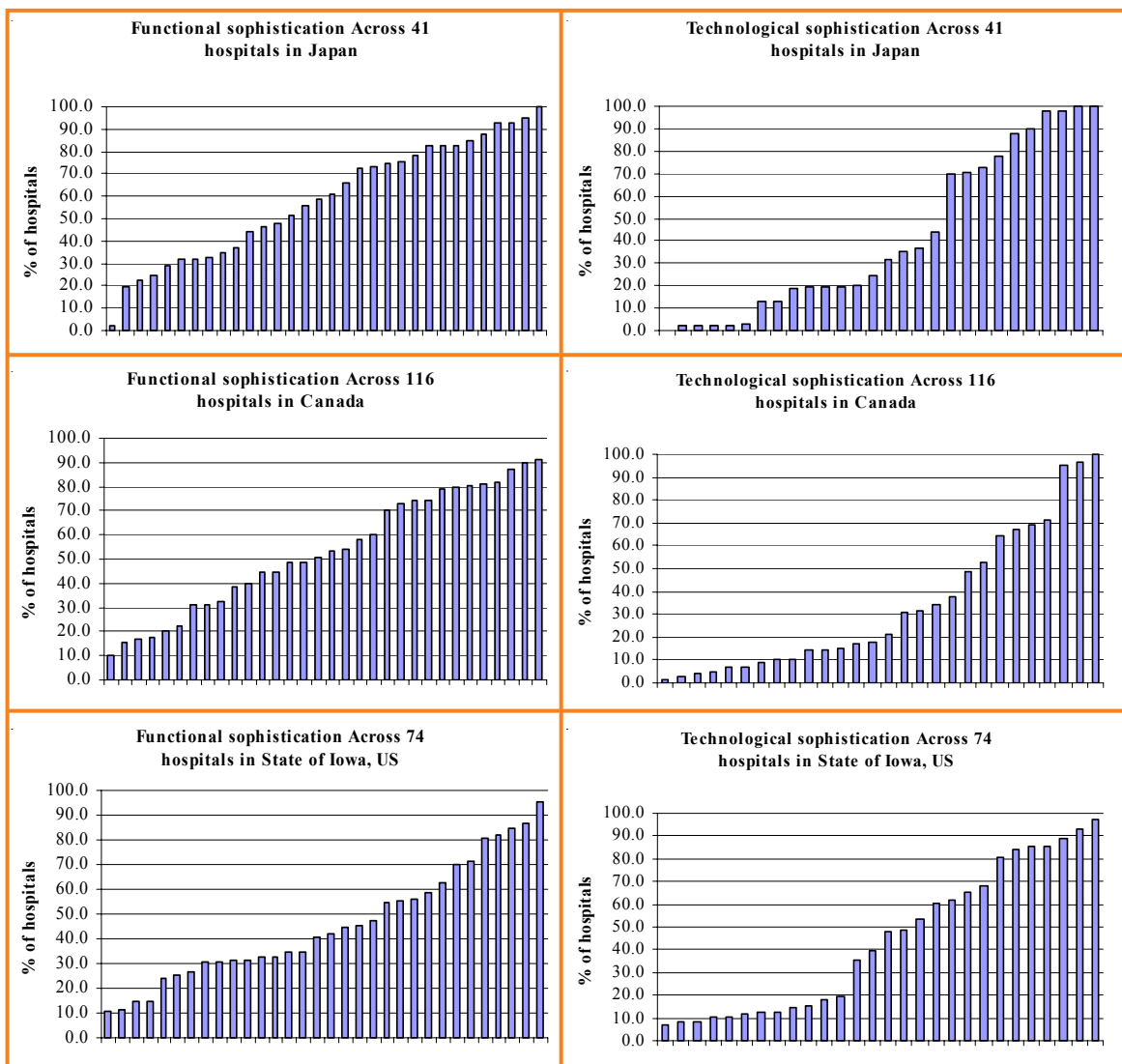


Figure 1: Clinical IT sophistication for the three countries.

Note: % hospitals are computed as the number of hospitals within a country who answered yes to the variables in the survey; Data for Canada and state of Iowa in the US were obtained from Reference [13] and [14] respectively.

surveyed. The response rate was only 12% of the original targeted random sample of 350 hospitals. But the responding hospitals did not differ from the non-responding hospitals on organisational characteristics. We used a measurement instrument that has been validated in both Iowa in the US and Canada. We translated the instrument into Japanese and modified some variables in the instrument, but this did not affect the reliability of the instrument as is exhibited in Table 4. Our Cronbach's alphas were somewhat lower than the ones found in the two previous studies. We suspect that the low *Alphas* obtained in this study could have resulted from the nature of the sample hospitals, which were already having some form of computer-based applications thus restricting variability in the scores. In general, all the alphas were well above the commonly accepted threshold level of 0.70, confirming that the results are reliable measures of clinical IT sophistication in the sample hospitals.

#### 4.1 Functional sophistication

Overall, functional clinical IT sophistication did not vary significantly between small and large hospitals. Nevertheless, some differences existed between the hospitals in the two categories as shown in Table 4. Materials (tools) management for operation, anaesthetic notes recording, historical drug information storage, refill reports making in pharmacy and label generation in radiology were supported by computer-based application in larger proportion of large hospitals than small hospitals. The fact that large hospitals were more computerised on these variables could be attributed to the fact that large hospitals tend to see more patients than small ones. For example, none of the small hospitals reported materials (tools) management in operation room to be computerised. Small hospitals see fewer and less complex cases than large hospitals and therefore tools tracking in the operating room can easily be managed manually. Similarly, anaesthetic notes recording, historical drug information storage, and making out drug refill reports in

the pharmacy and label generation for radiology are not common in small hospitals due probably to the workload available in such hospitals. Moreover, large hospitals had significantly higher total hospital budget and IT budget than the small ones (Table 3), a fact that could be enhancing computerisation in the large hospitals. However, as the trend elsewhere [17], most basic processes for patients' registration and admission have been computerised in large proportions across the sample hospitals. Particularly, processes in patient management and patient care were computerised in more than half of the sample hospitals. In all the clinical sections, processes and activities in the operating room were the least computerised.

It is noteworthy that all the sample hospitals had patient index computerised. This is a significant step in the implementation of computer-based applications in healthcare. The patient index if integrated to all other departments can form the first building block for expansion of the computer-based applications including but not limited to decision support systems.

#### 4.2 Technological sophistication

Technological sophistication was significantly higher in large hospitals than small hospitals. On further inspection, differences between the proportion of small and large hospitals (Table 6) were noted in three of the 18 variables measuring technological sophistication. A larger proportion of large hospitals were having connection to external databases, bar coding to track tools and telemedicine for results capturing compared to small hospitals. Overall, the proportions of hospitals with technologies were limited. Satisfactory technological sophistication (over 50% of the hospitals) was only observed in five variables namely, PCs or workstations at the bedside, electronic requisition for medications from clinical units, bar coding in laboratories and use of picture archiving systems (PACS) in radiology. As shown in Table 6, availability of many of the technologies in sample hospitals was

very low to almost nonexistent. Telemedicine for evaluation and triage purposes, expert systems and voice recognition systems for notes transcription were only available in less than 5% of sample hospitals. Some of the technologies that can improve patient safety (e.g. bar coding in operating room), and facilitate the care process (e.g. portable devices for data input) have not been implemented by a large number of sample hospitals. However, many of the sample hospitals have implemented technologies such as computerised physician order entry (CPOE) systems for drug requisitions, tests orders and results viewing which if incorporated with decision-making capabilities, can greatly reduce medical errors [18]. The use of CPOE should be carefully monitored and evaluated to avoid introduction of unintended medication errors [19]. The study also show that, apart from PACS system which is available in a large proportion of the sample hospitals, complex advanced technologies such as expert systems, voice recognition systems, dictation for post-operative reports and telemedicine remains low in the sample hospitals. We suspect that low adoption of these technologies could be due to large budgets required in implementing them. And since majority of the sample hospitals were mainly private hospitals (Table 2) that rarely receive grants from government, their adoption is constrained by the finances required to implement these technologies.

A majority of the sample hospitals in Japan are already having simple connectivity technologies (e.g. fax, LAN, fibre optics, wireless connections and websites) (Table 6). However, more advanced technologies such as microwave, satellite connections and infrared are almost nonexistent. We suspect that the low adoption of the more advanced connectivity technologies could be related to issues of maintaining security of data and the budget required to implement such connectivity technologies.

### 4.3 Integration sophistication

On a scale ranging from 1-7, “not at all” to “very much”, the level of integration of the clinical sections were all above 5 (Table 7) except the integration between patient care systems and external entities’ systems. This is consistent with the fact that WAN are not as common in the sample hospitals as LAN (Table 6). Healthcare in Japan is not characterised by integrated delivery networks (IDNS) such as the ones seen in the US [20] and therefore use of WAN is not common in Japan. In Japan, even in instances where some institutions have branches spread across the country (e.g. The Red Cross group of hospitals), each branch operate as an independent entity and does not share clinical data with any other branch. The high integration level found in this study was only within institutions (internal integration) rather than between institutions. This did not come as a surprise given that most of the hospitals surveyed were already using some form of computer-based applications. With the international standards (such as HL7) being adhered to by hardware and software developers, it has become much easier for systems within an institution to be integrated. Moreover, integration of systems within a single institution is much easier to implement as the number of stakeholders, especially the leader of the institution (the president of the hospital amongst others) can be easily convinced to take up integrated systems. It is much more difficult to integrate geographically dispersed institutions (external integration) with many stakeholders, each with a different opinion and view of patient data security across institutions. No wonder therefore that the overall level of external integration among the hospitals in Japan was only 3.8 (Table 7).

### 4.4 Benchmarking data

The benchmarking comparison made in this report is based on the results of the comprehensive analysis of clinical functional sophistication and technological sophistication from data collected at different points (in time)

in three countries -Japan, the US and Canada. The results are reported here in as far as they can elucidate the extent clinical IT sophistication in Japan compares to those of Canada and the US. No statistical tests were done due to the following reasons: First, in Japan we deliberately invited hospitals that were already having some form of computer-based processes and activities, unlike in the US and Canada where all hospitals regardless of their computerisation status were invited. This was likely to exaggerate the level of clinical IT sophistication in the sample hospitals in Japan. This approach was adopted purposefully to use the group that has adopted clinical information technology systems to convince other hospitals of the value of these systems. Secondly, the study in the US and Canada did not report the IT maturity level of the sample hospitals; we could not therefore determine whether the hospitals in the three countries are similar in terms of their IT maturity status. Above all, the data for the three studies were collected at different points of time, i.e. Canada (2001), the state of Iowa in the US (2002) and Japan (2006). These results may not be reflecting the current level of clinical sophistication in Canada and the state of Iowa in the US.

However, though the charts (Fig 1) reveal a similar trend between the three countries, a closer look suggests that some differences in the pattern of adoption exist between the three countries. Japan showed a rather higher level of functional clinical IT sophistication than Canada and the US. Based on the individual variables measuring functional clinical IT sophistication, 19 (59.4%) of the variables were reported by more than half of the sample hospitals in Japan compared to 17 (53.1%) in Canada and 12 (37.5%) in the US. Even though our sample was biased, contrary to our expectation, we did not see a much higher functional sophistication as compared to Canada and the US. On a hierarchical scale ranging from “1” (only departmental systems without any integration at all) to “5” (longitudinal collection of personal health information with systems integrated across healthcare facilities) [15],

most of the sample hospitals (56.0% [data not shown]) in Japan reported their IT maturity to be at level “3” (System that captures and stores significant data about clinical encounter with an institution-wide network has been implemented). The results clearly demonstrate that functional clinical IT sophistication remains limited even in hospitals that have adopted computer-based systems.

Technological sophistication appears to be higher in Japan than Canada but lower than the US. However, less than half of the variables measuring technological sophistication were reported by at least 50% of the sample hospitals in the three countries.

A detailed discussion between the survey in the state of Iowa in the US and Canada has been reported by Jaana et. al. [14].

### 4.5 Limitations

Several limitations concerning this study are worth mentioning. First, even though our sample of 42 hospitals did not differ on organisational characteristics from the original random sample of 350 hospitals, the response rate was very low (12%) that is likely to limit the extent the results could be generalised to the original 350 hospitals. Secondly, the Japanese version of the instrument used in this study was not fully validated through a rigorous measurement study [21]. However, the result of the internal consistency analysis revealed acceptable level of Cronbach’s alphas (Table 4). Finally, this study uses both primary and secondary data collected at different points in time between three countries. Therefore to what extent the conclusion can be drawn regarding the level of IT sophistication between the three countries remains limited: the hospitals could be different and the respondents could also have interpreted the concepts in the instrument differently. However, we tried to maintain the original meaning of the items through review of health informatics experts. Furthermore, the majority of our respondents were computer scientists as was the case in the Canada survey, giv-

ing us confidence that the respondents could be having the same interpretation of the concepts in the survey. Lastly, in reporting integration sophistication, mean scores were used. This is not methodologically sound in statistical sense [22]. However, this approach was adopted to be consistent with the reporting of results of the study in Canada [13] and the US [14] from which we drew our secondary data.

## 5. Conclusion

To the best of our knowledge, this is the first research reporting on the clinical IT sophistication profile in Japanese hospitals to the international medical informatics community. This study suggests that clinical IT sophistication remains limited and variable across the clinical areas. As the profile reflects, majority of the already computerised processes and activities (and the accompanying technology to support them) are relatively basic and simple to implement. Due to complex nature of healthcare, the tendency has always been to computerise order entry processes and admission procedure first [23] before implementing advanced procedure such as telemedicine for consultations, expert systems etc. And since the mean age of the program (systems) for the sample hospitals was about 3.7 years, these hospitals might still be at the initial stage of computerisation. As time goes on, we believe the hospitals are likely to expand the current systems by adding more advanced modules.

The Japanese Government policy targeting hospitals with 400 beds or more to computerise patient records by 2006 was based on the fact that large hospitals have resources and infrastructure necessary to implement computerised systems. Overall, this view was only supported on the technological dimension of clinical IT sophistication in the sample hospitals. The results suggest that even large hospitals have not been able to meet the target and may require extra incentives and motivation to implement more advanced systems.

The extent of clinical IT sophistication across countries is an important contribution and input to policy-making. We made an attempt to benchmark our results to other better-performing countries as a way of measuring outcome of policies, and monitoring progress in clinical IT diffusion. Using a standard selection of indicators, our results show that the extent of clinical IT sophistication is yet to reach 'saturation level' (the state where all patient-related activities and processes in hospital are done using computers in a paperless environment) even in hospitals that could be classified as "adopters". Though many hospitals in this study are moving towards the 'saturation level', it will take some time for hospitals to be fully paperless [24, 25]. To this end, this report has provided straightforward evidence as an essential input to policy analysis.

In summary, the results demonstrated that there exists substantial room for expanding clinical IT systems in hospitals.

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