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## **BMJ Open**

## Does Hospital Information Technology Infrastructure Promote the Implementation of Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals

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1	Does Hospital Information Technology Infrastructure Promote the Implementation of
2	Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals
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#### 1 Abstract

2	<b>Objectives:</b> It remains unclear whether insufficient information technology (IT) infrastructure
3	of hospitals hinder implementation of clinical practice guidelines (CPGs) and affects health
4	care quality. The objectives of this study were to describe the present state of IT infrastructure
5	provided in acute care hospitals across Japan and to investigate possible determinants of
6	healthcare quality.
7	Methods: A questionnaire survey of hospital administrators was conducted in 2015 to gather
8	information on hospital-level policies and elements of IT infrastructure. We calculated each
9	respondent's number of positive responses to the survey topics. Next, a composite quality
10	indicator score of hospital adherence to CPGs for perioperative antibiotic prophylaxis was
11	calculated using secondary administrative data. Based on this quality indicator score, we
12	performed a chi-squared automatic interaction detection (CHAID) analysis to identify
13	determinants of hospital healthcare quality. The independent variables included hospital size
14	and teaching status in addition to hospital policies and elements of IT infrastructure.
15	Results: Wide variations were observed in the availability of various IT infrastructure
16	elements across hospitals, especially in local area network availability and access to paid
17	evidence databases. The CHAID analysis showed that hospitals with a high level of access to
18	paid databases and Internet were strongly associated with increased care quality in larger or
19	teaching hospitals.
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1	Conclusions: Hospitals with superior IT infrastructure may provide high-quality care. This
2	allows clinicians to easily access the latest information on evidence-based medicine and
3	facilitate the dissemination of CPGs. The systematic improvement of hospital IT
4	infrastructure may promote CPG use and narrow the evidence-practice gaps.
5	Key words: Clinical practice guidelines; evidence-based practice; quality indicators;
6	healthcare quality; hospital IT infrastructure; evidence-practice gaps.
7	healthcare quality; hospital IT infrastructure; evidence-practice gaps.
	3

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1	Strengths and limitations of this study
2	• In this multicenter study, we observed wide variations in the provision of IT infrastructure
3	across acute care hospitals in Japan.
4	• Hospitals with superior IT infrastructure tended to have higher adherence to CPGs for
5	perioperative antibiotic prophylaxis.
6	• We found that high level of access to paid medical evidence databases and accessibility to
7	the Internet were the key factors of care quality in acute care hospitals using the CHAID
8	analysis.
9	• We shed light on new knowledge that establishment of hospital IT infrastructure for
10	medical information retrieval may support greater awareness and adherence to CPGs in
11	clinicians and narrow the evidence-practice gaps.
12	• The QI of the adherence to the CPGs for perioperative antibiotic use may describe only
13	one aspect of healthcare quality and the results from the survey conducted in Japan may
14	limit the generalizability.
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1. Introduction

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2	Due to the flood of renewed medical information and frequent updates to clinical practice
3	guidelines (CPGs) in the Internet era, clinicians can find it difficult to keep abreast of the
4	latest evidence. The availability and usability of the hospital information technology (IT)
5	infrastructure such as wireless local area networks (LAN) and medical evidence databases
6	may affect the ability of clinicians to update their knowledge and practice, which can
7	influence the quality of provided care. These infrastructure elements may facilitate
8	accessibility to various updated CPGs, which would be essential for CPG implementation in
9	daily practice [1].
10	CPGs for various diseases have been developed worldwide not only to help clinicians but
11	also to promote shared decision making with patients [2-4]. However, CPGs continue to be
12	underused even in developed countries despite intense efforts toward their development and
13	dissemination over the past several decades. These gaps between medical evidence and
14	clinical practice (i.e., "evidence-practice gaps") can lead to the provision of substandard or
15	potentially harmful treatments to patients [5-11]. System-level barriers as well as
16	individual-level barriers to evidence-based practice have been revealed in previous studies
17	[12-14,17]. For example, institutional equipment, technological capital, accessibility to
18	guideline-related resources are noted to be important in addition to individual awareness,
19	familiarity and agreement to the contents [15-17]. Clinical quality indicators (QIs) can
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1	monitor clinicians' adherence to the guidelines, but they are not necessarily utilized to assess
2	guideline implementation [18]. Furthermore, there are no clear evidence whether hospital IT
3	infrastructure may affect quality of provided care using these QIs.
4	On the other hand, health IT implementation studies are growing and they report positive
5	effects on quality, safety and efficiency [19-24]. However, most of these studies have focused
6	on clinical decision support systems, order entry, telecommunication systems, e-Prescriptions
7	[19,20] and strategic management systems [21]. It therefore remains unclear as to whether the
8	lack of an adequate IT infrastructure for medical information retrieval is a crucial
9	system-level barrier for CPG implementation. In Japan, over 180 evidence-based CPGs have
10	been assessed and disseminated by the Medical Information Network Distribution Service
11	(Minds) Guideline Center [22] over the last decade, but the actual use of these CPGs in daily
12	clinical practice also remains unknown.
13	This multicenter study aimed to describe the present state of IT infrastructure provided in
14	Japanese acute care hospitals and to investigate the possible determinants of healthcare quality,
15	including hospital size, hospital policies toward promoting evidence-based practice, and
16	hospital IT infrastructure.
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2. Methods

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2	2.1. Data sources
3	This study employed both primary data (based on a questionnaire survey of hospital
4	administrators) and secondary data (administrative claims data) in the analysis. Data were
5	obtained from hospitals enrolled in the Quality Indicator/Improvement Project (QIP), which is
6	an ongoing project launched in 1995 to monitor and improve clinical performance in acute
7	care hospitals across Japan through the analysis of administrative claims data [23,24].
8	Currently, over 500 QIP member hospitals voluntarily submit data for analysis, and the
9	project generates periodic reports of clinical and economic performance. The participating
10	hospitals vary widely in type (e.g., teaching status and hospital ownership), region of location,
11	patient and physician volume, bed numbers, and composition of specialties.
12	The Minds-QIP project was initiated in 2014 with the objective of effectively
13	implementing and disseminating CPGs across Japan. A survey was conducted as part of this
14	project by mailing questionnaires to the hospital administrators (including general managers)
15	of QIP member hospitals between January and March 2015. The questionnaire included items
16	on hospital policies toward evidence-based practice and hospital IT infrastructure, actual
17	provision of IT infrastructure (including LAN deployment and usability of medical evidence
18	databases), QI monitoring, and the use of clinical pathways. This study focused on hospital
19	policies and IT infrastructure. The questionnaire was developed based on a literature review,
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1	discussions with experts, and semi-structured face-to-face interviews with several hospital
2	administrators and IT managers from 5 major teaching hospitals. Survey respondents were
ć	asked to answer questions from a concise list about their institution and policies as
4	representatives of their hospital.
5	
6	2.2. Hospital policy and IT infrastructure
7	In order to identify each hospital's policies toward promoting evidence-based practice, the
8	questionnaire included items on whether the hospital has an explicit policy to enhance IT
ę	infrastructure to improve accessibility to medical information, explicitly recommends the
10	utilization of evidence-based medicine, and explicitly recommends to use CPGs.
11	The questionnaire was also designed to focus on the following 3 elements of hospital IT
12	infrastructure: (i) accessibility to the Internet and other information sources, including
13	wired/wireless LAN availability; (ii) access to paid medical evidence databases in English and
14	Japanese; and (iii) medical library and intranet usability, such as the availability of a
15	well-organized intranet interface, number of full-time medical librarians, and activities for
16	improving the medical library.
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18	2.3. Hospital quality of care
19	As a measure of hospital quality of care, a QI of adherence to CPGs for perioperative 8
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1	antibiotic prophylaxis was calculated using diagnosis procedure combination (DPC)
2	administrative claims data from the QIP. The DPC is a Japanese case-mix classification
3	system for hospital reimbursements, and more than 1600 hospitals nationwide had adopted
4	this system by 2016. The DPC database includes information on hospital codes, patient
5	demographics, admission and discharge dates, admission routes, outcomes, primary and
6	secondary diagnoses based on International Classification of Diseases (10th revision) codes,
7	comorbidities, complications, surgeries performed, and high cost procedures [23,24]. DPC
8	data from April 2013 to March 2014 were used as these were the most recent data available
9	for analysis.
10	The QI of interest for this study was a composite score (range: 0 to 100) that indicated a
11	hospital's proportion of adherence to CPGs for perioperative antibiotic prophylaxis [25], and
12	was aggregated from the results of the following 11 surgical types: evacuation of intracranial
13	hematoma, gastrectomy, cholecystectomy, total hip replacement, mastectomy for breast cancer,
14	thyroid surgery, prostate cancer surgery, uterine myoma surgery, uterine cancer surgery,
15	benign ovarian tumor surgery, and ovarian cancer surgery.
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17	2.4. Statistical analysis
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18	We first calculated descriptive statistics for the hospitals' and respondents' baseline
19	characteristics, which included hospital bed numbers, teaching status, number of full-time 9

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1	physicians, number of resident physicians (representing younger physicians who may be more
2	likely to incorporate IT into their practice), as well as respondent sex, age, and appointment.
3	The responses to the questions on the topics of hospital policies and IT infrastructure were
4	also summarized. The main items of interest in the questionnaire consisted of yes/no
5	questions, and we calculated each hospital's number of positive responses within each topic.
6	The hospitals were categorized into subgroups based on these response numbers, and the
7	mean QI score was calculated for each subgroup.
8	Finally, we performed a chi-squared automatic interaction detection (CHAID) tree
9	analysis to identify factors that determine hospital quality of care. The independent variables
10	included hospital size and teaching status, hospital policies toward promoting evidence-based
11	practice, and IT infrastructure (accessibility to the Internet and other information sources,
12	access to paid medical evidence databases, and medical library and intranet usability within
13	hospitals). The dependent variable was the mean QI score for perioperative antibiotic
14	prophylaxis. The CHAID tree analysis repeatedly uses chi-square statistics to split
15	independent variables into child nodes [26-28] to identify the relative interactions between the
16	independent variables and the outcome variables. This method is a classification tree
17	algorithm that is often utilized as a data mining method in fields with complex data sets, such
18	as marketing, health care [27], and nursing [28].
19	Statistical computations were conducted using SPSS software, version 20.0J and Decision
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#### 2.5. Patient and public involvement $\mathbf{2}$

Patients or public were not involved in the design and analysis of this study. 3

#### 3. Results 4

#### 3.1. Baseline characteristics, hospital policy, and IT infrastructure $\mathbf{5}$

6	Among the 239 hospitals that responded the questionnaire (response rate: 57.2%), we were
7	able to calculate and integrate the target QI data for 153 hospitals. Hospitals that had data on
8	at least one target QI were included. The hospital selection flow diagram is presented in
9	Figure 1. The baseline characteristics of the participant hospitals and respondents are shown
10	in Table 1. The median number of hospital beds were 303 (range:63–1161). Approximately
11	75% of all the hospitals were teaching hospitals, and there was a mean of approximately 21
12	junior and senior residents in each hospital.
13	Table 2 shows the results of the survey on hospital policies and IT infrastructure. Almost
14	all respondents reported that their hospitals had an explicit policy to enhance IT infrastructure
15	(94.1%). However, the provision of wireless LAN (71.9%) and access to paid medical
16	evidence databases in English (54.9%) was limited. Further, an intranet homepage was
17	provided only in a minority of hospitals (27.5%).
18	Figure 2 shows the information sources freely available or specifically provided by the
	11

1	participating hospitals. There were large variations in the provision of paid medical evidence
2	databases, and hospitals tended to subscribe to the Japanese-language database (77.1%) rather
3	than the English-language databases (9.8-46.4%). In general, the print editions of various
4	CPGs and medical information were provided more frequently than the electronic editions,
5	and there were relatively few hospitals that provided CPGs in either edition (41.2% in the
6	print edition and 15.0% in the electronic edition).
7	
8	3.2. Determinants of hospital quality of care
9	Table 3 shows the mean QI scores for the use of perioperative antibiotics according to the
10	various independent variables. Hospitals with a lower number of positive responses to topics
1	about hospital policies and IT infrastructure tended to have a lower QI score. Using the
12	CHAID analysis, we identified 3 major determinants of the QI score (Fig. 3). Hospital size
13	and teaching status was the strongest determinant of the QI score. The subgroup of "≤500-bed
4	non-teaching hospitals" had the lowest QI score (73.1 points, Node 2), and the other subgroup
15	(comprising larger or teaching hospitals) was further separated into 2 groups based on the
16	provision of access to paid medical evidence databases. The derived subgroup of "Japanese
17	and/or English databases" was again separated into 2 groups according to (i) accessibility to
18	the Internet, (ii) wireless LAN availability, and (iii) wired LAN availability at outpatient
19	clinics/wards; hospitals in the subgroup that provided the highest positive responses to these 3 12

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topics had the highest QI score (87.2 points, Node 6) among all nodes. In contrast, the subgroup that provided positive responses to 2 or fewer of these topics had a lower QI score  $\mathbf{2}$ (83.1 points, Node 5). The subgroup of hospitals with no IT infrastructure elements had the lowest QI score (75.1 points, Node 4) among the larger or teaching hospitals. These results indicated that the provision of access to paid medical evidence databases and accessibility to  $\mathbf{5}$ the Internet (including LAN availability) were strongly associated with hospital quality of  $\overline{7}$ care. 4. Discussion In this multicenter study, we observed wide variations in the provision of IT infrastructure across hospitals in Japan. Our results indicated that hospitals with superior IT infrastructure tended to have higher adherence to CPGs for perioperative antibiotic prophylaxis. Using a CHAID tree analysis, we found that the provision of access to paid medical evidence databases and accessibility to the Internet (including LAN availability) were strong indicators of quality of care in larger or teaching hospitals Despite the wide availability of new medical evidence, clinicians are not always able to acquire and apply the most recent and relevant information at the right moment in their daily practice. The lack of adequate IT infrastructure may affect the ability of clinicians to access this information, thereby contributing to evidence-practice gaps. There are more than For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

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1	8,000 hospitals in Japan, of which 80% (and almost all clinics) are privately owned [29].
2	Different leadership approaches among these hospitals may have resulted in considerable
3	variations in IT infrastructure. Our analysis found that there was an overall inadequate
4	provision of LAN, and accessibility to the Internet and electronic health records was limited
5	among the hospitals. In addition, the print editions of various CPGs and medical information
6	were provided more frequently than electronic editions. Previous studies on the activities to
7	improve accessibility to medical information within specific hospital networks [30,31] have
8	indicated the importance of hospital leadership in the development of IT infrastructure.
9	Our CHAID analysis found that the 3 most important determinants of hospital quality
10	of care were hospital size and teaching status, access to paid medical evidence databases, and
11	high accessibility to the Internet. Notably, hospital policies and library/intranet usability were
12	not identified as major determinants of healthcare quality. The identification of these 3 factors
13	may be explained by the following reasons. Firstly, from an economic perspective, teaching
14	hospitals are tended to be large and more likely to have the economic capability to provide
15	resources such as IT infrastructure and full-time librarians engaged to work on intranet
16	development. The results in Table 2 indicate that more than half of the participating hospitals
17	do not hire full-time medical librarians. Interviews with the administrators of several leading
18	teaching hospitals prior to the survey revealed that some administrators were actively working
19	to enhance their hospital's intranet environment. This included the hiring of full-time
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1	librarians to create user-friendly intranet homepages designed to guide clinicians to the most
2	recent and relevant clinical information. Our results are consistent with those of previous
3	reports that improvements in medical library functionality can improve patient health
4	outcomes while reducing the time needed for clinicians to search for required information
5	[32,33].
6	Secondly, we found that hospital administrators tended to provide access to free
7	medical databases first, followed by the paid Japanese database, and finally the paid databases
8	in English (Fig. 2). Besides the high cost of subscribing to English-language databases, the
9	administrators may have prioritized the Japanese database due to the possible language barrier
10	for Japanese clinicians; this phenomenon has also been observed in Taiwan [34]. However,
11	the failure to provide medical databases in English raises concerns that the clinicians may be
12	unable to retrieve the newest relevant information in a timely manner, which can directly
13	impact daily clinical practice. In addition, the availability of information in English may be
14	crucial to the efficient dissemination and effective implementation of CPGs.
15	Thirdly, the importance of Internet accessibility (including LAN availability) to
16	healthcare quality has been similarly observed in previous studies [1,21,30]. Our study sample
17	comprised a fairly high proportion of hospitals without wireless LAN (28.1%) or with limited
18	wired LAN availability at outpatient clinics and wards (64.1%). In order to encourage the
19	implementation of IT infrastructure that facilitates easy retrieval of evidence in all types of
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1	hospitals, it may be necessary to develop a standardized assessment tool for hospital IT
2	infrastructure and to include such assessments as a component of hospital accreditation.
3	In daily clinical practice, clinicians have limited time to search for and retrieve
4	medical information. Thus, an ideal search platform would allow the use of clinical questions
5	with several keywords and provide the requested information promptly and accurately. In
6	addition to improving the accessibility and usability of online information, it may be useful to
7	actively provide paid medical evidence databases (especially English-language databases) at
8	the hospital level to supply multiple layers of information ranging from abstracts to full-text
9	articles, as well as recommendations for CPGs and their evidence sources. In order to
10	maximize the use of this system, individual physicians should work to improve not only their
11	English language skills, but also their information searching skills and ability to implement
12	new knowledge into practice.
13	Our findings suggest that larger or teaching hospitals would have the most potential for
14	improvements in IT infrastructure that can lead to better quality of care (see Nodes 4, 5, and 6
15	in Fig. 3). As Doebbeling et al. noted, IT implementation is dependent on the support of
16	hospital management and "should be tailored to the needs of the organization, and not as a
17	'one size fits all' solution" [35]. It is also necessary to conduct balanced assessments of the
18	costs and effectiveness of these IT infrastructures in order to efficiently support the
19	implementation of evidence into practice under limited budgets.
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2	There are several limitations in this study. First, respondents were hospital administrators,
3	and the results may not indicate the usability of various IT infrastructure elements from the
4	physicians' perspective. Because individual physicians are the primary target users and are
5	likely to be the link between IT infrastructure and quality of care, further studies are required
6	to clarify the quality improvement mechanism in greater detail. Second, this survey was
7	performed in Japan, which may limit the generalizability of our results to other countries.
8	Third, the QI that we used was limited to adherence to the CPGs for perioperative antibiotic
9	use, and therefore describes only one aspect of healthcare quality. Finally, we were not able to
10	identify the amount of investment or affordability of each hospital's IT infrastructure, and
11	further studies are needed to examine the total effect of these issues on the quality of hospital
12	care.
13	
14	5. Conclusions
15	Hospitals with superior IT infrastructure may provide high-quality care. The provision of
16	access to paid medical evidence databases and accessibility to the Internet were strongly
17	associated with hospital quality of care, and may be key factors for improving healthcare

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18 quality in larger or teaching hospitals. These infrastructure elements may allow healthcare

19 professionals to retrieve the latest information on evidence-based medicine with greater ease

1	and facilitate the dissemination of CPGs in the Internet era. Hospitals should focus on
2	establishing adequate IT infrastructure to support the effective implementation of CPGs. The
3	systematic improvement of IT infrastructure in hospitals may support greater adherence to
4	CPGs and narrow the evidence-practice gaps.
5	Acknowledgements
6	We are grateful to all hospital administrators in the QIP hospitals who participated in this
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8	teaching hospitals for their time and assistance. Finally, we thank all staff at the Department
9	of EBM and Guidelines, Japan Council for Quality Health Care who were involved in the
10	Minds-QIP project.
11	Contributors
12	NS and YI had full access to all the data in the study and take responsibility for the analysis
13	and interpretation. Conception and design:NS,YI; Acquisition of data and analysis:NS, YI;
14	Interpretation of data:NS, NY,AO,MY, HS,YI; Drafting of the manuscript and statistical
15	analysis:NS,YI; Obtaining funding:NY,YI. All the authors (NS, NY,AO, MY, HS, and YI)
16	were involved in critical revisions and approved the final manuscript for publication.
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4	1	Competing interests
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6	2	The authors declare that they have no competing interests.
7	-	The autions declare that they have no competing interests.
8 9		
9 10	3	Ethics approval
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12	4	This study was approved by both the Ethics Committee of Kyoto University Graduate School
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15	5	and Faculty of Medicine, Japan (R0979, R0135) and that of Japan Council for Quality Health
16 17		
17	6	Care (Rin26-4).
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21	7	Provenance and peer review
22		
23	8	Not commissioned; externally peer reviewed.
24 25		
26	0	
27	9	Data sharing statement
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	10	No additional data are available.
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#### **Figure legends** 1

- Figure 1. Flow diagram of the subject hospital selection process.  $\mathbf{2}$
- Figure 2. Information sources freely available or specifically provided by the participating 3
- hospitals (153 hospitals). 4
- Figure 3. Chi-squared automatic interaction detection tree diagram showing the determinants  $\mathbf{5}$

#### of the QI score. 6

- \* These values indicate the numbers of positive responses to topics regarding (i) Electronic  $\overline{7}$
- health records and Internet availability, (ii) wireless LAN availability, and (iii) wired LAN 8
- atar availability at outpatient clinics/wards. DB, database; LAN, local area network; QI, quality 9
- indicator; SD, standard deviation. 10

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Hospital characteristics Beds, mean±SD (range); median Teaching hospitals, n(%)	Beds, mean $\pm$ SD (range); median 339 $\pm$ 182 (63-1161)	
Full-time physicians, mean±SD (range)	61.9±43.3 (8-26	58)
Resident physicians, mean±SD (range)	21.2±29.2 (0-1	
Respondent characteristics		(%)
Sex		
Male	125	(81.7)
Female		(12.4)
No response	9	(5.9)
Age	-	
20–29 years		(3.3)
30–39 years		(13.7)
40–49 years		(18.3)
50–59 years 60–69 years		(32.7) (25.5)
No response	39 10	· · · ·
Appointment	10	(0.5)
Hospital administrator (physician)	69	(45.1)
Chief general manager (non-physician)		(24.8)
Others	34	
No response	12	
	entatives of their ho	ospital.
		ospital.

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Table 2. Hospital policies and IT infrastructure (153 hospitals)

Questionnaire topics	n	(%)
Hospital policies		
Explicit policy to enhance IT infrastructure to improve accessibility to	144	(94.1
medical information (YES)		
Explicit recommendation for the utilization of evidence-based medicine	88	(57.5
(YES)		
Explicit recommendation for adherence to clinical practice guidelines	84	(54.9
(YES)		
Accessibility to the Internet and other information sources		
Electronic health records and Internet access		
Access to both electronic health records and the Internet	110	(71.9
Others	43	(28.1
Wireless LAN		
Available with no limitations/with limited access points	110	(71.9
Not available	43	(28.1
Major locations with wired LAN access (Multiple answers allowed)		
Outpatient clinics/wards	98	(64.1
Other locations (including medical offices and library)	144	(94.1
Access to paid medical evidence databases (Multiple answers allowed)		
Igaku Chuo Zasshi (ICHUSHI) Database <in japanese=""></in>	118	(77.1
Medical databases such as UpToDate <sup>®</sup> , Clinical Key <sup>®</sup> , Ovid <sup>®</sup> , and	84	(54.9
DynaMed <sup>®</sup>		
Medical library and intranet usability within the hospital		
Provision of an intranet homepage with user-friendly interface	42	(27.5
Number of full-time medical librarians		
≥1	66	(43.1
0	87	(56.9
Medical library activities (Multiple answers allowed)		
Periodic meetings held to improve the information retrieval	84	(54.9
environment		
Continuously working to improve library services and usability	60	(39.2
Participation in hospital librarian associations and communication	25	(16.3
with other hospital librarians		
Others	23	(15.0
formation technology, LAN, local area network.		

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Table 3. QI scores of hospital groups according to the number of positive responses to topics of	on
hospital policies, IT infrastructure, and hospital size (153 hospitals)	

Number of topics with positive responses	Mean QI score	n
Hospital policies <sup>a</sup>	Wiedli QI Score	11
	78.73	4
0	81.92	4 51
2	84.95	29
3	78.92	69
IT infrastructure	10.72	0)
Accessibility to the Internet and other information sources <sup>b</sup>		
0	78.59	5
1	82.20	32
2	78.70	62
3	83.32	54
Access to paid medical evidence databases <sup>c</sup>	05.52	51
0	72.55	25
	79.76	54
2	84.88	74
Medical library and intranet usability within the hospital <sup>d</sup>		
0	81.70	21
1	78.45	45
2	80.25	39
3	84.40	26
4–6	83.27	22
Hospital size and teaching status		
>500-bed non-teaching	87.64	4
>500-bed teaching	83.28	21
≤500-bed teaching	83.16	94
≤500-bed non-teaching	73.10	34

Questionnaire topics are as follows:

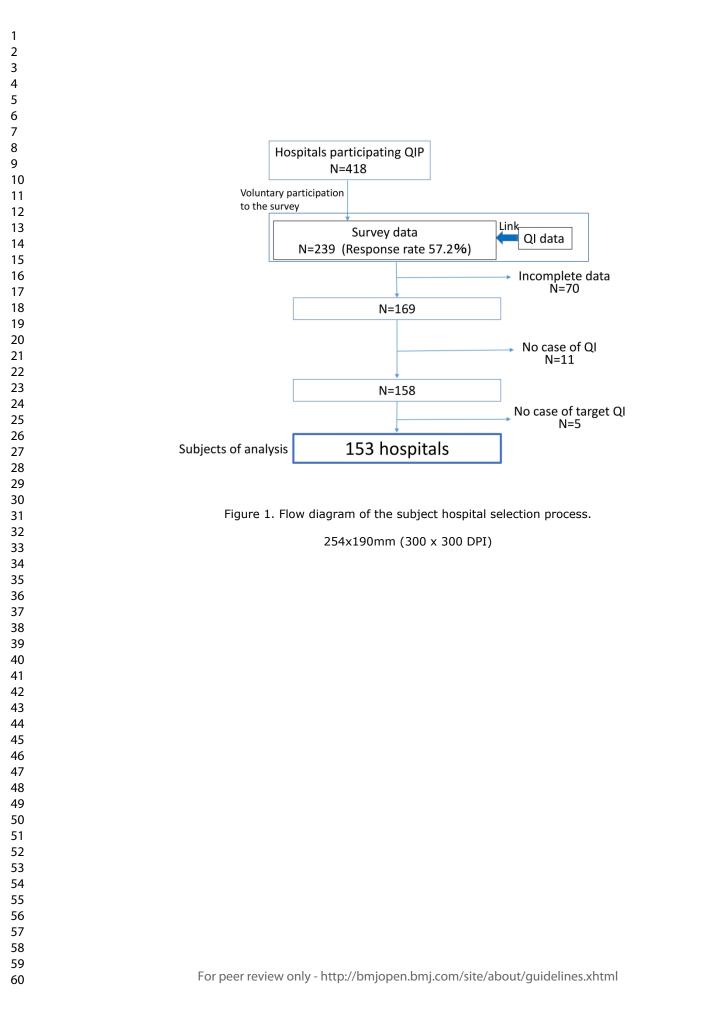
<sup>a</sup> Three topics: having explicit policy to enhance IT infrastructure, explicit recommendation for the utilization of evidence-based medicine, and explicit recommendation to use clinical practice guidelines.

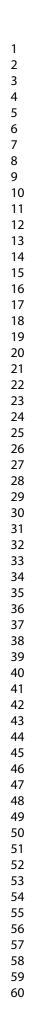
<sup>b</sup>Three topics: Electronic health records and Internet availability, wireless LAN availability, wired LAN availability at outpatient clinics/wards.

<sup>c</sup> Two topics: provision of access to the Japanese medical database and access to English-language medical databases.

<sup>d</sup> Six topics: provision of access to an intranet homepage, one or more full-time medical librarians, periodic meetings for library improvement, continuously working to improve library services and usability, communication with other hospital librarians, and others.

IT, information technology; LAN, local area network; QI, quality indicator.





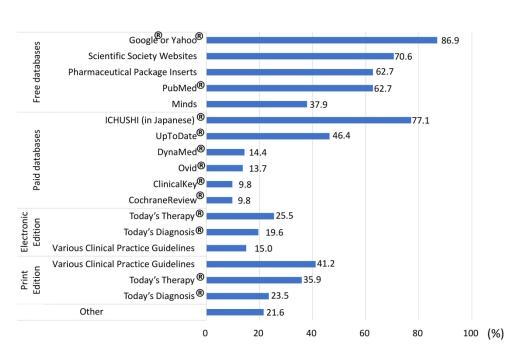
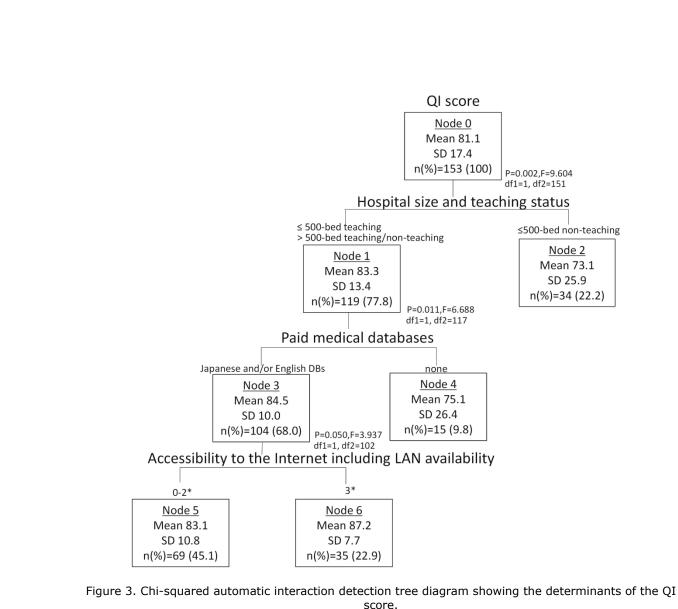


Figure 2. Information sources freely available or specifically provided by the participating hospitals (153 hospitals).

245x158mm (300 x 300 DPI)



\* These values indicate the numbers of positive responses to topics regarding (i) Electronic health records and Internet availability, (ii) wireless LAN availability, and (iii) wired LAN availability at outpatient clinics/wards. DB, database; LAN, local area network; QI, quality indicator; SD, standard deviation.

196x188mm (300 x 300 DPI)

#### STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cross-sectional studies

Section/Topic	ltem #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2, 5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	2,6
Methods			
Study design	4	Present key elements of study design early in the paper	2,7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2,7-10
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-10
Bias	9	Describe any efforts to address potential sources of bias	17
Study size	10	Explain how the study size was arrived at	7-11
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-10、Table3
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	9-11
		(b) Describe any methods used to examine subgroups and interactions	9-11
		(c) Explain how missing data were addressed	Fig1.
		(d) If applicable, describe analytical methods taking account of sampling strategy	*
		(e) Describe any sensitivity analyses	*
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility,	11, Fig1.
		confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	*
		(c) Consider use of a flow diagram	11, Fig1.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11, Table 1.
		(b) Indicate number of participants with missing data for each variable of interest	Fig1.
Outcome data	15*	Report numbers of outcome events or summary measures	Table 3. Figure 2.
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence	11-13, Table 2.
		interval). Make clear which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	11-13, Table 3
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	*
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-13, Table 3 Figure
			3.
Discussion			
Key results	18	Summarise key results with reference to study objectives	2-4,13,17-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	4, 17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	4,13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	4,17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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## Does Hospital Information Technology Infrastructure Promote the Implementation of Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals

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6 7 8	2	Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals
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2	<b>Objectives:</b> It remains unclear whether insufficient information technology (IT) infrastructure
3	in hospitals hinders implementation of clinical practice guidelines (CPGs) and affects health
4	care quality. The objectives of this study were to describe the present state of IT infrastructure
5	provided in acute care hospitals across Japan and to investigate its association with healthcare
6	quality.
7	Methods: A questionnaire survey of hospital administrators was conducted in 2015 to gather
8	information on hospital-level policies and elements of IT infrastructure. The number of
9	positive responses by each respondent to the survey items was tallied. Next, a composite
10	quality indicator score of hospital adherence to CPGs for perioperative antibiotic prophylaxis
11	was calculated using secondary administrative data. Based on this quality indicator score, we
12	performed a chi-squared automatic interaction detection (CHAID) analysis to identify
13	correlates of hospital healthcare quality. The independent variables included hospital size and
14	teaching status in addition to hospital policies and elements of IT infrastructure.
15	Results: Wide variations were observed in the availability of various IT infrastructure
16	elements across hospitals, especially in local area network availability and access to paid
17	evidence databases. The CHAID analysis showed that hospitals with a high level of access to
18	paid databases (p<0.05) and Internet (p<0.05) were strongly associated with increased care
19	quality in larger or teaching hospitals.

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Conclusions: Hospitals with superior IT infrastructure may provide higher-quality care. This  $\mathbf{2}$ allows clinicians to easily access the latest information on evidence-based medicine and facilitate the dissemination of CPGs. The systematic improvement of hospital IT infrastructure may promote CPG use and narrow the evidence-practice gaps. Key words: Clinical practice guidelines; evidence-based practice; quality indicators;  $\mathbf{5}$ healthcare quality; hospital IT infrastructure; evidence-practice gaps. 

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1	Strengths and limitations of this study
2	• In this multicenter study, we observed wide variations in the provision of IT
3	infrastructure across acute care hospitals in Japan.
4	• Hospitals with superior IT infrastructure tended to have higher adherence to CPGs for
5	perioperative antibiotic prophylaxis.
6	• We found that a high level of access to paid medical evidence databases and accessibility
7	to the Internet were the key factors of care quality in acute care hospitals using the
8	CHAID analysis.
9	• We shed light on new knowledge that establishing a hospital IT infrastructure for medical
10	information retrieval may promote greater awareness and adherence to CPGs by
11	clinicians and narrow evidence-practice gaps.
12	• The QI of adherence to CPGs for perioperative antibiotic use describe only one aspect of
13	healthcare quality; that the survey was conducted only in Japan and may limit
14	generalizability.

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2	Due to the growth of renewed medical information and frequent updates to clinical practice
3	guidelines (CPGs) in the Internet era, clinicians can find it difficult to keep abreast of the
4	latest evidence. The availability and usability of hospital information technology (IT)
5	infrastructure such as wireless local area networks (LAN) and medical evidence databases
6	may affect the ability of clinicians to update their knowledge and practice, which can
7	influence the quality of provided care. These infrastructure elements may facilitate
8	accessibility to various updated CPGs, which would be essential for CPG implementation in
9	daily practice [1].
10	CPGs for various diseases have been developed worldwide not only to help clinicians but
11	also to promote shared decision making with patients [2-4]. However, CPGs continue to be
12	underused even in countries even where CPGs are well developed over the past several
13	decades. These gaps between medical evidence and clinical practice (i.e., "evidence-practice
14	gaps") can lead to the provision of substandard or potentially harmful care to patients [5-11].
15	System-level barriers as well as individual-level barriers to evidence-based practice have been
16	revealed in previous studies [12-17]. For example, institutional equipment, technological
17	capital, and accessibility to guideline-related resources have been found to be important in
18	addition to individual awareness, familiarity and agreement with the contents [15-17].
19	Clinical quality indicators (QIs) can monitor clinicians' adherence to the guidelines, but they

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1	are not necessarily utilized to assess guideline implementation [18]. Furthermore, there is no
2	clear evidence regarding whether hospital IT infrastructure may affect the quality of provided
3	care using these QIs.
4	On the other hand, research related to the adoption of health information technology at the
5	organizational level is growing, and a number of studies have reported positive effects on
6	quality, safety and efficiency [19-21]. However, most of these studies have focused on
7	clinical decision support systems, order entry, telecommunication systems, e-Prescriptions
8	[19,20] and strategic management systems [21]. It thus remains unclear as to whether the lack
9	of an adequate IT infrastructure for medical information retrieval is a crucial system-level
10	barrier for CPG implementation. In Japan, over 180 evidence-based CPGs have been assessed
11	and disseminated by the government-funded Medical Information Network Distribution
12	Service (Minds) Guideline Center [22] over the last decade, but the actual use of these CPGs
13	in daily clinical practice remains unknown.
14	This multicenter study aimed to describe the present state of IT infrastructure provided in
15	Japanese acute care hospitals and to investigate its association with healthcare quality, taking
16	into account hospital size, hospital policies promoting evidence-based practice.
17	

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	1	2. Methods
	2	2.1. Data sources
) 1	3	This study employed both primary data (based on a questionnaire survey of hospital
2 3 4	4	administrators) and secondary data (administrative claims data) in the analysis. Data were
5 5 7	5	obtained from hospitals enrolled in the Quality Indicator/Improvement Project (QIP), which is
3 9 0	6	an ongoing project launched in 1995 to monitor and improve clinical performance in acute
1 <u>2</u> 3 4	7	care hospitals across Japan through the analysis of administrative claims data [23,24].
4 5 5	8	Currently, over 500 QIP member hospitals voluntarily submit data for analysis, and the
/ 3 9	9	project generates periodic reports of clinical and economic performance. The participating
) 1 2	10	hospitals vary widely in type (e.g., teaching status and hospital ownership), region of location,
3 4 5	11	patient and physician volume, bed numbers, and composition of specialties.
5 7 3	12	The Minds-QIP project, as a part of the activities of the Minds Guideline Center, was
€ ) 1	13	initiated in 2014, with the objective of effectively implementing and disseminating CPGs
2 3 4	14	across Japan. A survey was conducted as part of this project by mailing questionnaires to the
5 5 7	15	hospital administrators (including general managers) of QIP member hospitals between
3 9 0	16	January and March 2015. The questionnaire included items on hospital policies regarding
1 <u>2</u> 3	17	evidence-based practice and hospital IT infrastructure, actual provision of IT infrastructure
4 5 5	18	(including LAN deployment and usability of medical evidence databases), QI monitoring, and
7 3 9	19	the use of clinical pathways. This study focused on hospital policies and IT infrastructure. The

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questionnaire was developed based on literature reviews, discussions with experts, and
semi-structured face-to-face interviews with several hospital administrators and IT managers
from five major teaching hospitals. Survey respondents were asked to answer questions from
a concise list about their institution and policies as representatives of their hospital (Appendix
Table).

7 2.2. Hospital policy and IT infrastructure

In order to identify each hospital's policies promoting evidence-based practice, the questionnaire included items on whether the hospital has an explicit policy to enhance IT infrastructure in order to improve accessibility to medical information, whether it explicitly recommends the practice of evidence-based medicine, and whether it explicitly encourages the use of CPGs. The questionnaire was also designed to focus on the following three elements of hospital IT infrastructure: (i) accessibility to the Internet and other information sources, including wired/wireless LAN availability; (ii) access to paid medical evidence databases in English and Japanese; and (iii) medical library and intranet usability, such as the availability of a well-organized intranet interface, number of full-time medical librarians, and activities for improving the medical library.

1	2.3. Hospital quality of care
2	As a measure of hospital quality of care, a QI of adherence to CPGs for perioperative
3	antibiotic prophylaxis was calculated using diagnosis procedure combination (DPC)
4	administrative claims data from the QIP. The DPC is a Japanese case-mix classification
5	system for hospital reimbursements, and more than 1600 hospitals nationwide had adopted
6	this system by 2016. The DPC database includes information on hospital codes, patient
7	demographics, admission and discharge dates, admission routes, outcomes, primary and
8	secondary diagnoses based on International Classification of Diseases (10th revision) codes,
9	comorbidities, complications, surgeries performed, and high cost procedures [23,24]. DPC
10	data from April 2013 to March 2014 were used as these were the most recent data available
11	for analysis.
12	The QI of interest for this study was a composite score (range: 0 to 100) that indicated a
13	hospital's proportion of adherence to CPGs for perioperative antibiotic prophylaxis [25], and
14	was aggregated from the results of the following 11 surgical types (i.e., target QI in Fig.1) :
15	evacuation of intracranial hematoma, gastrectomy, cholecystectomy, total hip replacement,
16	mastectomy for breast cancer, thyroid surgery, prostate cancer surgery, uterine myoma
17	surgery, uterine cancer surgery, benign ovarian tumor surgery, and ovarian cancer surgery.
18	

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# 2.4. Statistical analysis

2	We first calculated descriptive statistics for the hospitals' and respondents' baseline
3	characteristics, which included hospital bed numbers, teaching status, number of full-time
4	physicians, number of resident physicians (representing younger physicians who may be more
5	likely to incorporate IT into their practice), as well as respondent sex, age, and appointment.
6	The responses to the questionnaire items related to hospital policies and IT infrastructure were
7	also summarized. The main items of interest consisted of yes/no questions; we calculated each
8	hospital's number of positive responses within each item. The hospitals were categorized into
9	subgroups based on these response numbers, and the mean QI score was calculated for each
10	subgroup.
11	Finally, we performed a chi-squared automatic interaction detection (CHAID) tree
12	analysis to identify factors that determine hospital quality of care. The independent variables
13	included hospital size and teaching status, hospital policies regarding the promotion of
14	evidence-based practice, and IT infrastructure (accessibility to the Internet and other
15	information sources, access to paid medical evidence databases, and medical library and
16	intranet usability within hospitals). The dependent variable was the mean QI score for
17	perioperative antibiotic prophylaxis. CHAID tree analysis repeatedly uses chi-square statistics
18	to split independent variables into child nodes [26-28] to identify the relative interactions
19	between the independent variables and the outcome variables. This method is a classification
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tree algorithm that is often utilized as a data mining method in fields with complex data sets,  $\mathbf{2}$ such as marketing, health care [27], and nursing [28]. We used the exhaustive CHAID algorithm, a modified version of the basic algorithm that performs a more thorough merging and testing of independent variables [29]. Statistical calculations were performed using SPSS 20.0J software and Decision Tree (SPSS Inc, Chicago, IL).  $\mathbf{5}$ 2.5. Patient and public involvement There was no patients or public involvement in the design and analysis of this study. 3. Results 3.1. Baseline characteristics, hospital policy, and IT infrastructure From the 239 hospitals that responded to the questionnaire (response rate: 57.2%), we were able to calculate and integrate the target QI data for 153 hospitals. Hospitals with data on at least one target QI were included. The hospital selection flow diagram is presented in Figure 1. The baseline characteristics of the participant hospitals and respondents are shown in Table 1. The median number of hospital beds was 303 (range: 63–1161). Approximately 75% of all the hospitals were teaching hospitals; the mean number of junior and senior residents in each hospital was approximately 21. Table 2 shows the results of the survey on hospital policies and IT infrastructure. Almost 

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all respondents reported that their hospitals had an explicit policy to enhance IT infrastructure (94.1%). However, the provision of wireless LAN (71.9%) and access to paid medical  $\mathbf{2}$ evidence databases in English (54.9%) was limited. Further, an intranet homepage was provided only in a minority of hospitals (27.5%). Figure 2 shows the information sources freely available or specifically provided by the  $\mathbf{5}$ participating hospitals. There were large variations in the provision of paid medical evidence databases, and hospitals tended to subscribe to the Japanese-language database (77.1%) rather than the English-language databases (9.8-46.4%). In general, the print editions of various CPGs and medical information were provided more frequently than the electronic editions, and there were relatively few hospitals that provided CPGs in either edition (41.2% in the print edition and 15.0% in the electronic edition). 

## 13 3.2. Correlates of hospital quality of care

Table 3 shows the mean QI scores for the use of perioperative antibiotics according to the various independent variables. Hospitals with a lower number of positive responses to items related to hospital policies and IT infrastructure tended to have a lower QI score. Using CHAID analysis, we identified three major correlates of QI score (Fig. 3; hospital size and teaching status were the strongest correlates. The subgroup of "≤500-bed non-teaching hospitals" had the lowest QI score (73.1 points, Node 2). The other subgroup (comprising

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1	larger or teaching hospitals) was divided into two groups based on the provision of access to
2	paid medical evidence databases. The derived subgroup of "Japanese and/or English
3	databases" was further divided into two groups according to (i) accessibility to the Internet,
4	(ii) wireless LAN availability, and (iii) wired LAN availability at outpatient clinics/wards;
5	hospitals in the subgroup that had the highest number of positive responses to these three
6	items had the highest QI score (87.2 points, Node 6) among all nodes. In contrast, the
7	subgroup that had positive responses to two or fewer of these items had a lower QI score
8	(83.1 points, Node 5). The subgroup of hospitals with no IT infrastructure elements had the
9	lowest QI score (75.1 points, Node 4) among the larger or teaching hospitals. These results
10	indicated that the provision of access to paid medical evidence databases and accessibility to
11	the Internet (including LAN availability) were strongly associated with hospital quality of
12	care.
13	
	4 Discussion
14	4. Discussion
15	In this multicenter study, we observed wide variations in the provision of IT infrastructure
16	across hospitals in Japan. Our results indicated that hospitals with superior IT infrastructure
17	tended to have higher adherence to CPGs for perioperative antibiotic prophylaxis. Using a
18	CHAID tree analysis, we found that the provision of access to paid medical evidence

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19 databases and accessibility to the Internet (including LAN availability) were strong indicators

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1	of quality of care in larger or teaching hospitals
2	Despite the wide availability of new medical evidence, clinicians are not always able
3	to acquire and apply the most recent and relevant information at the right moment in their
4	daily practice. The lack of adequate IT infrastructure may affect the ability of clinicians to
5	access this information, thereby contributing to evidence-practice gaps. There are more than
6	8,000 hospitals in Japan, of which 80% (and almost all clinics) are privately owned [30].
7	Different leadership approaches among these hospitals may have resulted in considerable
8	variations in IT infrastructure. Our analysis found that there was an overall inadequate
9	provision of LAN, and accessibility to the Internet and electronic health records was limited
10	among the hospitals. In addition, the print editions of various CPGs and medical information
11	were provided more frequently than electronic editions. Previous studies on the activities to
12	improve accessibility to medical information within specific hospital networks [31,32] have
13	indicated the importance of hospital leadership in the development of IT infrastructure.
14	Our CHAID analysis found that the three most important correlates of hospital
15	quality of care were hospital size and teaching status, access to paid medical evidence
16	databases, and high accessibility to the Internet. Notably, hospital policies and library/intranet
17	usability were not identified as major correlates. There are likely several reasons for the
18	identification of hospital size and teaching status, access to paid medical evidence databases,
19	and high accessibility to the Internet as the most important factors. Firstly, from an economic

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1	perspective, teaching hospitals tend to be large and more likely to have the economic
2	capability to provide resources such as IT infrastructure and full-time librarians engaged to
3	work on intranet development. The results in Table 2 indicate that more than half of the
4	participating hospitals do not hire full-time medical librarians. Interviews with the
5	administrators of several leading teaching hospitals prior to the survey revealed that some
6	administrators were actively working to enhance their hospital's intranet environment. This
7	included the hiring of full-time librarians to create user-friendly intranet homepages designed
8	to guide clinicians to the most recent and relevant clinical information. Our results are
9	consistent with those of previous reports that show improvements in medical library
10	functionality can improve patient health outcomes while reducing the time needed for
11	clinicians to search for required information [33,34].
12	Secondly, we found that hospital administrators tended to provide access to free
13	medical databases first, followed by the paid Japanese database, and finally the paid databases
14	in English (Fig. 2). Besides the high cost of subscribing to English-language databases, the
15	administrators may have prioritized the Japanese database due to the possible language barrier
16	for Japanese clinicians; this phenomenon has also been observed in Taiwan [35]. However,
17	the failure to provide medical databases in English raises concerns that the clinicians may be
18	unable to retrieve the newest relevant information in a timely manner, which can directly
19	impact daily clinical practice. In addition, the availability of information in English may be
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1	crucial to the efficient dissemination and effective implementation of CPGs.
2	Thirdly, the importance of Internet accessibility (including LAN availability) to
3	healthcare quality has been similarly observed in previous studies from the US and UK
4	[1,21,31]. Our study sample included a fairly high proportion of hospitals without wireless
5	LAN (28.1%) or with limited wired LAN availability at outpatient clinics and wards (64.1%).
6	In order to encourage the implementation of IT infrastructure that facilitates easy retrieval of
7	evidence in all types of hospitals, it may be necessary to develop a standardized assessment
8	tool for hospital IT infrastructure and to include such assessments as a component of hospital
9	accreditation.
10	In daily clinical practice, clinicians have limited time to search for and retrieve
11	medical information. Thus, an ideal search platform would allow the use of clinical questions
12	with several keywords and provide the requested information promptly and accurately. In
13	addition to improving the accessibility and usability of online information, it may be useful to
14	actively provide paid medical evidence databases (especially English-language databases) at
15	the hospital level to supply multiple layers of information ranging from abstracts to full-text
16	articles, as well as recommendations for CPGs and their evidence sources. In order to
17	maximize the use of this system, individual physicians should work to improve not only their
18	English language skills, but also their information searching skills and ability to implement
19	new knowledge into practice.

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1	Our findings suggest that larger or teaching hospitals would have the most potential for
2	improvements in IT infrastructure that can lead to better quality of care (see Nodes 4, 5, and 6
3	in Fig. 3). As Doebbeling et al. noted, IT implementation is dependent on the support of
4	hospital management and "should be tailored to the needs of the organization, and not as a
5	'one size fits all' solution" [36]. It is also necessary to conduct balanced assessments of the
6	costs and effectiveness of these IT infrastructures in order to efficiently support the
7	implementation of evidence into practice under limited budgets.
8	In a broader context, barriers to implementing CPG recommendations in daily practice
9	vary greatly at the individual level of specialists and physicians (e.g.perception, education,
10	incentives, professional autonomy), the institutional level (e.g., physician leadership, hospital
11	policies, finance, institutional culture, teamwork, IT infrastructure), national level (e.g.,
12	policies to promote CPG use, hospital accreditation) and the societal level (e.g.a culture of
13	shared-decision making with patients, information derived from mass media) [37,38,39]. Yet,
14	given the growing importance of IT use in an innovative society, the impact of IT adoption on
15	healthcare quality warrants far more consideration of the types of relationships that were
16	revealed in this study. According to previous research, IT itself needs to be understood as
17	having two distinct components-information technology and communication
18	technology-and these differently affect the autonomy of workers [40]. Further examination
19	is needed to clarify these issues in order to implement IT in practice settings.
	17

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1	There are several limitations to this study. First, the respondents were hospital
2	administrators, which means the results may not indicate the usability of various IT
3	infrastructure elements from a physician's perspective. In addition, as this was a self-reported
4	survey, the possible presence of social desirability bias may have caused these respondents to
5	underestimate the barriers being investigated. Because individual physicians are the primary
6	target users and are likely to be the link between IT infrastructure and quality of care, studies
7	focusing physicians are required in the future to clarify the quality improvement mechanism
8	in detail. Second, the survey was conducted in Japan, which may limit the generalizability of
9	our results to other countries. Third, the QI that we used was limited to adherence to the CPGs
10	for perioperative antibiotic use and therefore describes only one aspect of healthcare quality.
11	Fourth, as we used administrative claims data, we could not know the clinical information in
12	detail including appropriate exceptions in clinical practice. However, in this study, we
13	focused on perioperative antibiotic prophylaxis of the 11 surgeries, which we could identify
14	accurately based on the information of surgical procedure and drug use from the database.
15	Finally, we were not able to identify the amount of investment or the affordability of each
16	hospital's IT infrastructure, and further studies are needed to examine the total effect of these
17	issues on the quality of hospital care.
18	

# 5. Conclusions

 $\mathbf{2}$ Hospitals with superior IT infrastructure may provide higher-quality care. The provision of access to paid medical evidence databases and accessibility to the Internet were strongly associated with hospital quality of care, and may be key factors for improving healthcare quality in larger or teaching hospitals. These infrastructure elements may allow healthcare professionals to retrieve the latest information on evidence-based medicine with greater ease and facilitate the dissemination of CPGs in the Internet era. Hospitals should focus on  $\overline{7}$ establishing adequate IT infrastructure to support the effective implementation of CPGs. The systematic improvement of IT infrastructure in hospitals may support greater adherence to CPGs and narrow the evidence-practice gaps. Acknowledgements We are grateful to all hospital administrators in the QIP hospitals who participated in this questionnaire survey. Furthermore, we sincerely appreciate the interviewees of several leading teaching hospitals for their time and assistance. Finally, we thank all staff at the Department of EBM and Guidelines, Japan Council for Quality Health Care who were

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16 involved in the Minds-QIP project.

### 17 Contributors

NS and YI had full access to all the data in the study and take responsibility for the analysis
and interpretation. Conception and design:NS,YI; Acquisition of data and analysis:NS, YI;

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1 Interpretation of data:NS, NY,AO,MY, HS,YI; Drafting of the manuscript and statistical

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7 Competing interests

8 The authors declare that they have no competing interests.

# 9 Ethics approval

- 10 This study was approved by both the Ethics Committee of Kyoto University Graduate School
- and Faculty of Medicine, Japan (R0979, R0135) and that of Japan Council for Quality Health
- 12 Care (Rin26-4). Informed consent was received from all participants prior to the survey, and
- 13 they were also informed that the data was being collected for research purposes. Regarding
- 14 the DPC data, we collect anonymous data based on a process designated by the ethics
- 15 guideline from the Japanese government, and the consent to participate from each patients

16 was omitted.

17 **Provenance and peer review** 

18 Not commissioned; externally peer reviewed.

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3 4	1	Data sharing statement
5	1	Data sharing statement
6 7 8	2	No data are available.
9 10		
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3 4	1	Figure legends
5	1	rigure legenus
6 7 8	2	Figure 1. Flow diagram of the subject hospital selection process.
9 10 11	3	*Target QI indicates QI of perioperative antibiotic prophylaxis of the 11 surgical procedures
12 13 14 15	4	mentioned in the manuscript.
16 17 18	5	Figure 2. Information sources freely available or specifically provided by the participating
19 20 21	6	hospitals (153 hospitals).
22 23 24	7	Figure 3. Chi-squared automatic interaction detection tree diagram showing the correlates of
25 26 27	8	the QI score.
28 29 30	9	* These values indicate the numbers of positive responses to questionnaire items related to (i)
31 32 33	10	Electronic health records and Internet availability, (ii) wireless LAN availability, and (iii)
34 35 36	11	wired LAN availability at outpatient clinics/wards. DB, database; LAN, local area network;
37 38 39 40	12 13	QI, quality indicator; SD, standard deviation. ** p=0.0499, in detail.
41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60		p=0.0499, in detail.
		97

 $\mathbf{2}$ 

Hospital characteristics Beds, mean±SD (range); median	$339 \pm 182$ (63-	1161); 303
Teaching hospitals, n(%)	· · · · · · · · · · · · · · · · · · ·	(75.2)
Hospital size, n(%)		
>500 beds	25 (	(16.3)
$\leq$ 500 beds		83.7)
Full-time physicians, mean±SD (range)		.3 (8-268)
Resident physicians, mean±SD (range)		.2 (0-197)
Respondent characteristics		(%)
Sex		
Male	125	(81.7)
Female	19	(12.4)
No response	9	(5.9)
Age		
20–29 years	5	(3.3)
30–39 years	21	(13.7)
40–49 years	28	(18.3)
50–59 years	50	(32.7)
60–69 years	39	(25.5)
No response	10	(6.5)
Appointment		
Hospital administrator (physician)	69	(45.1)
Chief general manager (non-physician)	38	(24.8)
Others	34	(22.2)
No response	12	(7.8)
<sup>a</sup> Respondents answered the questions as repres	entatives of their ho	spital.
SD, standard deviation.		

### Table 2. Hospital policies and IT infrastructure (153 hospitals)

Questionnaire items	n	(%)
Hospital policies		
Explicit policy to enhance IT infrastructure to improve accessibility to	144	(94.1)
medical information (YES)		
Explicit recommendation for the utilization of evidence-based medicine	88	(57.5)
(YES)		
Explicit recommendation for adherence to clinical practice guidelines	84	(54.9)
(YES)		
Accessibility to the Internet and other information sources		
Electronic health records and Internet access		
Access to both electronic health records and the Internet	110	(71.9)
Other	43	(28.1)
Wireless LAN		
Available with no limitations/with limited access points	110	(71.9)
Not available	43	(28.1)
Major locations with wired LAN access (Multiple answers allowed)		
Outpatient clinics/wards	98	(64.1)
Other locations (including medical offices and library)	144	(94.1)
Access to paid medical evidence databases (Multiple answers allowed)		
Igaku Chuo Zasshi (ICHUSHI) Database <in japanese=""></in>	118	(77.1)
Medical databases such as UpToDate®, Clinical Key®, Ovid®, and	84	(54.9)
DynaMed <sup>®</sup>		
Medical library and intranet usability within the hospital		
Provision of an intranet homepage with user-friendly interface	42	(27.5)
Number of full-time medical librarians		
≥1	66	(43.1)
0	87	(56.9)
Medical library activities (Multiple answers allowed)		
Periodic meetings held to improve the information retrieval	84	(54.9)
environment		
Continuously working to improve library services and usability	60	(39.2)
Participation in hospital librarian associations and communication	25	(16.3)
with other hospital librarians		
Other	23	(15.0)

2 IT, information technology, LAN, local area network.

Hospital policies <sup>a</sup>	
0	78.73
1	81.92
2	84.95
3	78.92
IT infrastructure	
Accessibility to the Internet and other information sources <sup>b</sup>	
0	78.59
	82.20
2	78.70
3	83.32
Access to paid medical evidence databases °	03.52
	72.55
1	79.76
$\frac{1}{2}$	84.88
Medical library and intranet usability within the hospital <sup>d</sup>	01.00
0	81.70
1	78.45
2	80.25
3	84.40
4–6	83.27
Hospital size and teaching status	
>500-bed non-teaching	87.64
>500-bed teaching	83.28
≤500-bed teaching	83.16
≤500-bed non-teaching	73.10

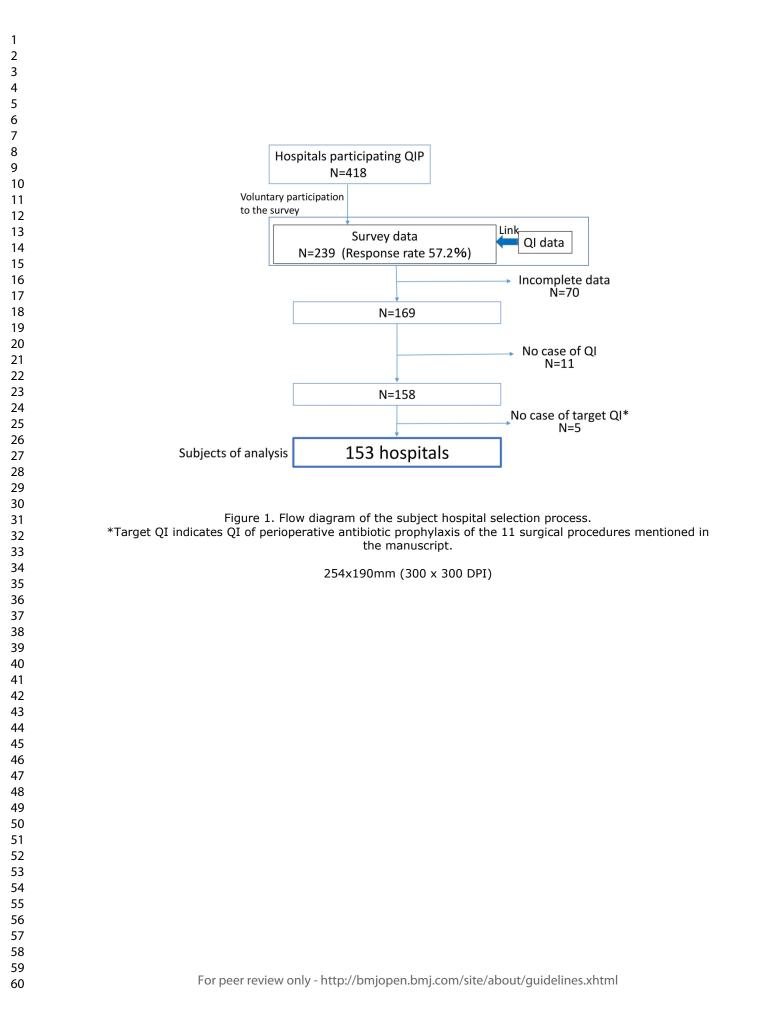
<sup>b</sup>Three items: Electronic health records and Internet availability, wireless LAN availability, wired LAN availability at outpatient clinics/wards.

<sup>c</sup> Two items: provision of access to the Japanese medical database and access to English-language medical databases.

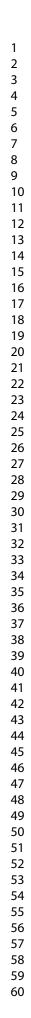
<sup>d</sup> Six items: provision of access to an intranet homepage, one or more full-time medical librarians, periodic meetings for library improvement, continuously working to improve library services and usability, communication with other hospital librarians, and others.

IT, information technology; LAN, local area network; QI, quality indicator.

 $\mathbf{2}$ 



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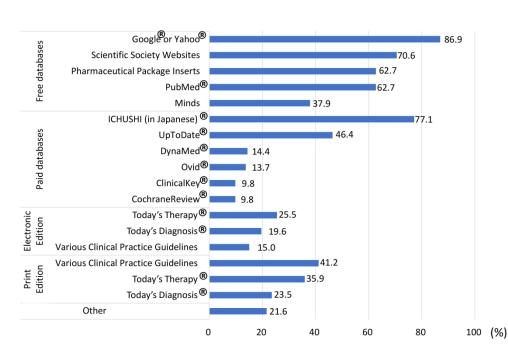


Figure 2. Information sources freely available or specifically provided by the participating hospitals (153 hospitals).

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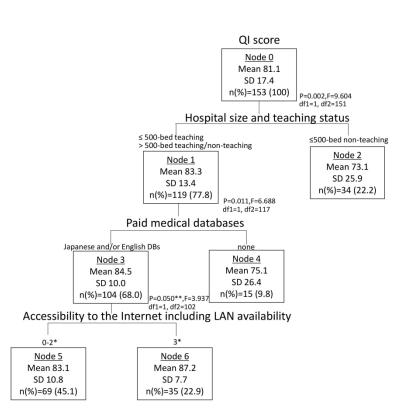


Figure 3. Chi-squared automatic interaction detection tree diagram showing the correlates of the QI score.
 \* These values indicate the numbers of positive responses to questionnaire items related to (i) Electronic health records and Internet availability, (ii) wireless LAN availability, and (iii) wired LAN availability at outpatient clinics/wards. DB, database; LAN, local area network; QI, quality indicator; SD, standard deviation.
 \*\* p=0.0499, in detail.

254x190mm (300 x 300 DPI)

medical informati	
$\Box$ Yes $\Box$ No	□ Other
<ul> <li>□ 1. PubMed □2</li> <li>□ 5. Scientific S</li> <li>□ 7. Igaku Chuo</li> <li>□ 8. Igaku Chuo</li> </ul>	nation sources are available in your hospital? (Please choose all options that would apply) 2. Google/Yahoo $\Box$ 3. Pharmaceutical Package Inserts $\Box$ 4. Pharmaceutical Interview Forms ociety Websites $\Box$ 6. MINDS 2. Zasshi (ICHUSHI) Medical Literature Database [ <b>Hospital</b> Subscription] 2. Zasshi (ICHUSHI) Medical Literature Database [ <b>Medical Office</b> Subscription] 2. Lagrated Subscription] $\Box$ 10. Lagraphate [ <b>Medical Office</b> Subscription]
□ 11. Cochrane	[Hospital Subscription] □ 10. UpToDate [Medical Office Subscription] Review □ 12. ClinicalKey □13. Ovid □ 14. DynaMed iagnosis [Electronic Edition] □ 16. Today's Therapy [Electronic Edition]
	linical Practice Guidelines [Electronic Versions]
$\Box$ 18. Today's D	iagnosis [Print Edition] 🗆 19. Today's Therapy [Print Edition]
$\Box$ 20. Various Cl	linical Practice Guidelines [ <b>Print Versions</b> ] □21. Other
□ Access to bot □ Access to bot	of accessibility to the Internet and other information sources is available in your hospital? h electronic health records (EHRs) and the Internet is permitted from the same computer. h EHRs and the Internet is permitted from different computers.
computers to	IRs is permitted only in the hospital network. Therefore, healthcare workers have to use their ow access the Internet.
□ EHRs are not □ Other	available.
	LAN available in your hospital? $\Box$ with limited access points. $\Box$ No, not available.
Q2-3. Where are <i>allowed</i> )	the major locations in your hospital for Internet use with wired LAN access? (Multiple answer
□ Outpatient cli □ Other	inics   Wards  Medical offices  Libraries
Q3-1. How many □ Full-time:	librarians are there in your hospital?
Q3-2. Does your l	nospital provide an intranet homepage with user-friendly interface?
□ Yes □ No	
	ies to your hospital regarding medical library activities? ( <i>Multiple answers allowed</i> ) tings held to improve the information retrieval environment
Continuously	working to improve library services and usability (e.g., promoting paperless movements) in hospital librarian associations and communication with other hospital librarians
Q4. Do you have □ Yes □ No	an explicit recommendation for the utilization of evidence-based medicine in your hospital?
Q5. Do you have	an explicit recommendation for adherence to clinical practice guidelines in your hospital?

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		BMJ Open BMJ Open	
ूੜ क्र STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cress-sectional studies			
Section/Topic	ltem #	Recommendation	Reported on page
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		لة لم مَنْ الله (b) Provide in the abstract an informative and balanced summary of what was done and what av	2-3
Introduction		ated	
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported 6	2, 5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	2,6
Methods		anded	
Study design	4	Present key elements of study design early in the paper	2,7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure ww-up, and data collection	2,7-11
Participants	6	( <i>a</i> ) Give the eligibility criteria, and the sources and methods of selection of participants	7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modified. Get diagnostic criteria, if applicable	7-11
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-11
Bias	9	Describe any efforts to address potential sources of bias	17
Study size	10	Explain how the study size was arrived at	7-11
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which grothings were chosen and why	7-11、Table3
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	9-11
		(b) Describe any methods used to examine subgroups and interactions	9-11
		(c) Explain how missing data were addressed	Fig1.
		(d) If applicable, describe analytical methods taking account of sampling strategy	*
		(e) Describe any sensitivity analyses     a	*

		BMJ Open BMJ Open-2011	Pag
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examin of for eligibility,	11, Fig1.
		confirmed eligible, included in the study, completing follow-up, and analysed            (b) Give reasons for non-participation at each stage	*
		(c) Consider use of a flow diagram	11, Fig1.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information to me posures and potential confounders	11, Table 1.
		(b) Indicate number of participants with missing data for each variable of interest	Fig1.
Outcome data	15*	Report numbers of outcome events or summary measures	Table 3. Figure 2.
Main results	16	( <i>a</i> ) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence	11-13, Table 2.
		interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized	11-13, Table 3
			*
Other analyses	17	(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningfut period Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analy	11-13, Table 3 Figu 3.
Discussion			
Key results	18	Summarise key results with reference to study objectives	2-4,13,17-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	4, 17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicities and other relevant evidence	4,13-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	4,18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable for be original study on which the present article is based	20

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in centrol studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published exan billight for transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine Birg/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.secobe-statement.org.

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# **BMJ Open**

## Does Hospital Information Technology Infrastructure Promote the Implementation of Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals

Journal:	BMJ Open
Manuscript ID	bmjopen-2018-024700.R2
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Date Submitted by the Author:	12-Apr-2019
Complete List of Authors:	Sasaki, Noriko; Kyoto University Graduate School of Medicine, Department of Healthcare Economics and Quality Management Yamaguchi, Naohito; Japan Council for Quality Health Care, Tokyo, Japan Okumura, Akiko; Japan Council for Quality Health Care, Tokyo, Japan Yoshida, Masahiro; Japan Council for Quality Health Care, Tokyo, Japan Sugawara, Hiroyuki; Japan Council for Quality Health Care, Tokyo, Japan Imanaka, Yuichi; Kyoto University Graduate School of Medicine, Department of Healthcare Economics and Quality Management
<b>Primary Subject Heading</b> :	Evidence based practice
Secondary Subject Heading:	Health informatics
Keywords:	Clinical practice guidelines, evidence-based practice, quality indicators, healthcare quality, hospital IT infrastructure, evidence-practice gaps



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2 3 4 5	1	Does Hospital Information Technology Infrastructure Promote the Implementation of
6 7 8	2	Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals
9 10 11	3	
12 13 14	4	Noriko Sasaki, MD, PhD, <sup>1</sup> Naohito Yamaguchi, MD, PhD, <sup>2</sup> Akiko Okumura, MPH, <sup>2</sup>
15 16 17	5	Masahiro Yoshida, MD, PhD, <sup>2</sup> Hiroyuki Sugawara, MMS, <sup>2</sup> and Yuichi Imanaka, MD, PhD <sup>1,2</sup>
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## Abstract

2	<b>Objectives:</b> It remains unclear whether insufficient information technology (IT) infrastructure
3	in hospitals hinders implementation of clinical practice guidelines (CPGs) and affects health
4	care quality. The objectives of this study were to describe the present state of IT infrastructure
5	provided in acute care hospitals across Japan and to investigate its association with healthcare
6	quality.
7	Methods: A questionnaire survey of hospital administrators was conducted in 2015 to gather
8	information on hospital-level policies and elements of IT infrastructure. The number of
9	positive responses by each respondent to the survey items was tallied. Next, a composite
10	quality indicator score of hospital adherence to CPGs for perioperative antibiotic prophylaxis
11	was calculated using administrative claims data. Based on this quality indicator score, we
12	performed a chi-squared automatic interaction detection (CHAID) analysis to identify
13	correlates of hospital healthcare quality. The independent variables included hospital size and
14	teaching status in addition to hospital policies and elements of IT infrastructure.
15	Results: Wide variations were observed in the availability of various IT infrastructure
16	elements across hospitals, especially in local area network availability and access to paid
17	evidence databases. The CHAID analysis showed that hospitals with a high level of access to
18	paid databases (p<0.05) and Internet (p<0.05) were strongly associated with increased care
19	quality in larger or teaching hospitals.

 $\mathbf{2}$ 

Conclusions: Hospitals with superior IT infrastructure may provide higher-quality care. This  $\mathbf{2}$ allows clinicians to easily access the latest information on evidence-based medicine and facilitate the dissemination of CPGs. The systematic improvement of hospital IT infrastructure may promote CPG use and narrow the evidence-practice gaps. Key words: Clinical practice guidelines; evidence-based practice; quality indicators;  $\mathbf{5}$ healthcare quality; hospital IT infrastructure; evidence-practice gaps. 

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1	Strengths and limitations of this study
2	• We integrated a hospital questionnaire survey and administrative claims data at hospital
3	level in the analysis.
4	• We described the present state of IT infrastructure of Japanese acute care hospitals and
5	investigated its association with a composite quality indicator of adherence to the
6	guidelines for perioperative antibiotic prophylaxis, using a chi-squared automatic
7	interaction detection analysis.
8	• As an infrastructure to promote evidence-based practice, we focused on IT infrastructure
9	such as accessibility to the Internet and other information sources, access to paid medical
10	evidence databases, and medical library and intranet usability within hospitals.
11	• The QI that we used was limited to adherence to the guidelines for perioperative
12	antibiotic use and therefore describes only one aspect of healthcare quality.
13	• As we used administrative claims data, we could not know the clinical information in
14	detail including appropriate exceptions in clinical practice.

**1. Introduction** 

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1	
2	Due to the growth of renewed medical information and frequent updates to clinical practice
3	guidelines (CPGs) in the Internet era, clinicians can find it difficult to keep abreast of the
4	latest evidence. The availability and usability of hospital information technology (IT)
5	infrastructure such as wireless local area networks (LAN) and medical evidence databases
6	may affect the ability of clinicians to update their knowledge and practice, which can
7	influence the quality of provided care. These infrastructure elements may facilitate
8	accessibility to various updated CPGs, which would be essential for CPG implementation in
9	daily practice [1].
10	CPGs for various diseases have been developed worldwide not only to help clinicians but
11	also to promote shared decision making with patients [2-4]. However, CPGs continue to be
12	underused even in countries even where CPGs are well developed over the past several
13	decades. These gaps between medical evidence and clinical practice (i.e., "evidence-practice
14	gaps") can lead to the provision of substandard or potentially harmful care to patients [5-11].
15	System-level barriers as well as individual-level barriers to evidence-based practice have been
16	revealed in previous studies [12-17]. For example, institutional equipment, technological
17	capital, and accessibility to guideline-related resources have been found to be important in
18	addition to individual awareness, familiarity and agreement with the contents [15-17].
19	Clinical quality indicators (QIs) can monitor clinicians' adherence to the guidelines, but they

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1	are not necessarily utilized to assess guideline implementation [18]. Furthermore, there is no
2	clear evidence regarding whether hospital IT infrastructure may affect the quality of provided
3	care using these QIs.
4	On the other hand, research related to the adoption of health information technology at the
5	organizational level is growing, and a number of studies have reported positive effects on
6	quality, safety and efficiency [19-21]. However, most of these studies have focused on
7	clinical decision support systems, order entry, telecommunication systems, e-Prescriptions
8	[19,20] and strategic management systems [21]. It thus remains unclear as to whether the lack
9	of an adequate IT infrastructure for medical information retrieval is a crucial system-level
10	barrier for CPG implementation. In Japan, over 180 evidence-based CPGs have been assessed
11	and disseminated by the government-funded Medical Information Network Distribution
12	Service (Minds) Guideline Center [22] over the last decade, but the actual use of these CPGs
13	in daily clinical practice remains unknown.
14	This multicenter study aimed to describe the present state of IT infrastructure provided in
15	Japanese acute care hospitals and to investigate its association with healthcare quality, taking
16	into account hospital size, hospital policies promoting evidence-based practice.
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2. Methods

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2	2.1. Data sources
3	We integrated a hospital questionnaire survey and administrative claims data at hospital level
4	in the analysis. Data were obtained from hospitals enrolled in the Quality
5	Indicator/Improvement Project (QIP), which is an ongoing project launched in 1995 to
6	monitor and improve clinical performance in acute care hospitals across Japan through the
7	analysis of administrative claims data [23,24]. Currently, over 500 QIP member hospitals
8	voluntarily submit data for analysis, and the project generates periodic reports of clinical and
9	economic performance. The participating hospitals vary widely in type (e.g., teaching status
10	and hospital ownership), region of location, patient and physician volume, bed numbers, and
11	composition of specialties.
12	
	The Minds-QIP project, as a part of the activities of the Minds Guideline Center, was
13	initiated in 2014, with the objective of effectively implementing and disseminating CPGs
13 14	
	initiated in 2014, with the objective of effectively implementing and disseminating CPGs
14	initiated in 2014, with the objective of effectively implementing and disseminating CPGs across Japan. A survey was conducted as part of this project by mailing questionnaires to the
14 15	initiated in 2014, with the objective of effectively implementing and disseminating CPGs across Japan. A survey was conducted as part of this project by mailing questionnaires to the hospital administrators (including general managers) of QIP member hospitals between
14 15 16	initiated in 2014, with the objective of effectively implementing and disseminating CPGs across Japan. A survey was conducted as part of this project by mailing questionnaires to the hospital administrators (including general managers) of QIP member hospitals between January and March 2015. The questionnaire included items on hospital policies regarding
14 15 16 17	initiated in 2014, with the objective of effectively implementing and disseminating CPGs across Japan. A survey was conducted as part of this project by mailing questionnaires to the hospital administrators (including general managers) of QIP member hospitals between January and March 2015. The questionnaire included items on hospital policies regarding evidence-based practice and hospital IT infrastructure, actual provision of IT infrastructure

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 1
 questionnaire was developed based on literature reviews, discussions with experts, and

 2
 semi-structured face-to-face interviews with several hospital administrators and IT managers

 3
 from five major teaching hospitals. Survey respondents were asked to answer questions from

 4
 a concise list about their institution and policies as representatives of their hospital (Appendix

 5
 Table).

 6
 Image: Construction of the construction of th

9 questionnaire included items on whether the hospital has an explicit policy to enhance IT

10 infrastructure intending to improve information accessibility, whether it explicitly

11 recommends the practice of evidence-based medicine, and whether it explicitly encourages

12 the use of CPGs.

The questionnaire was also designed to focus on the following three elements of hospital IT infrastructure: (i) accessibility to the Internet and other information sources, including wired/wireless LAN availability; (ii) access to paid medical evidence databases in English and Japanese; and (iii) medical library and intranet usability, such as the availability of a well-organized intranet interface, number of full-time medical librarians, and activities for improving the medical library.

2.3. Hospital	quality of care
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2	As a measure of hospital quality of care, a QI of adherence to CPGs for perioperative
3	antibiotic prophylaxis was calculated using diagnosis procedure combination (DPC)
4	administrative claims data from the QIP. The DPC is a Japanese case-mix classification
5	system for hospital reimbursements, and more than 1600 hospitals nationwide had adopted
6	this system by 2016. The DPC database includes information on hospital codes, patient
7	demographics, admission and discharge dates, admission routes, outcomes, primary and
8	secondary diagnoses based on International Classification of Diseases (10th revision) codes,
9	comorbidities, complications, surgeries performed, and high cost procedures [23,24]. DPC
10	data from April 2013 to March 2014 were used as these were the most recent data available
11	for analysis.
12	The QI of interest for this study was a composite score (range: 0 to 100) that indicated a
13	hospital's proportion of adherence to CPGs for perioperative antibiotic prophylaxis [25], and
14	was aggregated from the results of the following 11 surgical types (i.e., target QI in Fig.1) :
15	evacuation of intracranial hematoma, gastrectomy, cholecystectomy, total hip replacement,
16	mastectomy for breast cancer, thyroid surgery, prostate cancer surgery, uterine myoma
17	surgery, uterine cancer surgery, benign ovarian tumor surgery, and ovarian cancer surgery.
18	The QI score was calculated based on the administrative data when and what kind of the
19	antibiotics were used, and this medication information is very precise in the Japanese

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administrative data. Therefore, the QI score is accurate in any hospital.  $\mathbf{2}$ 2.4. Statistical analysis We first calculated descriptive statistics for the hospitals' and respondents' baseline characteristics, which included hospital bed numbers, teaching status, number of full-time  $\mathbf{5}$ physicians, number of resident physicians (representing younger physicians who may be more likely to incorporate IT into their practice), as well as respondent sex, age, and appointment. The responses to the questionnaire items related to hospital policies and IT infrastructure were also summarized. The main items of interest consisted of yes/no questions; we calculated each hospital's number of positive responses within each item. The hospitals were categorized into subgroups based on these response numbers, and the mean QI score was calculated for each subgroup. Finally, we performed a chi-squared automatic interaction detection (CHAID) tree analysis to identify factors that determine hospital quality of care. The independent variables included hospital size and teaching status, hospital policies regarding the promotion of evidence-based practice, and IT infrastructure (accessibility to the Internet and other information sources, access to paid medical evidence databases, and medical library and intranet usability within hospitals). The dependent variable was the mean QI score for perioperative antibiotic prophylaxis. CHAID tree analysis repeatedly uses chi-square statistics 

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to split independent variables into child nodes [26-28] to identify the relative interactions between the independent variables and the outcome variables. This method is a classification  $\mathbf{2}$ tree algorithm that is often utilized as a data mining method in fields with complex data sets, such as marketing, health care [27], and nursing [28]. We used the exhaustive CHAID algorithm, a modified version of the basic algorithm that performs a more thorough merging  $\mathbf{5}$ and testing of independent variables [29]. Statistical calculations were performed using SPSS 20.0J software and Decision Tree (SPSS Inc, Chicago, IL). 2.5. Patient and public involvement There was no patients or public involvement in the design and analysis of this study. eyien 3. Results 3.1. Baseline characteristics, hospital policy, and IT infrastructure From the 239 hospitals that responded to the questionnaire (response rate: 57.2%), we were able to calculate and integrate the target QI data for 153 hospitals. Hospitals with data on at least one target QI were included. The hospital selection flow diagram is presented in Figure 1. The baseline characteristics of the participant hospitals and respondents are shown in Table 1. The median number of hospital beds was 303 (range: 63–1161). Approximately 75% of all 

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18 the hospitals were teaching hospitals; the mean number of junior and senior residents in each

hospital was approximately 21.  $\mathbf{2}$ Table 2 shows the results of the survey on hospital policies and IT infrastructure. Almost all respondents reported that their hospitals had an explicit policy to enhance IT infrastructure (94.1%). However, the provision of wireless LAN (71.9%) and access to paid medical evidence databases in English (54.9%) was limited. Further, an intranet homepage was  $\mathbf{5}$ provided only in a minority of hospitals (27.5%). Figure 2 shows the information sources freely available or specifically provided by the participating hospitals. There were large variations in the provision of paid medical evidence databases, and hospitals tended to subscribe to the Japanese-language database (77.1%) rather than the English-language databases (9.8–46.4%). In general, the print editions of various CPGs and medical information were provided more frequently than the electronic editions, and there were relatively few hospitals that provided CPGs in either edition (41.2% in the print edition and 15.0% in the electronic edition). 3.2. Correlates of hospital quality of care Table 3 shows the mean QI scores for the use of perioperative antibiotics according to the various independent variables. Hospitals with a lower number of positive responses to items 

18 related to hospital policies and IT infrastructure tended to have a lower QI score. Using

19 CHAID analysis, we identified three major correlates of QI score (Fig. 3; hospital size and

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1	teaching status were the strongest correlates. The subgroup of " $\leq$ 500-bed non-teaching
2	hospitals" had the lowest QI score (73.1 points, Node 2). The other subgroup (comprising
3	larger or teaching hospitals) was divided into two groups based on the provision of access to
4	paid medical evidence databases. The derived subgroup of "Japanese and/or English
5	databases" was further divided into two groups according to (i) accessibility to the Internet,
6	(ii) wireless LAN availability, and (iii) wired LAN availability at outpatient clinics/wards;
7	hospitals in the subgroup that had the highest number of positive responses to these three
8	items had the highest QI score (87.2 points, Node 6) among all nodes. In contrast, the
9	subgroup that had positive responses to two or fewer of these items had a lower QI score
10	(83.1 points, Node 5). The subgroup of hospitals with no IT infrastructure elements had the
11	lowest QI score (75.1 points, Node 4) among the larger or teaching hospitals. These results
12	indicated that the provision of access to paid medical evidence databases and accessibility to
13	the Internet (including LAN availability) were strongly associated with hospital quality of
14	care.
15	
16	4. Discussion
17	In this multicenter study, we observed wide variations in the provision of IT infrastructure
18	across hospitals in Japan. Our results indicated that hospitals with superior IT infrastructure
10	tended to have higher adherence to CPGs for perioperative antibiotic prophylaxis. Using a
10	to have induce induce to er es for perioperative antibiotic prophytaxis. Using a

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1	CHAID tree analysis, we found that the provision of access to paid medical evidence
2	databases and accessibility to the Internet (including LAN availability) were strong indicators
3	of quality of care in larger or teaching hospitals
4	Despite the wide availability of new medical evidence, clinicians are not always able
5	to acquire and apply the most recent and relevant information at the right moment in their
6	daily practice. The lack of adequate IT infrastructure may affect the ability of clinicians to
7	access this information, thereby contributing to evidence-practice gaps. There are more than
8	8,000 hospitals in Japan, of which 80% (and almost all clinics) are privately owned [30].
9	Different leadership approaches among these hospitals may have resulted in considerable
10	variations in IT infrastructure. Our analysis found that there was an overall inadequate
11	provision of LAN, and accessibility to the Internet and electronic health records was limited
12	among the hospitals. In addition, the print editions of various CPGs and medical information
13	were provided more frequently than electronic editions. Previous studies on the activities to
14	improve accessibility to medical information within specific hospital networks [31,32] have
15	indicated the importance of hospital leadership in the development of IT infrastructure.
16	Our CHAID analysis found that the three most important correlates of hospital
17	quality of care were hospital size and teaching status, access to paid medical evidence
18	databases, and high accessibility to the Internet. Notably, hospital policies and library/intranet
19	usability were not identified as major correlates. There are likely several reasons for the

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1	identification of hospital size and teaching status, access to paid medical evidence databases,
2	and high accessibility to the Internet as the most important factors. Firstly, from an economic
3	perspective, teaching hospitals tend to be large and more likely to have the economic
4	capability to provide resources such as IT infrastructure and full-time librarians engaged to
5	work on intranet development. The results in Table 2 indicate that more than half of the
6	participating hospitals do not hire full-time medical librarians. Interviews with the
7	administrators of several leading teaching hospitals prior to the survey revealed that some
8	administrators were actively working to enhance their hospital's intranet environment. This
9	included the hiring of full-time librarians to create user-friendly intranet homepages designed
10	to guide clinicians to the most recent and relevant clinical information. Our results are
11	consistent with those of previous reports that show improvements in medical library
12	functionality can improve patient health outcomes while reducing the time needed for
13	clinicians to search for required information [33,34]. From a cultural perspective, "teaching"
14	nature of the teaching hospitals makes them more committed to evidence-based thinking and
15	promote evidence-based practice. In the Japanese context, highly motivated teaching staffs
16	tend to gather in large-scale teaching hospitals, and these cultural elements may also explain
17	our results in part.
18	Secondly, we found that hospital administrators tended to provide access to free
19	medical databases first, followed by the paid Japanese database, and finally the paid databases

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1	in English (Fig. 2). Besides the high cost of subscribing to English-language databases, the
2	administrators may have prioritized the Japanese database due to the possible language barrier
3	for Japanese clinicians; this phenomenon has also been observed in Taiwan [35]. However,
4	the failure to provide medical databases in English raises concerns that the clinicians may be
5	unable to retrieve the newest relevant information in a timely manner, which can directly
6	impact daily clinical practice. In addition, the availability of information in English may be
7	crucial to the efficient dissemination and effective implementation of CPGs.
8	Thirdly, the importance of Internet accessibility (including LAN availability) to
9	healthcare quality has been similarly observed in previous studies from the US and UK
10	[1,21,31]. Our study sample included a fairly high proportion of hospitals without wireless
11	LAN (28.1%) or with limited wired LAN availability at outpatient clinics and wards (64.1%).
12	In order to encourage the implementation of IT infrastructure that facilitates easy retrieval of
13	evidence in all types of hospitals, it may be necessary to develop a standardized assessment
14	tool for hospital IT infrastructure and to include such assessments as a component of hospital
15	accreditation.
16	In daily clinical practice, clinicians have limited time to search for and retrieve
17	medical information. Thus, an ideal search platform would allow the use of clinical questions
18	with several keywords and provide the requested information promptly and accurately. In
19	addition to improving the accessibility and usability of online information, it may be useful to
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1	actively provide paid medical evidence databases (especially English-language databases) at
2	the hospital level to supply multiple layers of information ranging from abstracts to full-text
3	articles, as well as recommendations for CPGs and their evidence sources. In order to
4	maximize the use of this system, individual physicians should work to improve not only their
5	English language skills, but also their information searching skills and ability to implement
6	new knowledge into practice.
7	Our findings suggest that larger or teaching hospitals would have the most potential for
8	improvements in IT infrastructure that can lead to better quality of care (see Nodes 4, 5, and 6
9	in Fig. 3). As Doebbeling et al. noted, IT implementation is dependent on the support of
10	hospital management and "should be tailored to the needs of the organization, and not as a
11	'one size fits all' solution" [36]. It is also necessary to conduct balanced assessments of the
12	costs and effectiveness of these IT infrastructures in order to efficiently support the
13	implementation of evidence into practice under limited budgets.
14	In a broader context, barriers to implementing CPG recommendations in daily practice
15	vary greatly at the individual level of specialists and physicians (e.g. perception, education,
16	incentives, professional autonomy), the institutional level (e.g., physician leadership, hospital
17	policies, finance, institutional culture, teamwork, IT infrastructure), national level (e.g.,
18	policies to promote CPG use, hospital accreditation) and the social level (e.g. a culture of
19	shared-decision making with patients, information derived from mass media) [37,38,39]. Yet,
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1	given the growing importance of IT use in an innovative society, the impact of IT adoption on
2	healthcare quality warrants far more consideration of the types of relationships that were
3	revealed in this study. According to previous research, IT itself needs to be understood as
4	having two distinct components-information technology and communication
5	technology—and these differently affect the autonomy of workers [40]. Further examination
6	is needed to clarify these issues in order to implement IT in practice settings.
7	There are several limitations to this study. First, the respondents were hospital
8	administrators, which means the results may not indicate the usability of various IT
9	infrastructure elements from a physician's perspective. In addition, as this was a self-reported
10	survey, the possible presence of social desirability bias may have caused these respondents to
11	underestimate the barriers being investigated. Because individual physicians are the primary
12	target users and are likely to be the link between IT infrastructure and quality of care, studies
13	focusing physicians are required in the future to clarify the quality improvement mechanism
14	in detail. Second, the survey was conducted in Japan, which may limit the generalizability of
15	our results to other countries. Third, the QI that we used was limited to adherence to the CPGs
16	for perioperative antibiotic use and therefore describes only one aspect of healthcare quality.
17	Fourth, as we used administrative claims data, we could not know the clinical information in
18	detail including appropriate exceptions in clinical practice. However, in this study, we
19	focused on perioperative antibiotic prophylaxis of the 11 surgeries, which we could identify

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accurately based on the information of surgical procedure and drug use from the database.Finally, we were not able to identify the amount of investment or the affordability of each hospital's IT infrastructure, and further studies are needed to examine the total effect of these issues on the quality of hospital care.

## 5. Conclusions

Hospitals with superior IT infrastructure may provide higher-quality care. The provision of access to paid medical evidence databases and accessibility to the Internet were strongly associated with hospital quality of care, and may be key factors for improving healthcare quality in larger or teaching hospitals. These infrastructure elements may allow healthcare professionals to retrieve the latest information on evidence-based medicine with greater ease and facilitate the dissemination of CPGs in the Internet era. Hospitals should focus on establishing adequate IT infrastructure to support the effective implementation of CPGs. The systematic improvement of IT infrastructure in hospitals may support greater adherence to CPGs and narrow the evidence-practice gaps. 

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2	involved in the Minds-QIP project.
3	Contributors
4	NS and YI had full access to all the data in the study and take responsibility for the analysis
5	and interpretation. Conception and design:NS,YI; Acquisition of data and analysis:NS, YI;
6	Interpretation of data:NS, NY,AO,MY, HS,YI; Drafting of the manuscript and statistical
7	analysis:NS,YI; Obtaining funding:NY,YI. All the authors (NS, NY,AO, MY, HS, and YI)
8	were involved in critical revisions and approved the final manuscript for publication.
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10	This research was financially supported by the Ministry of Health, Labour and Welfare of
11	Japan and Japan Council for Quality Health Care.
12	Competing interests
13	The authors declare that they have no competing interests.
14	Ethics approval
15	This study was approved by both the Ethics Committee of Kyoto University Graduate School
16	and Faculty of Medicine, Japan (R0979, R0135) and that of Japan Council for Quality Health
17	Care (Rin26-4). Informed consent was received from all participants prior to the survey, and
18	they were also informed that the data was being collected for research purposes. Regarding
19	the DPC data, we collect anonymous data based on a process designated by the ethics

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3 4 5	1	guideline from the Japanese government, and the consent to participate from each patients
6 7 8	2	was omitted.
9 10 11	3	Provenance and peer review
12 13 14	4	Not commissioned; externally peer reviewed.
15 16 17	5	Data sharing statement
18 19 20	6	No data are available.
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## 1 Figure legends

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- 2 Figure 1. Flow diagram of the subject hospital selection process.
  - \*Target QI indicates QI of perioperative antibiotic prophylaxis of the 11 surgical procedures

4 mentioned in the manuscript.

- 5 Figure 2. Information sources freely available or specifically provided by the participating
- 6 hospitals (153 hospitals).

Figure 3. Chi-squared automatic interaction detection tree diagram showing the correlates of

8 the QI score.

- 9 \* These values indicate the numbers of positive responses to questionnaire items related to (i)
- 10 Electronic health records and Internet availability, (ii) wireless LAN availability, and (iii)
- 11 wired LAN availability at outpatient clinics/wards. DB, database; LAN, local area network;
- 12 QI, quality indicator; SD, standard deviation.
- 13 \*\* p=0.0499, in detail.

Hospital characteristics	$220 \pm 182$ (C2)	11(1), 20
Beds, mean $\pm$ SD (range); median	$339 \pm 182 (63 - 115)$	· · ·
Teaching hospitals, $n(\%)$	115	(75.2)
Hospital size, $n(\%)$	25 (	(1(2))
> 500 beds		(16.3)
$\leq$ 500 beds		(83.7)
Full-time physicians, mean $\pm$ SD (range)		3.3(8-268)
Resident physicians, mean $\pm$ SD (range)		9.2(0-197)
Respondent characteristics	n	(%)
Sex Male	125	(01.7)
		(81.7)
Female	19 9	(12.4) (5.9)
No response	9	(3.9)
Age 20–29 years	5	(3.3)
30–39 years	21	(13.7)
40–49 years	21 28	(13.7) (18.3)
50–59 years	28 50	(10.3) (32.7)
60–69 years	39	(32.7) (25.5)
No response	10	(6.5)
Appointment	10	(0.5)
Hospital administrator (physician)	69	(45.1)
Chief general manager (non-physician)	38	(24.8)
Others	34	(22.2)
No response	12	(7.8)
<sup>a</sup> Respondents answered the questions as represe		
SD, standard deviation.		opiun.
SD, standard deviation.		

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Table 2. Hospital p	oolicies and IT infrastructure (	153 hospitals)
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Questionnaire items	n	(%)
Hospital policies		
Explicit policy to enhance IT infrastructure to improve accessibility to medical information (YES)	144	(94.1)
Explicit recommendation for the utilization of evidence-based medicine (YES)	88	(57.5)
Explicit recommendation for adherence to clinical practice guidelines (YES)	84	(54.9)
Accessibility to the Internet and other information sources		
Electronic health records and Internet access	110	(71.0)
Access to both electronic health records and the Internet	110	(71.9)
Other Wireless LAN	43	(28.1)
Available with no limitations/with limited access points	110	(71.9)
Not available	43	(28.1)
Major locations with wired LAN access (Multiple answers allowed)		× /
Outpatient clinics/wards	98	(64.1)
Other locations (including medical offices and library)	144	(94.1)
Access to paid medical evidence databases (Multiple answers allowed)		()
Igaku Chuo Zasshi (ICHUSHI) Database <in japanese=""></in>	118	(77.1)
Medical databases such as UpToDate <sup>®</sup> , Clinical Key <sup>®</sup> , Ovid <sup>®</sup> , and	84	(54.9)
DynaMed®	-	()
Medical library and intranet usability within the hospital		
Provision of an intranet homepage with user-friendly interface	42	(27.5)
Number of full-time medical librarians		( )
	66	(43.1)
$\geq 1$	87	(56.9)
Medical library activities (Multiple answers allowed)	0,	(00.5)
Periodic meetings held to improve the information retrieval	84	(54.9)
environment		
Continuously working to improve library services and usability	60	(39.2)
Participation in hospital librarian associations and communication	25	(16.3)
with other hospital librarians		. ,
Other	23	(15.0)

 $2 \qquad {\rm IT, \, information \, technology, \, LAN, \, local \, area \, network.}$ 

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Number of questionnaire items with positive responses	Mean QI score	
Hospital policies <sup>a</sup>		
0	78.73	
1	81.92	
2	84.95	
3	78.92	
IT infrastructure		
Accessibility to the Internet and other information sources <sup>b</sup>		
0	78.59	
1	82.20	
2	78.70	
3	83.32	
Access to paid medical evidence databases <sup>c</sup>		
0	72.55	
1	79.76	
2	84.88	
Medical library and intranet usability within the hospital <sup>d</sup>		
0	81.70	
1	78.45	
2	80.25	
3	84.40	
4–6	83.27	
Hospital size and teaching status		
> 500-bed non-teaching	87.64	
> 500-bed teaching	83.28	
$\leq$ 500-bed teaching	83.16	
$\leq$ 500-bed non-teaching	73.10	

Questionnaire items are as follows:

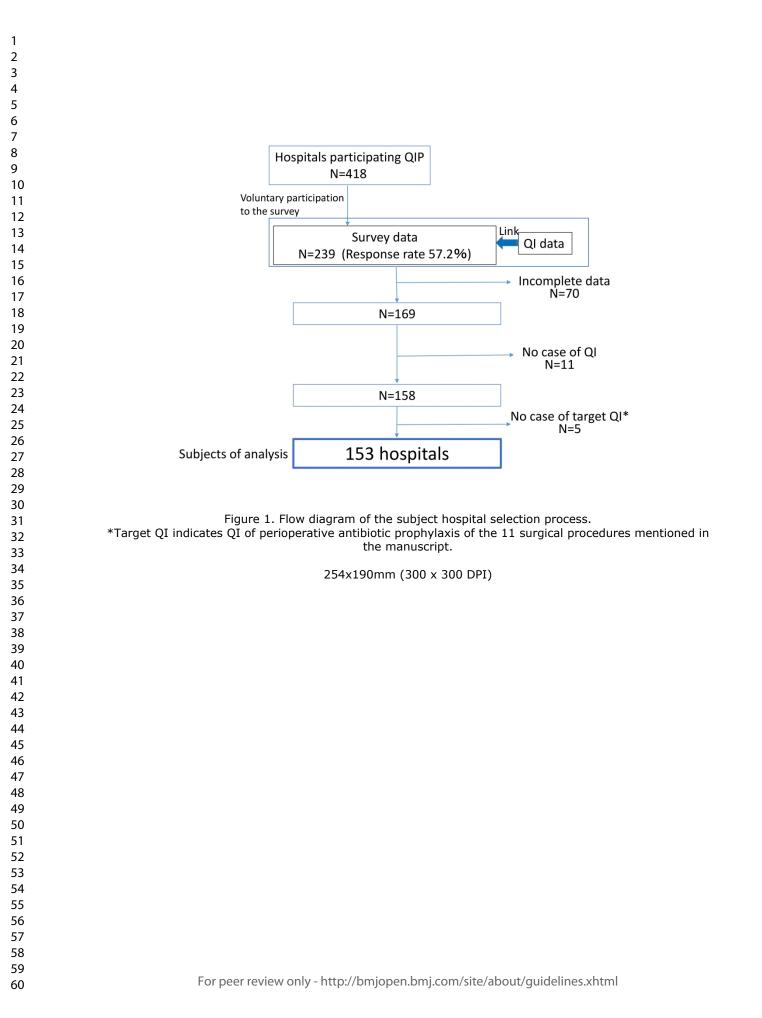
<sup>a</sup> Three items: having explicit policy to enhance IT infrastructure, explicit recommendation for the utilization of evidence-based medicine, and explicit recommendation to use clinical practice guidelines.

<sup>b</sup>Three items: Electronic health records and Internet availability, wireless LAN availability, wired LAN availability at outpatient clinics/wards.

<sup>c</sup> Two items: provision of access to the Japanese medical database and access to English-language medical databases.

<sup>d</sup> Six items: provision of access to an intranet homepage, one or more full-time medical librarians, periodic meetings for library improvement, continuously working to improve library services and usability, communication with other hospital librarians, and others.

IT, information technology; LAN, local area network; QI, quality indicator.



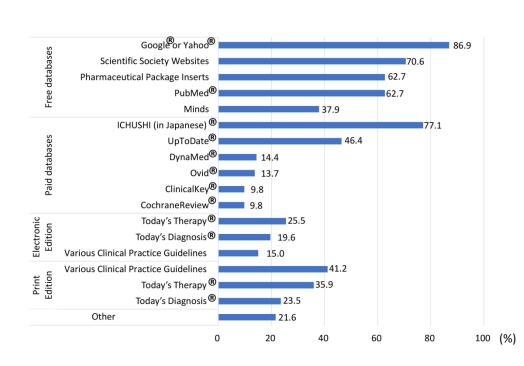


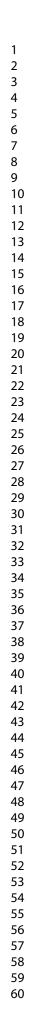
Figure 2. Information sources freely available or specifically provided by the participating hospitals (153 hospitals).

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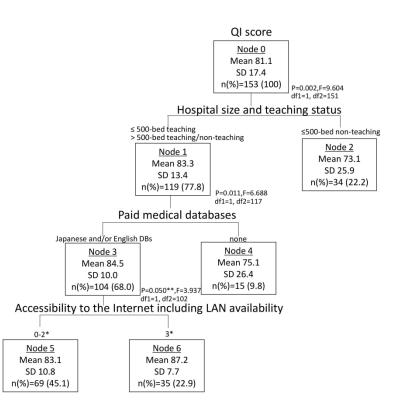


Figure 3. Chi-squared automatic interaction detection tree diagram showing the correlates of the QI score.
 \* These values indicate the numbers of positive responses to questionnaire items related to (i) Electronic health records and Internet availability, (ii) wireless LAN availability, and (iii) wired LAN availability at outpatient clinics/wards. DB, database; LAN, local area network; QI, quality indicator; SD, standard deviation.
 \*\* p=0.0499, in detail.

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med	<ul> <li>Does your hospital have an explicit policy to enhance IT infrastructure in order to improve accessibility ical information?</li> <li>Yes □ No □ Other</li> </ul>
	<ol> <li>What information sources are available in your hospital? (Please choose all options that would apply)</li> <li>PubMed □2. Google/Yahoo □3. Pharmaceutical Package Inserts □ 4. Pharmaceutical Interview Forms</li> <li>Scientific Society Websites □ 6. MINDS</li> <li><i>Igaku Chuo Zasshi</i> (ICHUSHI) Medical Literature Database [Hospital Subscription]</li> <li><i>Igaku Chuo Zasshi</i> (ICHUSHI) Medical Literature Database [Medical Office Subscription]</li> <li>UpToDate [Hospital Subscription] □ 10. UpToDate [Medical Office Subscription]</li> <li>Cochrane Review □ 12. ClinicalKey □13. Ovid □ 14. DynaMed</li> <li><i>Today's Diagnosis</i> [Electronic Edition] □ 16. <i>Today's Therapy</i> [Electronic Edition]</li> <li>Various Clinical Practice Guidelines [Electronic Versions]</li> <li><i>Today's Diagnosis</i> [Print Edition] □ 19. <i>Today's Therapy</i> [Print Edition]</li> </ol>
	20. Various Clinical Practice Guidelines [ <b>Print Versions</b> ] $\Box$ 21. Other
	1. What type of accessibility to the Internet and other information sources is available in your hospital? Access to both electronic health records (EHRs) and the Internet is permitted from the same computer. Access to both EHRs and the Internet is permitted from different computers. Access to EHRs is permitted only in the hospital network. Therefore, healthcare workers have to use their ov computers to access the Internet. EHRs are not available.
	Other
	<ul> <li>2. Is <i>wireless</i> LAN available in your hospital?</li> <li>Yes, available with no limitations. □Yes, with limited access points. □ No, not available.</li> <li>3. Where are the major locations in your hospital for Internet use with <i>wired</i> LAN access? (<i>Multiple answe wed</i>)</li> </ul>
	Outpatient clinics  Umber Wards  Medical offices  Libraries Other
	1. How many librarians are there in your hospital? Full-time:
-	2. Does your hospital provide an intranet homepage with user-friendly interface? Yes $\Box$ No $\Box$ Other
	3. Which applies to your hospital regarding medical library activities? ( <i>Multiple answers allowed</i> ) Periodic meetings held to improve the information retrieval environment Continuously working to improve library services and usability (e.g., promoting paperless movements) Participation in hospital librarian associations and communication with other hospital librarians Other
	Do you have an explicit recommendation for the utilization of evidence-based medicine in your hospital? Yes $\Box$ No $\Box$ Other
	Do you have an explicit recommendation for adherence to clinical practice guidelines in your hospital? Yes $\Box$ No $\Box$ Other

		BMJ Open by copyrig 20	Page 36
	STR	OBE 2007 (v4) Statement—Checklist of items that should be included in reports of cress-ctional studies	
Section/Topic	ltem #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		لا الله الله الله الله الله الله الله ا	2-3
Introduction		ared ared area area area area area area	
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2, 5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	2,6
Methods		and ed	
Study design	4	Present key elements of study design early in the paper	2,7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure www-up, and data collection	2,7-11
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modified. Ge diagnostic criteria, if applicable	7-11
Data sources/	8*	For each variable of interest, give sources of data and details of methods of assessment (meagurement). Describe	7-11
measurement		comparability of assessment methods if there is more than one group	
Bias	9	Describe any efforts to address potential sources of bias	17
Study size	10	Explain how the study size was arrived at	7-11
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which gro bings were chosen and why	7-11、Table3
Statistical methods	12	( <i>a</i> ) Describe all statistical methods, including those used to control for confounding	9-11
		(b) Describe any methods used to examine subgroups and interactions	9-11
		(c) Explain how missing data were addressed	Fig1.
		(d) If applicable, describe analytical methods taking account of sampling strategy	*
		(a) Describe any constituity analyses	*
Results			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examining for eligibility,	11, Fig1.
		confirmed eligible, included in the study, completing follow-up, and analysed	*
		(c) Consider use of a flow diagram	11, Fig1.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information and potential confounders	11, Table 1.
		(b) Indicate number of participants with missing data for each variable of interest	Fig1.
Outcome data	15*	Report numbers of outcome events or summary measures	Table 3. Figure 2.
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-13, Table 2.
		(b) Report category boundaries when continuous variables were categorized	11-13, Table 3
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaning of the period	*
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analy	11-13, Table 3 Figu 3.
Discussion		y, A	
Key results	18	Summarise key results with reference to study objectives 5	2-4,13,17-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision.	4, 17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicit of analyses, results from similar studies, and other relevant evidence	4,13-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	4,18
Other information		echr 11	
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable or be original study on which the present article is based	20

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in centrol studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published exan billight for transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine Brg/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.secobe-statement.org.