BMJ Open

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

1 **Does Hospital Information Technology Infrastructure Promote the Implementation of**

2 **Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals**

3

4 Noriko Sasaki, MD, PhD,[1] Naohito Yamaguchi, MD, PhD,[2] Akiko Okumura, MPH,[2]

5 Masahiro Yoshida, MD, PhD, [2] Hiroyuki Sugawara, MMS, [2] and Yuichi Imanaka, MD, PhD[1,2]

6 [1] Department of Healthcare Economics and Quality Management,

7 Kyoto University Graduate School of Medicine, Kyoto, Japan

8 [2] Japan Council for Quality Health Care, Tokyo, Japan

9

10

11

12

13 Correspondence to: Professor Yuichi Imanaka; imanaka-y@umin.net

1

1   **Abstract**

2   **Objectives:** 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.

2

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

3

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.

15

4

1   **1. Introduction**

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

5

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.

17

1   **2. Methods**

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,

7

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

3 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

9 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.

17

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

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.

16

17   *2.4. Statistical analysis*

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

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

10

1   Tree (SPSS Inc, Chicago, IL).

2   *2.5. Patient and public involvement*

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

4   **3. Results**

5   *3.1. Baseline characteristics, hospital policy, and IT infrastructure*

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

11   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

14   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

1   topics had the highest QI score (87.2 points, Node 6) among all nodes. In contrast, the

2   subgroup that provided positive responses to 2 or fewer of these topics had a lower QI score

3   (83.1 points, Node 5). The subgroup of hospitals with no IT infrastructure elements had the

4   lowest QI score (75.1 points, Node 4) among the larger or teaching hospitals. These results

5   indicated that the provision of access to paid medical evidence databases and accessibility to

6   the Internet (including LAN availability) were strongly associated with hospital quality of

7   care.

8

9   **4. Discussion**

10   In this multicenter study, we observed wide variations in the provision of IT infrastructure

11   across hospitals in Japan. Our results indicated that hospitals with superior IT infrastructure

12   tended to have higher adherence to CPGs for perioperative antibiotic prophylaxis. Using a

13   CHAID tree analysis, we found that the provision of access to paid medical evidence

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

15   of quality of care in larger or teaching hospitals

16   Despite the wide availability of new medical evidence, clinicians are not always able

17   to acquire and apply the most recent and relevant information at the right moment in their

18   daily practice. The lack of adequate IT infrastructure may affect the ability of clinicians to

19   access this information, thereby contributing to evidence-practice gaps. There are more than

13

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

14

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

15

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.

16

1

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

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

17

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**

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.

17   **Funding**

18

1 **Competing interests**

2 The authors declare that they have no competing interests.

3 **Ethics approval**

4 This study was approved by both the Ethics Committee of Kyoto University Graduate School

5 and Faculty of Medicine, Japan (R0979, R0135) and that of Japan Council for Quality Health

6 Care (Rin26-4).

7 **Provenance and peer review**

8 Not commissioned; externally peer reviewed.

9 **Data sharing statement**

10 No additional data are available.

11 **REFERENCES**

12 [1] Gray P, Olfman L. Careers and education in information systems.. In:Bates MJ,

13 editor.Understanding information retrieval systems:management, types and standards.Boca

14 Raton: CRC Press; 2011. p. 91-110.

15 [2] van der Weijden T, Pieterse AH, Koelewijn-van Loon MS, Knaapen L, Légaré F, Boivin A,

16 et al. How can clinical practice guidelines be adapted to facilitate shared decision making? A

17 qualitative key-informant study. BMJ Qual Saf. 2013;22:855-63

18 [3] Légaré F, Witteman HO. Shared decision making: examining key elements and barriers to

19 adoption into routine clinical practice. Health Aff. 2013;32:276-84.

19

1   [4] Blanc X, Collet TH, Auer R, Fischer R, Locatelli I, Iriarte P, et al. Publication trends of

2   shared decision making in 15 high impact medical journals: a full-text review with

3   bibliometric analysis. BMC Med Inform Decis Mak. 2014;14:71.

4   [5] Lang ES, Wyer PC, Haynes RB. Knowledge translation:Closing the evidence-to-practice

5   gap. Ann Emerg Med. 2007;49:355-63.

6   [6] Institute of Medicine, Committee on quality of health care in America.Crossing the quality

7   chasm: a new health system for the 21st century. Washington, DC:National Academy

8   Press ;2001.

9   [7] Grimshaw JM, Thomas RE, MacLennan G, Fraser C, Ramsay CR, Vale L, et al.

10 Effectiveness and efficiency of guideline dissemination and implementation strategies. Health

11 Technol Assess. 2004;8:1-72.

12 [8] McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, et al. The quality of

13 health care delivered to adults in the United States. N Engl J Med. 2003;26:79-89.

14 [9] Gagliardi AR, Brouwers MC. Do guidelines offer implementation advice to target users? A

15 systematic review of guideline applicability. BMJ Open. 2015;5:e007047. doi:

16 10.1136/bmjopen-2014-007047.

17 [10] Ubbink DT, Vermeulen H, Knops AM, Legemate DA, Oude Rengerink K, Heineman MJ,

18 et al. Implementation of evidence-based practice: outside the box, throughout the hospital.

19 Neth J Med. 2011;69:87-94.

20

1   [11] Gagliardi AR, Brouwers MC, Palda VA, Lemieux-Charles L, Grimshaw JM. How can we

2   improve guideline use? A conceptual framework of implementability. Implement Sci.

3   2011;6:26.

4   [12] Grimshaw J, Eccles M, Tetroe J. Implementing clinical guidelines: current evidence and

5   future implications. J Contin Educ Health Prof. 2004;24 Suppl 1:S31-7. Review.

6   [13] Cochrane LJ, Olson CA, Murray S, Dupuis M, Tooman T, Hayes S. Gaps between

7   knowing and doing: understanding and assessing the barriers to optimal health care. J Contin

8   Educ Health Prof. 2007;27:94-102.

9   [14] Cabana MD, Rand CS, Powe NR, Wu AW, Wilson MH, Abboud PA, et al. Why don't

10   physicians follow clinical practice guidelines? A framework for improvement.

11   JAMA.1999;28:1458-65. Review.

12   [15] Barth JH, Misra S, Aakre KM, Langlois MR, Watine J, Twomey PJ, et al. Why are

13   clinical practice guidelines not followed? Clin Chem Lab Med.2016;54:1133-39.

14   [16] Taba P, Rosenthal M, Habicht J, Tarien H, Mathiesen M, Hill S, et al. Barriers and

15   facilitators to the implementation of clinical practice guidelines: a cross-sectional survey

16   among physicians in Estonia. BMC Health Serv Res.2012;12:455

17   [17] Lyons SS, Tripp-Reimer T, Sorofman BA, Dewitt JE, Bootsmiller BJ, Vaughn TE, et al.

18   VA QUERI informatics paper: information technology for clinical guideline implementation:

19   perceptions of multidisciplinary stakeholders. J Am Med Inform Assoc. 2005;12:64-71.

21

1   [18] De Vos M, Graafmans W, Kooistra M, Meijboom B, Van Der Voort P, Westert G. Using

2   quality indicators to improve hospital care: a review of the literature. Int J Qual Health

3   Care.2009;21;11.

4   [19] Jones SS, Rudin RS, Perry T, Shekelle PG. Health information technology: an updated

5   systematic review with a focus on meaningful use. Ann Intern Med. 2014;160: 48–54.

6   [20] Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, et al. Systematic review:

7   impact of health information technology on quality, efficiency, and costs of medical care. Ann

8   Intern Med. 2006;144: 742–52.

9   [21] Menachemi N, Chukmaitov A, Saunders C, Brooks RG. Hospital quality of care: does

10   information technology matter? The relationship between information technology adoption

11   and quality of care. Health Care Manage Rev. 2008;33: 51–9.

12   [22] Medical Information Network Distribution Service (Minds).

13   http://minds.jcqhc.or.jp/english/english.php (accessed 7 June 2018).

14   [23] Sasaki N, Lee J, Park S, Umegaki T, Kunisawa S, Otsubo T, et al. Development and

15   validation of an acute heart failure-specific mortality predictive model based on

16   administrative data. Can J Cardiol. 2013;29: 1055–61.

17   [24] Hamada H, Sekimoto M, Imanaka Y. Effects of the per diem prospective payment system

18   with DRG-like grouping system (DPC/PDPS) on resource usage and healthcare quality in

19   Japan. Health Policy. 2012;107:194-201.

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

26

27

28

29

30

31

32

33

34

35

36

37

38

39

40

41

42

43

44

45

46

47

48

49

50

51

52

53

54

55

56

57

58

59

60

1   [25] Japanese Association for Infectious Diseases, Japanese Society of Chemotherapy,ed.

2   Guidelines for antibiotic use. Tokyo; Kyowa Kikaku.2005-2010.[Only in Japanese]

3   [26] Kass, GV. An exploratory technique for investigating large quantities of categorical data.

4   Journal of Applied Statistics.1980;29, 119-127.

5   [27] Huang YH, Wu CY, Lin KC, Hsieh YW, Snow WM, Wang TN. Determinants of change

6   in stroke-specific quality of life after distributed constraint-induced therapy. Am J Occup Ther.

7   2013;67,54-63.

8   [28] Dudley WN, Dilorio C, Soet J. Detecting and explicating interactions in categorical data.

9   Nurs Res. 2000;49,53-6.

10   [29] Maeda A, Araujo E, Cashin C, Harris J, Ikegami N, Reich MR. Universal Health

11   Coverage for Inclusive and Sustainable Development:A Synthesis of 11 Country Case

12   Studies.Washington, DC; The World Bank.2014

13   [30] Séror AC. Internet infrastructures and health care systems: a qualitative comparative

14   analysis on networks and markets in the British National Health Service and Kaiser

15   Permanente. J Med Internet Res. 2002;4,E21.

16   [31] Peter J, Peredy G. The Permanente knowledge connection: A national

17   strategy for clinician use of web technology. Report of the web integration council -clinical

18   subcommittee. The Permanente Journal. 1998;2,69-75.

19   [32] King DN. The contribution of hospital library information services to clinical care: a

23

1   study in eight hospitals. Bull Med Libr Assoc. 1987;75,291-301.

2   [33] Weightman AL, Williamson J; Library & Knowledge Development Network (LKDN)

3   Quality and Statistics Group. The value and impact of information provided through library

4   services for patient care: a systematic review. Health Info Libr J. 2005,22,4-25.

5   [34] Chiu YW, Weng YH, Lo HL, Shih YH, Hsu CC, Kuo KN. Comparison of accessing

6   online databases between physicians and nurses in Taiwan. Inform Health Soc Care

7   2012;37:230-41.

8   [35] Doebbeling BN, Chou AF, Tierney WM. Priorities and strategies for the implementation

9   of integrated informatics and communications technology to improve evidence-based practice.

10   J Gen Intern Med. 2006;21:S50-7.

11

24

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Figure legends**

2 Figure 1. Flow diagram of the subject hospital selection process.

3 Figure 2. Information sources freely available or specifically provided by the participating

4 hospitals (153 hospitals).

5 Figure 3. Chi-squared automatic interaction detection tree diagram showing the determinants

6 of the QI score.

7 * These values indicate the numbers of positive responses to topics regarding (i) Electronic

8 health records and Internet availability, (ii) wireless LAN availability, and (iii) wired LAN

9 availability at outpatient clinics/wards. DB, database; LAN, local area network; QI, quality

10 indicator; SD, standard deviation.

25

1

Table 1. Characteristics of the hospitals and respondents [a] (153 hospitals)

Hospital characteristics	
Beds, mean±SD (range); median	339 ± 182 (63-1161); 303
Teaching hospitals, n（%）	115 (75.2)
Full-time physicians, mean±SD (range)	61.9±43.3 (8-268)
Resident physicians, mean±SD (range)	21.2±29.2 (0-197)
Respondent characteristics	n (%)
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)

[a] Respondents answered the questions as representatives of their hospital.

SD, standard deviation.

2

3

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1

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

Questionnaire topics	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		
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>	118	(77.1)
Medical databases such as UpToDate®, Clinical Key®, Ovid®, and DynaMed®	84	(54.9)
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 environment	84	(54.9)
Continuously working to improve library services and usability	60	(39.2)
Participation in hospital librarian associations and communication with other hospital librarians	25	(16.3)
Others	23	(15.0)

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

3

4

27

1

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

Number of topics with positive responses	Mean QI score	n
Hospital policies [a]		
0	78.73	4
1	81.92	51
2	84.95	29
3	78.92	69
IT infrastructure		
Accessibility to the Internet and other information sources [b]		
0	78.59	5
1	82.20	32
2	78.70	62
3	83.32	54
Access to paid medical evidence databases [c]		
0	72.55	25
1	79.76	54
2	84.88	74
Medical library and intranet usability within the hospital [d]		
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:

[a] 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.

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

[c] Two topics: provision of access to the Japanese medical database and access to English-language medical databases.

[d] 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.

2

28

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
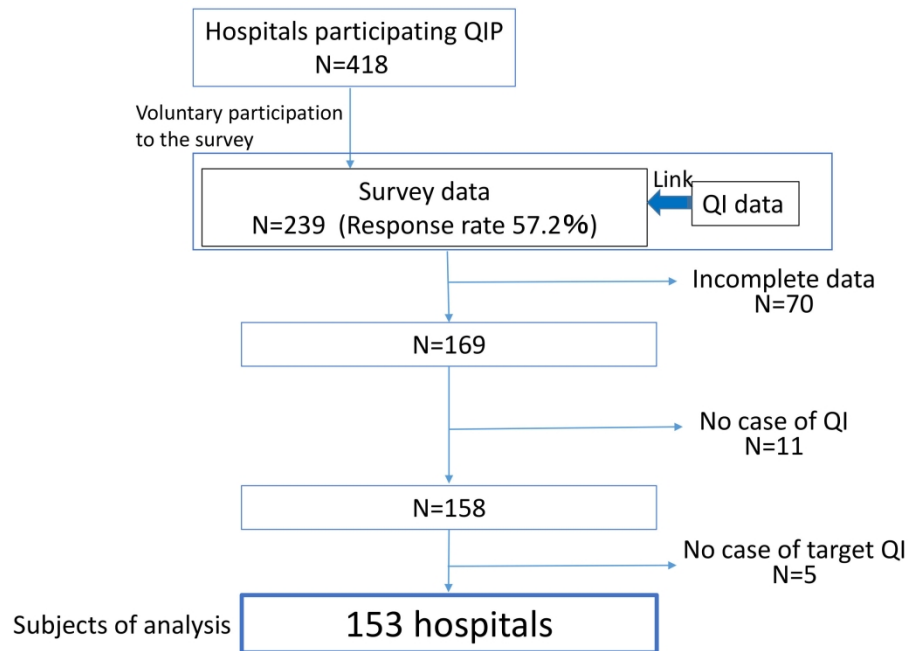
Figure 1. Flow diagram of the subject hospital selection process.

254x190mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
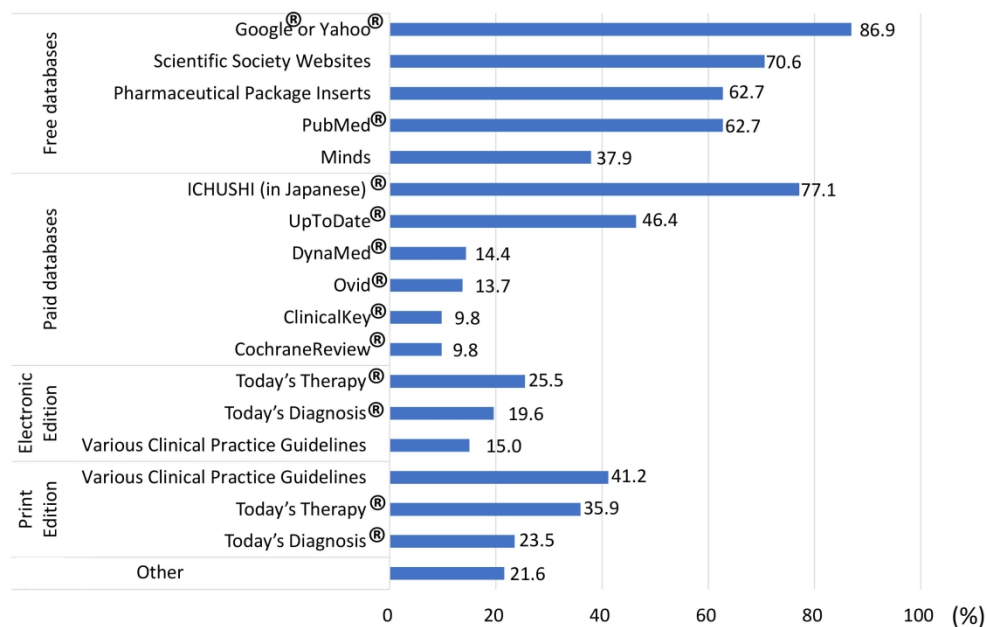42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

245x158mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

QI score

Node 0
Mean 81.1
SD 17.4
n(%)=153 (100)

P=0.002,F=9.604
df1=1, df2=151

Hospital size and teaching status

≤ 500-bed teaching
> 500-bed teaching/non-teaching

≤500-bed non-teaching

Node 1
Mean 83.3
SD 13.4
n(%)=119 (77.8)

Node 2
Mean 73.1
SD 25.9
n(%)=34 (22.2)

P=0.011,F=6.688
df1=1, df2=117

Paid medical databases

Japanese and/or English DBs

Node 3
Mean 84.5
SD 10.0
n(%)=104 (68.0)

Node 4
Mean 75.1
SD 26.4
n(%)=15 (9.8)

P=0.050,F=3.937
df1=1, df2=102

Accessibility to the Internet including LAN availability

0-2*

3*

Node 5
Mean 83.1
SD 10.8
n(%)=69 (45.1)
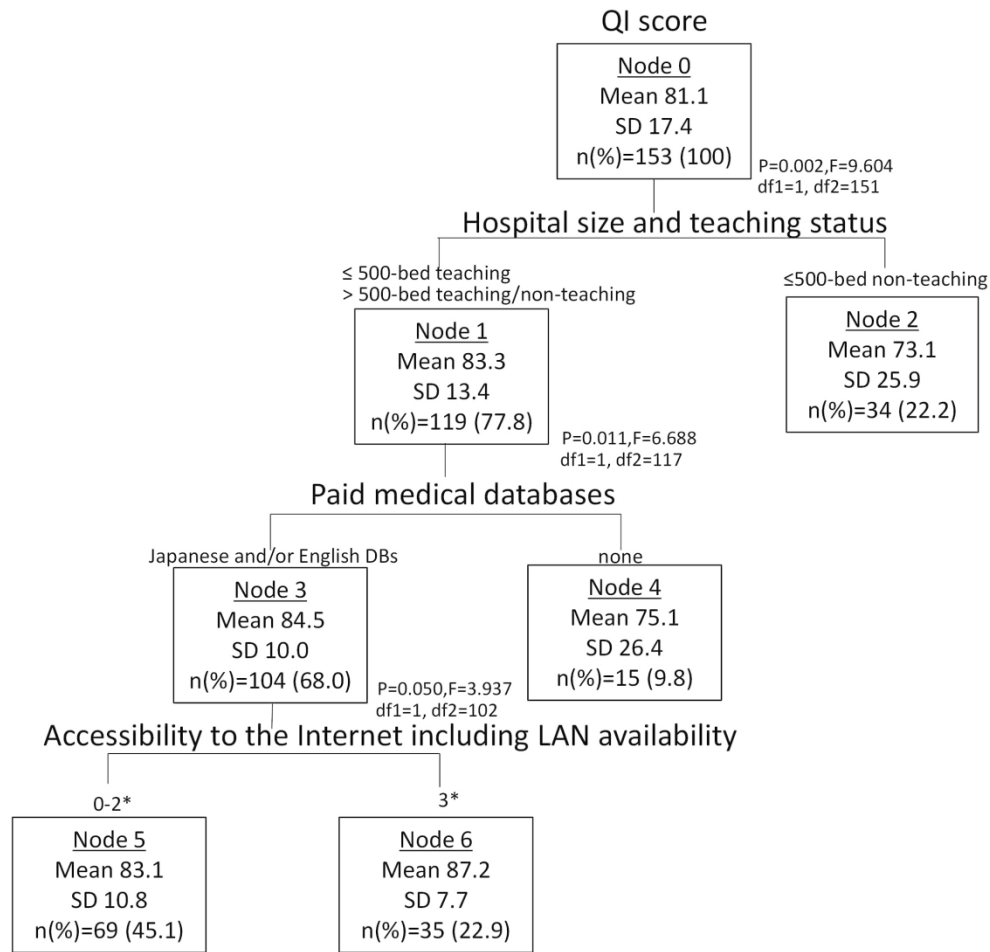
Node 6
Mean 87.2
SD 7.7
n(%)=35 (22.9)

Figure 3. Chi-squared automatic interaction detection tree diagram showing the determinants of the QI score.
* 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)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47

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

Section/Topic	Item #	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			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11, Fig1.
		(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 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 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.

BMJ Open

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

SCHOLARONE™
Manuscripts

1 **Does Hospital Information Technology Infrastructure Promote the Implementation of**

2 **Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals**

3

4 Noriko Sasaki, MD, PhD,[1] Naohito Yamaguchi, MD, PhD,[2] Akiko Okumura, MPH,[2]

5 Masahiro Yoshida, MD, PhD,[2] Hiroyuki Sugawara, MMS,[2] and Yuichi Imanaka, MD, PhD[1,2]

6 [1]Department of Healthcare Economics and Quality Management,

7 Kyoto University Graduate School of Medicine, Kyoto, Japan

8 [2] Japan Council for Quality Health Care, Tokyo, Japan

9

10

11

12

13 Correspondence to: Professor Yuichi Imanaka; imanaka-y@umin.net

1

1   **Abstract**

2   **Objectives:** 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.

2

1   **Conclusions:** Hospitals with superior IT infrastructure may provide higher-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.

3

Strengths and limitations of this study

- In this multicenter study, we observed wide variations in the provision of IT infrastructure across acute care hospitals in Japan.

- Hospitals with superior IT infrastructure tended to have higher adherence to CPGs for perioperative antibiotic prophylaxis.

- We found that a high level of access to paid medical evidence databases and accessibility to the Internet were the key factors of care quality in acute care hospitals using the CHAID analysis.

- We shed light on new knowledge that establishing a hospital IT infrastructure for medical information retrieval may promote greater awareness and adherence to CPGs by clinicians and narrow evidence-practice gaps.

- The QI of adherence to CPGs for perioperative antibiotic use describe only one aspect of healthcare quality; that the survey was conducted only in Japan and may limit generalizability.

4

1. Introduction

Due to the growth of renewed medical information and frequent updates to clinical practice

guidelines (CPGs) in the Internet era, clinicians can find it difficult to keep abreast of the

latest evidence. The availability and usability of hospital information technology (IT)

infrastructure such as wireless local area networks (LAN) and medical evidence databases

may affect the ability of clinicians to update their knowledge and practice, which can

influence the quality of provided care. These infrastructure elements may facilitate

accessibility to various updated CPGs, which would be essential for CPG implementation in

daily practice [1].

CPGs for various diseases have been developed worldwide not only to help clinicians but

also to promote shared decision making with patients [2-4]. However, CPGs continue to be

underused even in countries even where CPGs are well developed over the past several

decades. These gaps between medical evidence and clinical practice (i.e., "evidence-practice

gaps") can lead to the provision of substandard or potentially harmful care to patients [5-11].

System-level barriers as well as individual-level barriers to evidence-based practice have been

revealed in previous studies [12-17]. For example, institutional equipment, technological

capital, and accessibility to guideline-related resources have been found to be important in

addition to individual awareness, familiarity and agreement with the contents [15-17].

Clinical quality indicators (QIs) can monitor clinicians' adherence to the guidelines, but they

5

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

6

1
2
3   1   **2. Methods**
4
5
6
7   2   *2.1. Data sources*
8
9
10   3   This study employed both primary data (based on a questionnaire survey of hospital
11
12
13   4   administrators) and secondary data (administrative claims data) in the analysis. Data were
14
15
16   5   obtained from hospitals enrolled in the Quality Indicator/Improvement Project (QIP), which is
17
18
19   6   an ongoing project launched in 1995 to monitor and improve clinical performance in acute
20
21
22   7   care hospitals across Japan through the analysis of administrative claims data [23,24].
23
24
25   8   Currently, over 500 QIP member hospitals voluntarily submit data for analysis, and the
26
27
28   9   project generates periodic reports of clinical and economic performance. The participating
29
30
31   10   hospitals vary widely in type (e.g., teaching status and hospital ownership), region of location,
32
33
34   11   patient and physician volume, bed numbers, and composition of specialties.
35
36
37   12   The Minds-QIP project, as a part of the activities of the Minds Guideline Center, was
38
39
40   13   initiated in 2014, with the objective of effectively implementing and disseminating CPGs
41
42
43   14   across Japan. A survey was conducted as part of this project by mailing questionnaires to the
44
45
46   15   hospital administrators (including general managers) of QIP member hospitals between
47
48
49   16   January and March 2015. The questionnaire included items on hospital policies regarding
50
51
52   17   evidence-based practice and hospital IT infrastructure, actual provision of IT infrastructure
53
54
55   18   (including LAN deployment and usability of medical evidence databases), QI monitoring, and
56
57
58   19   the use of clinical pathways. This study focused on hospital policies and IT infrastructure. The
59
60

7

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

7 *2.2. Hospital policy and IT infrastructure*

8 In order to identify each hospital's policies promoting evidence-based practice, the

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

10 infrastructure in order to improve accessibility to medical information, whether it explicitly

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

12 the use of CPGs.

13   The questionnaire was also designed to focus on the following three elements of hospital

14 IT infrastructure: (i) accessibility to the Internet and other information sources, including

15 wired/wireless LAN availability; (ii) access to paid medical evidence databases in English and

16 Japanese; and (iii) medical library and intranet usability, such as the availability of a

17 well-organized intranet interface, number of full-time medical librarians, and activities for

18 improving the medical library.

19

8

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

9

1   *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

1   tree algorithm that is often utilized as a data mining method in fields with complex data sets,

2   such as marketing, health care [27], and nursing [28]. We used the exhaustive CHAID

3   algorithm, a modified version of the basic algorithm that performs a more thorough merging

4   and testing of independent variables [29]. Statistical calculations were performed using SPSS

5   20.0J software and Decision Tree (SPSS Inc, Chicago, IL).

6   *2.5. Patient and public involvement*

7   There was no patients or public involvement in the design and analysis of this study.

8

9   **3. Results**

10 *3.1. Baseline characteristics, hospital policy, and IT infrastructure*

11 From the 239 hospitals that responded to the questionnaire (response rate: 57.2%), we were

12 able to calculate and integrate the target QI data for 153 hospitals. Hospitals with data on at

13 least one target QI were included. The hospital selection flow diagram is presented in Figure 1.

14 The baseline characteristics of the participant hospitals and respondents are shown in Table 1.

15 The median number of hospital beds was 303 (range: 63–1161). Approximately 75% of all

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

17 hospital was approximately 21.

18   Table 2 shows the results of the survey on hospital policies and IT infrastructure. Almost

11

1 all respondents reported that their hospitals had an explicit policy to enhance IT infrastructure

2 (94.1%). However, the provision of wireless LAN (71.9%) and access to paid medical

3 evidence databases in English (54.9%) was limited. Further, an intranet homepage was

4 provided only in a minority of hospitals (27.5%).

5 Figure 2 shows the information sources freely available or specifically provided by the

6 participating hospitals. There were large variations in the provision of paid medical evidence

7 databases, and hospitals tended to subscribe to the Japanese-language database (77.1%) rather

8 than the English-language databases (9.8–46.4%). In general, the print editions of various

9 CPGs and medical information were provided more frequently than the electronic editions,

10 and there were relatively few hospitals that provided CPGs in either edition (41.2% in the

11 print edition and 15.0% in the electronic edition).

12

13 **3.2. Correlates of hospital quality of care**

14 Table 3 shows the mean QI scores for the use of perioperative antibiotics according to the

15 various independent variables. Hospitals with a lower number of positive responses to items

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

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

18 teaching status were the strongest correlates. The subgroup of "≤500-bed non-teaching

19 hospitals" had the lowest QI score (73.1 points, Node 2). The other subgroup (comprising

12

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

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

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

13

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

14

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

15

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.

16

1
2
3
4 1   Our findings suggest that larger or teaching hospitals would have the most potential for
5
6
7 2 improvements in IT infrastructure that can lead to better quality of care (see Nodes 4, 5, and 6
8
9
10 3 in Fig. 3). As Doebbeling et al. noted, IT implementation is dependent on the support of
11
12
13 4 hospital management and "should be tailored to the needs of the organization, and not as a
14
15
16 5 'one size fits all' solution" [36]. It is also necessary to conduct balanced assessments of the
17
18
19 6 costs and effectiveness of these IT infrastructures in order to efficiently support the
20
21
22 7 implementation of evidence into practice under limited budgets.
23
24
25 8   In a broader context, barriers to implementing CPG recommendations in daily practice
26
27
28 9 vary greatly at the individual level of specialists and physicians (e.g.perception, education,
29
30
31 10 incentives, professional autonomy), the institutional level (e.g., physician leadership, hospital
32
33
34 11 policies, finance, institutional culture, teamwork, IT infrastructure), national level (e.g.,
35
36
37 12 policies to promote CPG use, hospital accreditation) and the societal level (e.g.a culture of
38
39
40 13 shared-decision making with patients, information derived from mass media) [37,38,39]. Yet,
41
42
43 14 given the growing importance of IT use in an innovative society, the impact of IT adoption on
44
45
46 15 healthcare quality warrants far more consideration of the types of relationships that were
47
48
49 16 revealed in this study. According to previous research, IT itself needs to be understood as
50
51
52 17 having two distinct components—information technology and communication
53
54
55 18 technology—and these differently affect the autonomy of workers [40]. Further examination
56
57
58 19 is needed to clarify these issues in order to implement IT in practice settings.
59
60

17

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

18

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **5. Conclusions**

2 Hospitals with superior IT infrastructure may provide higher-quality care. The provision of

3 access to paid medical evidence databases and accessibility to the Internet were strongly

4 associated with hospital quality of care, and may be key factors for improving healthcare

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

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

7 and facilitate the dissemination of CPGs in the Internet era. Hospitals should focus on

8 establishing adequate IT infrastructure to support the effective implementation of CPGs. The

9 systematic improvement of IT infrastructure in hospitals may support greater adherence to

10 CPGs and narrow the evidence-practice gaps.

11 **Acknowledgements**

12 We are grateful to all hospital administrators in the QIP hospitals who participated in this

13 questionnaire survey. Furthermore, we sincerely appreciate the interviewees of several

14 leading teaching hospitals for their time and assistance. Finally, we thank all staff at the

15 Department of EBM and Guidelines, Japan Council for Quality Health Care who were

16 involved in the Minds-QIP project.

17 **Contributors**

18 NS and YI had full access to all the data in the study and take responsibility for the analysis

19 and interpretation. Conception and design:NS,YI; Acquisition of data and analysis:NS, YI;

19

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

2   analysis:NS,YI; Obtaining funding:NY,YI. All the authors (NS, NY,AO, MY, HS, and YI)

3   were involved in critical revisions and approved the final manuscript for publication.

4   **Funding**

5   This research was financially supported by the Ministry of Health, Labour and Welfare of

6   Japan and Japan Council for Quality Health Care.

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

11   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.

20

1   **Data sharing statement**

2   No data are available.

3   **REFERENCES**

4   [1] Gray P, Olfman L. Careers and education in information systems. In:Bates MJ,

5   editor.Understanding information retrieval systems:management, types and standards.Boca

6   Raton: CRC Press; 2011. p. 91-110.

7   [2] van der Weijden T, Pieterse AH, Koelewijn-van Loon MS, Knaapen L, Légaré F, Boivin

8   A, et al. How can clinical practice guidelines be adapted to facilitate shared decision making?

9   A qualitative key-informant study. BMJ Qual Saf. 2013;22:855-63

10   [3] Légaré F, Witteman HO. Shared decision making: examining key elements and barriers to

11   adoption into routine clinical practice. Health Aff. 2013;32:276-84.

12   [4] Blanc X, Collet TH, Auer R, Fischer R, Locatelli I, Iriarte P, et al. Publication trends of

13   shared decision making in 15 high impact medical journals: a full-text review with

14   bibliometric analysis. BMC Med Inform Decis Mak. 2014;14:71.

15   [5] Lang ES, Wyer PC, Haynes RB. Knowledge translation:Closing the evidence-to-practice

16   gap. Ann Emerg Med. 2007;49:355-63.

17   [6] Institute of Medicine, Committee on quality of health care in America.Crossing the quality

18   chasm: a new health system for the 21st century. Washington, DC:National Academy

19   Press ;2001.

21

1   [7] Grimshaw JM, Thomas RE, MacLennan G, Fraser C, Ramsay CR, Vale L, et al.

2   Effectiveness and efficiency of guideline dissemination and implementation strategies. Health

3   Technol Assess. 2004;8:1-72.

4   [8] McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, et al. The quality of

5   health care delivered to adults in the United States. N Engl J Med. 2003;26:79-89.

6   [9] Gagliardi AR, Brouwers MC. Do guidelines offer implementation advice to target users?

7   A systematic review of guideline applicability. BMJ Open. 2015;5:e007047. doi:

8   10.1136/bmjopen-2014-007047.

9   [10] Ubbink DT, Vermeulen H, Knops AM, Legemate DA, Oude Rengerink K, Heineman MJ,

10 et al. Implementation of evidence-based practice: outside the box, throughout the hospital.

11 Neth J Med. 2011;69:87-94.

12 [11] Gagliardi AR, Brouwers MC, Palda VA, Lemieux-Charles L, Grimshaw JM. How can

13 we improve guideline use? A conceptual framework of implementability. Implement Sci.

14 2011;6:26.

15 [12] Grimshaw J, Eccles M, Tetroe J. Implementing clinical guidelines: current evidence and

16 future implications. J Contin Educ Health Prof. 2004;24 Suppl 1:S31-7. Review.

17 [13] Cochrane LJ, Olson CA, Murray S, Dupuis M, Tooman T, Hayes S. Gaps between

18 knowing and doing: understanding and assessing the barriers to optimal health care. J Contin

19 Educ Health Prof. 2007;27:94-102.

1   [14] Cabana MD, Rand CS, Powe NR, Wu AW, Wilson MH, Abboud PA, et al. Why don't

2   physicians follow clinical practice guidelines? A framework for improvement.

3   JAMA.1999;28:1458-65. Review.

4   [15] Barth JH, Misra S, Aakre KM, Langlois MR, Watine J, Twomey PJ, et al. Why are

5   clinical practice guidelines not followed? Clin Chem Lab Med.2016;54:1133-39.

6   [16] Taba P, Rosenthal M, Habicht J, Tarien H, Mathiesen M, Hill S, et al. Barriers and

7   facilitators to the implementation of clinical practice guidelines: a cross-sectional survey

8   among physicians in Estonia. BMC Health Serv Res.2012;12:455

9   [17] Lyons SS, Tripp-Reimer T, Sorofman BA, Dewitt JE, Bootsmiller BJ, Vaughn TE, et al.

10 VA QUERI informatics paper: information technology for clinical guideline implementation:

11 perceptions of multidisciplinary stakeholders. J Am Med Inform Assoc. 2005;12:64-71.

12 [18] De Vos M, Graafmans W, Kooistra M, Meijboom B, Van Der Voort P, Westert G. Using

13 quality indicators to improve hospital care: a review of the literature. Int J Qual Health

14 Care.2009;21;11.

15 [19] Jones SS, Rudin RS, Perry T, Shekelle PG. Health information technology: an updated

16 systematic review with a focus on meaningful use. Ann Intern Med. 2014;160: 48–54.

17 [20] Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, et al. Systematic review:

18 impact of health information technology on quality, efficiency, and costs of medical care. Ann

19 Intern Med. 2006;144: 742–52.

23

1   [21] Menachemi N, Chukmaitov A, Saunders C, Brooks RG. Hospital quality of care: does

2   information technology matter? The relationship between information technology adoption

3   and quality of care. Health Care Manage Rev. 2008;33: 51–9.

4   [22] Medical Information Network Distribution Service (Minds).

5   http://minds.jcqhc.or.jp/english/english.php (accessed 7 June 2018).

6   [23] Sasaki N, Lee J, Park S, Umegaki T, Kunisawa S, Otsubo T, et al. Development and

7   validation of an acute heart failure-specific mortality predictive model based on

8   administrative data. Can J Cardiol. 2013;29: 1055–61.

9   [24] Hamada H, Sekimoto M, Imanaka Y. Effects of the per diem prospective payment

10   system with DRG-like grouping system (DPC/PDPS) on resource usage and healthcare

11   quality in Japan. Health Policy. 2012;107:194-201.

12   [25] Japanese Association for Infectious Diseases, Japanese Society of Chemotherapy,ed.

13   Guidelines for antibiotic use. Tokyo; Kyowa Kikaku.2005-2010.[Only in Japanese]

14   [26] Kass, GV. An exploratory technique for investigating large quantities of categorical data.

15   Journal of Applied Statistics.1980;29, 119-127.

16   [27] Huang YH, Wu CY, Lin KC, Hsieh YW, Snow WM, Wang TN. Determinants of change

17   in stroke-specific quality of life after distributed constraint-induced therapy. Am J Occup Ther.

18   2013;67,54-63.

19   [28] Dudley WN, Dilorio C, Soet J. Detecting and explicating interactions in categorical data.

24

1   Nurs Res. 2000;49,53-6.

2   [29] Nisbet R, Elder J, Miner G.Handbook of Statistical Analysis and Data Mining

3   Applications.Academic Press. 2009

4   [30] Maeda A, Araujo E, Cashin C, Harris J, Ikegami N, Reich MR. Universal Health

5   Coverage for Inclusive and Sustainable Development:A Synthesis of 11 Country Case

6   Studies.Washington, DC; The World Bank.2014

7   [31] Séror AC. Internet infrastructures and health care systems: a qualitative comparative

8   analysis on networks and markets in the British National Health Service and Kaiser

9   Permanente. J Med Internet Res. 2002;4,E21.

10   [32] Peter J, Peredy G. The Permanente knowledge connection: A national

11   strategy for clinician use of web technology. Report of the web integration council -clinical

12   subcommittee. The Permanente Journal. 1998;2,69-75.

13   [33] King DN. The contribution of hospital library information services to clinical care: a

14   study in eight hospitals. Bull Med Libr Assoc. 1987;75,291-301.

15   [34] Weightman AL, Williamson J; Library & Knowledge Development Network (LKDN)

16   Quality and Statistics Group. The value and impact of information provided through library

17   services for patient care: a systematic review. Health Info Libr J. 2005,22,4-25.

18   [35] Chiu YW, Weng YH, Lo HL, Shih YH, Hsu CC, Kuo KN. Comparison of accessing

19   online databases between physicians and nurses in Taiwan. Inform Health Soc Care

1   2012;37:230-41.

2   [36] Doebbeling BN, Chou AF, Tierney WM. Priorities and strategies for the implementation

3   of integrated informatics and communications technology to improve evidence-based practice.

4   J Gen Intern Med. 2006;21:S50-7.

5   [37] Ministerio de Salud y Protección Social. Implementation manual for evidence-based

6   clinical practice guidelines in health institutions in colombia.2014.

7   http://gpc.minsalud.gov.co/recursos/Documentos%20compartidos/Implementation_guide_ing

8   les.pdf (accessed 13 February 2019)

9   [38] Hamilton AB, Mittman BS.Implementation science in health care. In:Brownson RC, et al,

10   editor.Dissemination and implementation research in health:translating science into

11   practice.2nd ed.New York: Oxford University Press; 2018. p. 385-400.

12   [39] Goodall AH. Physician-leaders and hospital performance: is there an association?

13   Soc Sci Med. 2011;73:535-539.

14   [40] Bloom N, Garicano L, Sadun R,Van Reenen J.The distinct effects of information

15   technology and communication technology on firm organization. Management

16   Science.2014;60:2859-2885.

26

1   **Figure legends**

2   Figure 1. Flow diagram of the subject hospital selection process.

3   *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).

7   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.

27

1

Table 1. Characteristics of the hospitals and respondents[a] (153 hospitals)

Hospital characteristics	
Beds, mean±SD (range); median	339 ± 182 (63-1161); 303
Teaching hospitals, n（%）	115 (75.2)
Hospital size, n（%）	
>500 beds	25 (16.3)
≦500 beds	128 (83.7)
Full-time physicians, mean±SD (range)	61.9±43.3 (8-268)
Resident physicians, mean±SD (range)	21.2±29.2 (0-197)
Respondent characteristics	n (%)
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)

[a] Respondents answered the questions as representatives of their hospital.

SD, standard deviation.

2

28

1

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

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		
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>	118	(77.1)
Medical databases such as UpToDate®, Clinical Key®, Ovid®, and DynaMed®	84	(54.9)
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 environment	84	(54.9)
Continuously working to improve library services and usability	60	(39.2)
Participation in hospital librarian associations and communication with other hospital librarians	25	(16.3)
Other	23	(15.0)

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

3

29

1

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

Number of questionnaire items with positive responses	Mean QI score	n
Hospital policies [a]		
0	78.73	4
1	81.92	51
2	84.95	29
3	78.92	69
IT infrastructure		
Accessibility to the Internet and other information sources [b]		
0	78.59	5
1	82.20	32
2	78.70	62
3	83.32	54
Access to paid medical evidence databases [c]		
0	72.55	25
1	79.76	54
2	84.88	74
Medical library and intranet usability within the hospital [d]		
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 items are as follows:

[a] 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.

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

[c] Two items: provision of access to the Japanese medical database and access to English-language
medical databases.

[d] 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.

2

30

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Figure 1. Flow diagram of the subject hospital selection process.
*Target QI indicates QI of perioperative antibiotic prophylaxis of the 11 surgical procedures mentioned in the manuscript.

254x190mm (300 x 300 DPI)

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

245x158mm (300 x 300 DPI)

QI score

Node 0
Mean 81.1
SD 17.4
n(%)=153 (100)

P=0.002,F=9.604
df1=1, df2=151

Hospital size and teaching status

≤ 500-bed teaching
> 500-bed teaching/non-teaching

≤500-bed non-teaching

Node 1
Mean 83.3
SD 13.4
n(%)=119 (77.8)

Node 2
Mean 73.1
SD 25.9
n(%)=34 (22.2)

P=0.011,F=6.688
df1=1, df2=117

Paid medical databases

Japanese and/or English DBs

Node 3
Mean 84.5
SD 10.0
n(%)=104 (68.0)

Node 4
Mean 75.1
SD 26.4
n(%)=15 (9.8)

P=0.050**,F=3.937
df1=1, df2=102

Accessibility to the Internet including LAN availability

0-2*

3*

Node 5
Mean 83.1
SD 10.8
n(%)=69 (45.1)

Node 6
Mean 87.2
SD 7.7
n(%)=35 (22.9)

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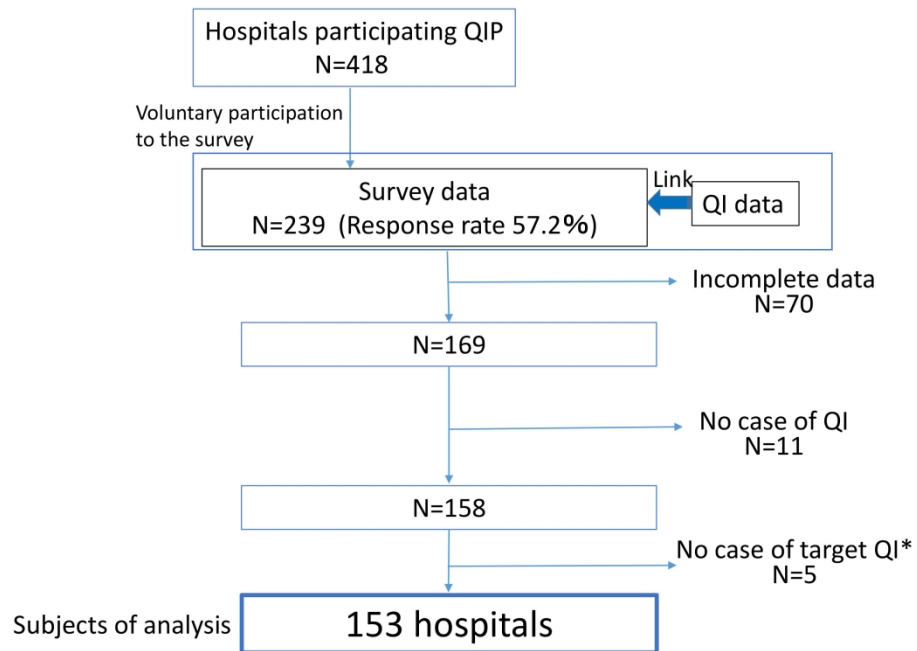* These values indicate the numbers of positive responses to questionnaire items related to (i) Electronic health records and Internet availability, (ii) wireless LAN availability, and (iii) wired LAN availability at outpatient clinics/wards. DB, database; LAN, local area network; QI, quality indicator;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

254x190mm (300 x 300 DPI)

Appendix_Table. Original Questions

Q1-1. Does your hospital have an explicit policy to enhance IT infrastructure in order to improve accessibility to medical information?
   □ Yes   □ No   □ Other

Q1-2. What information sources are available in your hospital? (Please choose all options that would apply)
   □ 1. PubMed □2. Google/Yahoo □3. Pharmaceutical Package Inserts □ 4. Pharmaceutical Interview Forms
   □ 5. Scientific Society Websites □ 6. MINDS
   □ 7. *Igaku Chuo Zasshi* (ICHUSHI) Medical Literature Database [**Hospital** Subscription]
   □ 8. *Igaku Chuo Zasshi* (ICHUSHI) Medical Literature Database [**Medical Office** Subscription]
   □ 9. UpToDate [**Hospital** Subscription] □ 10. UpToDate [**Medical Office** Subscription]
   □ 11. Cochrane Review   □ 12. ClinicalKey   □13. Ovid   □ 14. DynaMed
   □ 15. *Today's Diagnosis* [**Electronic Edition**]   □ 16. *Today's Therapy* [**Electronic Edition**]
   □ 17. Various Clinical Practice Guidelines [**Electronic Versions**]
   □ 18. *Today's Diagnosis* [**Print Edition**]   □ 19. *Today's Therapy* [**Print Edition**]
   □ 20. Various Clinical Practice Guidelines [**Print Versions**]   □21. Other

Q2-1. 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 own computers to access the Internet.
   □ EHRs are not available.
   □ Other

Q2-2. Is *wireless* LAN available in your hospital?
   □Yes, available with no limitations.   □Yes, with limited access points.   □ No, not available.

Q2-3. Where are the major locations in your hospital for Internet use with *wired* LAN access? *(Multiple answers allowed)*
   □ Outpatient clinics   □ Wards   □ Medical offices   □ Libraries
   □ Other

Q3-1. How many librarians are there in your hospital?
   □ Full-time: □ Part-time:

Q3-2. Does your hospital provide an intranet homepage with user-friendly interface?
   □ Yes   □ No   □ Other

Q3-3. Which applies to your hospital regarding medical library activities? *(Multiple answers allowed)*
   □ 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

Q4. Do you have an explicit recommendation for the utilization of evidence-based medicine in your hospital?
   □ Yes   □ No   □ Other

Q5. Do you have an explicit recommendation for adherence to clinical practice guidelines in your hospital?
   □ Yes   □ No   □ Other

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

Section/Topic	Item #	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	2,7-11
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 modifiers. Give 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 groupings 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	*
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11, Fig1.
		(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 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 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, 17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	4,13-18
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 the 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 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.

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
Article Type:	Research
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
Primary Subject Heading:	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

SCHOLARONE™
Manuscripts

1 **Does Hospital Information Technology Infrastructure Promote the Implementation of**

2 **Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals**

3

4 Noriko Sasaki, MD, PhD,[1] Naohito Yamaguchi, MD, PhD,[2] Akiko Okumura, MPH,[2]

5 Masahiro Yoshida, MD, PhD, [2] Hiroyuki Sugawara, MMS, [2] and Yuichi Imanaka, MD, PhD[1,2]

6 [1]Department of Healthcare Economics and Quality Management,

7 Kyoto University Graduate School of Medicine, Kyoto, Japan

8 [2] Japan Council for Quality Health Care, Tokyo, Japan

9

10

11

12

13 Correspondence to: Professor Yuichi Imanaka; imanaka-y@umin.net

1

1   **Abstract**

2   **Objectives:** 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.

2

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Conclusions:** Hospitals with superior IT infrastructure may provide higher-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.

3

Strengths and limitations of this study

- We integrated a hospital questionnaire survey and administrative claims data at hospital level in the analysis.

- We described the present state of IT infrastructure of Japanese acute care hospitals and investigated its association with a composite quality indicator of adherence to the guidelines for perioperative antibiotic prophylaxis, using a chi-squared automatic interaction detection analysis.

- As an infrastructure to promote evidence-based practice, we focused on IT infrastructure such as accessibility to the Internet and other information sources, access to paid medical evidence databases, and medical library and intranet usability within hospitals.

- The QI that we used was limited to adherence to the guidelines for perioperative antibiotic use and therefore describes only one aspect of healthcare quality.

- As we used administrative claims data, we could not know the clinical information in detail including appropriate exceptions in clinical practice.

4

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **1. Introduction**

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

5

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

6

1
2
3   1   **2. Methods**
4
5
6
7   2   *2.1. Data sources*
8
9
10   3   We integrated a hospital questionnaire survey and administrative claims data at hospital level
11
12
13   4   in the analysis. Data were obtained from hospitals enrolled in the Quality
14
15
16   5   Indicator/Improvement Project (QIP), which is an ongoing project launched in 1995 to
17
18
19   6   monitor and improve clinical performance in acute care hospitals across Japan through the
20
21
22   7   analysis of administrative claims data [23,24]. Currently, over 500 QIP member hospitals
23
24
25   8   voluntarily submit data for analysis, and the project generates periodic reports of clinical and
26
27
28   9   economic performance. The participating hospitals vary widely in type (e.g., teaching status
29
30
31   10   and hospital ownership), region of location, patient and physician volume, bed numbers, and
32
33
34   11   composition of specialties.
35
36
37   12   The Minds-QIP project, as a part of the activities of the Minds Guideline Center, was
38
39
40   13   initiated in 2014, with the objective of effectively implementing and disseminating CPGs
41
42
43   14   across Japan. A survey was conducted as part of this project by mailing questionnaires to the
44
45
46   15   hospital administrators (including general managers) of QIP member hospitals between
47
48
49   16   January and March 2015. The questionnaire included items on hospital policies regarding
50
51
52   17   evidence-based practice and hospital IT infrastructure, actual provision of IT infrastructure
53
54
55   18   (including LAN deployment and usability of medical evidence databases), QI monitoring, and
56
57
58   19   the use of clinical pathways. This study focused on hospital policies and IT infrastructure. The
59
60

7

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

7   *2.2. Hospital policy and IT infrastructure*

8   In order to identify each hospital's policies promoting evidence-based practice, the

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.

13   The questionnaire was also designed to focus on the following three elements of hospital

14   IT infrastructure: (i) accessibility to the Internet and other information sources, including

15   wired/wireless LAN availability; (ii) access to paid medical evidence databases in English and

16   Japanese; and (iii) medical library and intranet usability, such as the availability of a

17   well-organized intranet interface, number of full-time medical librarians, and activities for

18   improving the medical library.

19

8

1
2
3
4   1   *2.3. Hospital quality of care*
5
6
7   2   As a measure of hospital quality of care, a QI of adherence to CPGs for perioperative
8
9
10   3   antibiotic prophylaxis was calculated using diagnosis procedure combination (DPC)
11
12
13   4   administrative claims data from the QIP. The DPC is a Japanese case-mix classification
14
15
16   5   system for hospital reimbursements, and more than 1600 hospitals nationwide had adopted
17
18
19   6   this system by 2016. The DPC database includes information on hospital codes, patient
20
21
22   7   demographics, admission and discharge dates, admission routes, outcomes, primary and
23
24
25   8   secondary diagnoses based on International Classification of Diseases (10th revision) codes,
26
27
28   9   comorbidities, complications, surgeries performed, and high cost procedures [23,24]. DPC
29
30
31   10   data from April 2013 to March 2014 were used as these were the most recent data available
32
33
34   11   for analysis.
35
36
37   12   The QI of interest for this study was a composite score (range: 0 to 100) that indicated a
38
39
40   13   hospital's proportion of adherence to CPGs for perioperative antibiotic prophylaxis [25], and
41
42
43   14   was aggregated from the results of the following 11 surgical types (i.e., target QI in Fig.1) :
44
45
46   15   evacuation of intracranial hematoma, gastrectomy, cholecystectomy, total hip replacement,
47
48
49   16   mastectomy for breast cancer, thyroid surgery, prostate cancer surgery, uterine myoma
50
51
52   17   surgery, uterine cancer surgery, benign ovarian tumor surgery, and ovarian cancer surgery.
53
54
55   18   The QI score was calculated based on the administrative data when and what kind of the
56
57
58   19   antibiotics were used, and this medication information is very precise in the Japanese
59
60

9

1   administrative data. Therefore, the QI score is accurate in any hospital.

2

3   *2.4. Statistical analysis*

4   We first calculated descriptive statistics for the hospitals' and respondents' baseline

5   characteristics, which included hospital bed numbers, teaching status, number of full-time

6   physicians, number of resident physicians (representing younger physicians who may be more

7   likely to incorporate IT into their practice), as well as respondent sex, age, and appointment.

8   The responses to the questionnaire items related to hospital policies and IT infrastructure were

9   also summarized. The main items of interest consisted of yes/no questions; we calculated each

10 hospital's number of positive responses within each item. The hospitals were categorized into

11 subgroups based on these response numbers, and the mean QI score was calculated for each

12 subgroup.

13 Finally, we performed a chi-squared automatic interaction detection (CHAID) tree

14 analysis to identify factors that determine hospital quality of care. The independent variables

15 included hospital size and teaching status, hospital policies regarding the promotion of

16 evidence-based practice, and IT infrastructure (accessibility to the Internet and other

17 information sources, access to paid medical evidence databases, and medical library and

18 intranet usability within hospitals). The dependent variable was the mean QI score for

19 perioperative antibiotic prophylaxis. CHAID tree analysis repeatedly uses chi-square statistics

10

1   to split independent variables into child nodes [26-28] to identify the relative interactions

2   between the independent variables and the outcome variables. This method is a classification

3   tree algorithm that is often utilized as a data mining method in fields with complex data sets,

4   such as marketing, health care [27], and nursing [28]. We used the exhaustive CHAID

5   algorithm, a modified version of the basic algorithm that performs a more thorough merging

6   and testing of independent variables [29]. Statistical calculations were performed using SPSS

7   20.0J software and Decision Tree (SPSS Inc, Chicago, IL).

8   *2.5. Patient and public involvement*

9   There was no patients or public involvement in the design and analysis of this study.

10

11   **3. Results**

12   *3.1. Baseline characteristics, hospital policy, and IT infrastructure*

13   From the 239 hospitals that responded to the questionnaire (response rate: 57.2%), we were

14   able to calculate and integrate the target QI data for 153 hospitals. Hospitals with data on at

15   least one target QI were included. The hospital selection flow diagram is presented in Figure 1.

16   The baseline characteristics of the participant hospitals and respondents are shown in Table 1.

17   The median number of hospital beds was 303 (range: 63–1161). Approximately 75% of all

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

11

1   hospital was approximately 21.

2   Table 2 shows the results of the survey on hospital policies and IT infrastructure. Almost

3   all respondents reported that their hospitals had an explicit policy to enhance IT infrastructure

4   (94.1%). However, the provision of wireless LAN (71.9%) and access to paid medical

5   evidence databases in English (54.9%) was limited. Further, an intranet homepage was

6   provided only in a minority of hospitals (27.5%).

7   Figure 2 shows the information sources freely available or specifically provided by the

8   participating hospitals. There were large variations in the provision of paid medical evidence

9   databases, and hospitals tended to subscribe to the Japanese-language database (77.1%) rather

10 than the English-language databases (9.8–46.4%). In general, the print editions of various

11 CPGs and medical information were provided more frequently than the electronic editions,

12 and there were relatively few hospitals that provided CPGs in either edition (41.2% in the

13 print edition and 15.0% in the electronic edition).

14

15 *3.2. Correlates of hospital quality of care*

16 Table 3 shows the mean QI scores for the use of perioperative antibiotics according to the

17 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

12

1   teaching status were the strongest correlates. The subgroup of "≤ 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

19   tended to have higher adherence to CPGs for perioperative antibiotic prophylaxis. Using a

13

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

14

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

15

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

16

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,

17

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

18

1 accurately based on the information of surgical procedure and drug use from the database.

2 Finally, we were not able to identify the amount of investment or the affordability of each

3 hospital's IT infrastructure, and further studies are needed to examine the total effect of these

4 issues on the quality of hospital care.

5

5. Conclusions

7 Hospitals with superior IT infrastructure may provide higher-quality care. The provision of

8 access to paid medical evidence databases and accessibility to the Internet were strongly

9 associated with hospital quality of care, and may be key factors for improving healthcare

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

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

12 and facilitate the dissemination of CPGs in the Internet era. Hospitals should focus on

13 establishing adequate IT infrastructure to support the effective implementation of CPGs. The

14 systematic improvement of IT infrastructure in hospitals may support greater adherence to

15 CPGs and narrow the evidence-practice gaps.

19

1   Department of EBM and Guidelines, Japan Council for Quality Health Care who were

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.

9   **Funding**

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

20

1   guideline from the Japanese government, and the consent to participate from each patients

2   was omitted.

3   **Provenance and peer review**

4   Not commissioned; externally peer reviewed.

5   **Data sharing statement**

6   No data are available.

7   **REFERENCES**

8   [1] Gray P, Olfman L. Careers and education in information systems. In:Bates MJ,

9   editor.Understanding information retrieval systems:management, types and standards.Boca

10   Raton: CRC Press; 2011. p. 91-110.

11   [2] van der Weijden T, Pieterse AH, Koelewijn-van Loon MS, Knaapen L, Légaré F, Boivin

12   A, et al. How can clinical practice guidelines be adapted to facilitate shared decision making?

13   A qualitative key-informant study. BMJ Qual Saf. 2013;22:855-63

14   [3] Légaré F, Witteman HO. Shared decision making: examining key elements and barriers to

15   adoption into routine clinical practice. Health Aff. 2013;32:276-84.

16   [4] Blanc X, Collet TH, Auer R, Fischer R, Locatelli I, Iriarte P, et al. Publication trends of

17   shared decision making in 15 high impact medical journals: a full-text review with

18   bibliometric analysis. BMC Med Inform Decis Mak. 2014;14:71.

19   [5] Lang ES, Wyer PC, Haynes RB. Knowledge translation:Closing the evidence-to-practice

21

1   gap. Ann Emerg Med. 2007;49:355-63.

2   [6] Institute of Medicine, Committee on quality of health care in America.Crossing the quality

3   chasm: a new health system for the 21st century. Washington, DC:National Academy

4   Press ;2001.

5   [7] Grimshaw JM, Thomas RE, MacLennan G, Fraser C, Ramsay CR, Vale L, et al.

6   Effectiveness and efficiency of guideline dissemination and implementation strategies. Health

7   Technol Assess. 2004;8:1-72.

8   [8] McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, et al. The quality of

9   health care delivered to adults in the United States. N Engl J Med. 2003;26:79-89.

10   [9] Gagliardi AR, Brouwers MC. Do guidelines offer implementation advice to target users?

11   A systematic review of guideline applicability. BMJ Open. 2015;5:e007047. doi:

12   10.1136/bmjopen-2014-007047.

13   [10] Ubbink DT, Vermeulen H, Knops AM, Legemate DA, Oude Rengerink K, Heineman MJ,

14   et al. Implementation of evidence-based practice: outside the box, throughout the hospital.

15   Neth J Med. 2011;69:87-94.

16   [11] Gagliardi AR, Brouwers MC, Palda VA, Lemieux-Charles L, Grimshaw JM. How can

17   we improve guideline use? A conceptual framework of implementability. Implement Sci.

18   2011;6:26.

19   [12] Grimshaw J, Eccles M, Tetroe J. Implementing clinical guidelines: current evidence and

22

1   future implications. J Contin Educ Health Prof. 2004;24 Suppl 1:S31-7. Review.

2   [13] Cochrane LJ, Olson CA, Murray S, Dupuis M, Tooman T, Hayes S. Gaps between

3   knowing and doing: understanding and assessing the barriers to optimal health care. J Contin

4   Educ Health Prof. 2007;27:94-102.

5   [14] Cabana MD, Rand CS, Powe NR, Wu AW, Wilson MH, Abboud PA, et al. Why don't

6   physicians follow clinical practice guidelines? A framework for improvement.

7   JAMA.1999;28:1458-65. Review.

8   [15] Barth JH, Misra S, Aakre KM, Langlois MR, Watine J, Twomey PJ, et al. Why are

9   clinical practice guidelines not followed? Clin Chem Lab Med.2016;54:1133-39.

10   [16] Taba P, Rosenthal M, Habicht J, Tarien H, Mathiesen M, Hill S, et al. Barriers and

11   facilitators to the implementation of clinical practice guidelines: a cross-sectional survey

12   among physicians in Estonia. BMC Health Serv Res.2012;12:455

13   [17] Lyons SS, Tripp-Reimer T, Sorofman BA, Dewitt JE, Bootsmiller BJ, Vaughn TE, et al.

14   VA QUERI informatics paper: information technology for clinical guideline implementation:

15   perceptions of multidisciplinary stakeholders. J Am Med Inform Assoc. 2005;12:64-71.

16   [18] De Vos M, Graafmans W, Kooistra M, Meijboom B, Van Der Voort P, Westert G. Using

17   quality indicators to improve hospital care: a review of the literature. Int J Qual Health

18   Care.2009;21;11.

19   [19] Jones SS, Rudin RS, Perry T, Shekelle PG. Health information technology: an updated

1   systematic review with a focus on meaningful use. Ann Intern Med. 2014;160: 48–54.

2   [20] Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, et al. Systematic review:

3   impact of health information technology on quality, efficiency, and costs of medical care. Ann

4   Intern Med. 2006;144: 742–52.

5   [21] Menachemi N, Chukmaitov A, Saunders C, Brooks RG. Hospital quality of care: does

6   information technology matter? The relationship between information technology adoption

7   and quality of care. Health Care Manage Rev. 2008;33: 51–9.

8   [22] Medical Information Network Distribution Service (Minds).

9   http://minds.jcqhc.or.jp/english/english.php (accessed 7 June 2018).

10   [23] Sasaki N, Lee J, Park S, Umegaki T, Kunisawa S, Otsubo T, et al. Development and

11   validation of an acute heart failure-specific mortality predictive model based on

12   administrative data. Can J Cardiol. 2013;29: 1055–61.

13   [24] Hamada H, Sekimoto M, Imanaka Y. Effects of the per diem prospective payment

14   system with DRG-like grouping system (DPC/PDPS) on resource usage and healthcare

15   quality in Japan. Health Policy. 2012;107:194-201.

16   [25] Japanese Association for Infectious Diseases, Japanese Society of Chemotherapy,ed.

17   Guidelines for antibiotic use. Tokyo; Kyowa Kikaku.2005-2010.[Only in Japanese]

18   [26] Kass, GV. An exploratory technique for investigating large quantities of categorical data.

19   Journal of Applied Statistics.1980;29, 119-127.

24

1   [27] Huang YH, Wu CY, Lin KC, Hsieh YW, Snow WM, Wang TN. Determinants of change

2   in stroke-specific quality of life after distributed constraint-induced therapy. Am J Occup Ther.

3   2013;67,54-63.

4   [28] Dudley WN, Dilorio C, Soet J. Detecting and explicating interactions in categorical data.

5   Nurs Res. 2000;49,53-6.

6   [29] Nisbet R, Elder J, Miner G.Handbook of Statistical Analysis and Data Mining

7   Applications.Academic Press. 2009

8   [30] Maeda A, Araujo E, Cashin C, Harris J, Ikegami N, Reich MR. Universal Health

9   Coverage for Inclusive and Sustainable Development:A Synthesis of 11 Country Case

10   Studies.Washington, DC; The World Bank.2014

11   [31] Séror AC. Internet infrastructures and health care systems: a qualitative comparative

12   analysis on networks and markets in the British National Health Service and Kaiser

13   Permanente. J Med Internet Res. 2002;4,E21.

14   [32] Peter J, Peredy G. The Permanente knowledge connection: A national

15   strategy for clinician use of web technology. Report of the web integration council -clinical

16   subcommittee. The Permanente Journal. 1998;2,69-75.

17   [33] King DN. The contribution of hospital library information services to clinical care: a

18   study in eight hospitals. Bull Med Libr Assoc. 1987;75,291-301.

19   [34] Weightman AL, Williamson J; Library & Knowledge Development Network (LKDN)

1   Quality and Statistics Group. The value and impact of information provided through library

2   services for patient care: a systematic review. Health Info Libr J. 2005,22,4-25.

3   [35] Chiu YW, Weng YH, Lo HL, Shih YH, Hsu CC, Kuo KN. Comparison of accessing

4   online databases between physicians and nurses in Taiwan. Inform Health Soc Care

5   2012;37:230-41.

6   [36] Doebbeling BN, Chou AF, Tierney WM. Priorities and strategies for the implementation

7   of integrated informatics and communications technology to improve evidence-based practice.

8   J Gen Intern Med. 2006;21:S50-7.

9   [37] Ministerio de Salud y Protección Social. Implementation manual for evidence-based

10   clinical practice guidelines in health institutions in colombia.2014.

11   http://gpc.minsalud.gov.co/recursos/Documentos%20compartidos/Implementation_guide_ing

12   les.pdf (accessed 13 February 2019)

13   [38] Hamilton AB, Mittman BS.Implementation science in health care. In:Brownson RC, et al,

14   editor.Dissemination and implementation research in health:translating science into

15   practice.2nd ed.New York: Oxford University Press; 2018. p. 385-400.

16   [39] Goodall AH. Physician-leaders and hospital performance: is there an association?

17   Soc Sci Med. 2011;73:535-539.

18   [40] Bloom N, Garicano L, Sadun R,Van Reenen J.The distinct effects of information

19   technology and communication technology on firm organization. Management

26

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 Science.2014;60:2859-2885.

27

1 **Figure legends**

2 Figure 1. Flow diagram of the subject hospital selection process.

3 *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).

7 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.

28

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1

Table 1. Characteristics of the hospitals and respondents [a] (153 hospitals)

Hospital characteristics	
Beds, mean ± SD (range); median	339 ± 182 (63-1161); 303
Teaching hospitals, n（%）	115 (75.2)
Hospital size, n（%）	
> 500 beds	25 (16.3)
≤ 500 beds	128 (83.7)
Full-time physicians, mean ± SD (range)	61.9 ± 43.3 (8-268)
Resident physicians, mean ± SD (range)	21.2 ± 29.2 (0-197)
Respondent characteristics	n (%)
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)

[a] Respondents answered the questions as representatives of their hospital.

SD, standard deviation.

2

29

1

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

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		
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>	118	(77.1)
Medical databases such as UpToDate®, Clinical Key®, Ovid®, and DynaMed®	84	(54.9)
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 environment	84	(54.9)
Continuously working to improve library services and usability	60	(39.2)
Participation in hospital librarian associations and communication with other hospital librarians	25	(16.3)
Other	23	(15.0)

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

3

30

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1

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

Number of questionnaire items with positive responses	Mean QI score	n
Hospital policies [a]		
0	78.73	4
1	81.92	51
2	84.95	29
3	78.92	69
IT infrastructure		
Accessibility to the Internet and other information sources [b]		
0	78.59	5
1	82.20	32
2	78.70	62
3	83.32	54
Access to paid medical evidence databases [c]		
0	72.55	25
1	79.76	54
2	84.88	74
Medical library and intranet usability within the hospital [d]		
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 items are as follows:

[a] 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.

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

[c] Two items: provision of access to the Japanese medical database and access to English-language medical databases.

[d] 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.
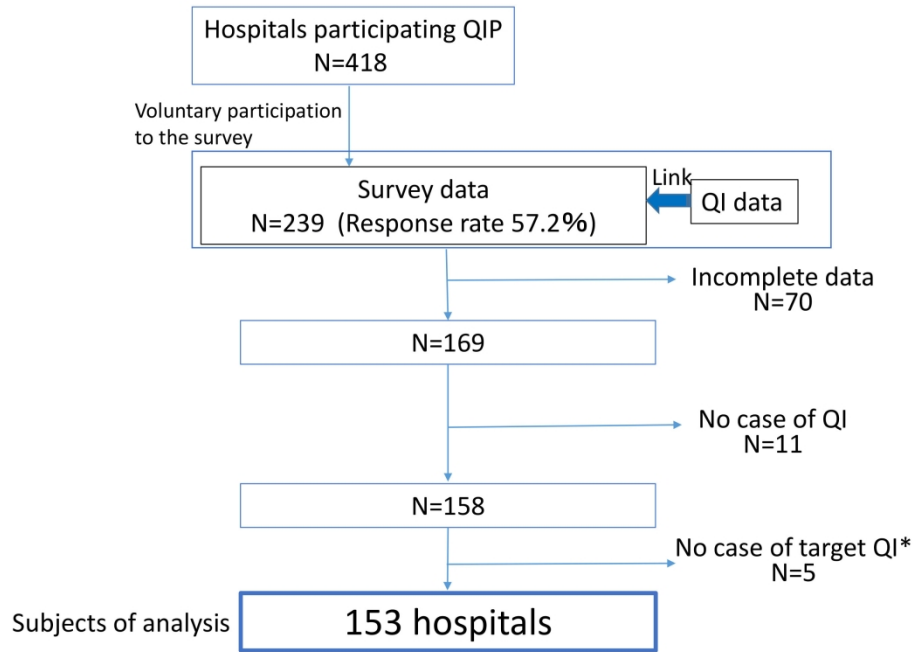
2

31

Figure 1. Flow diagram of the subject hospital selection process.
*Target QI indicates QI of perioperative antibiotic prophylaxis of the 11 surgical procedures mentioned in the manuscript.
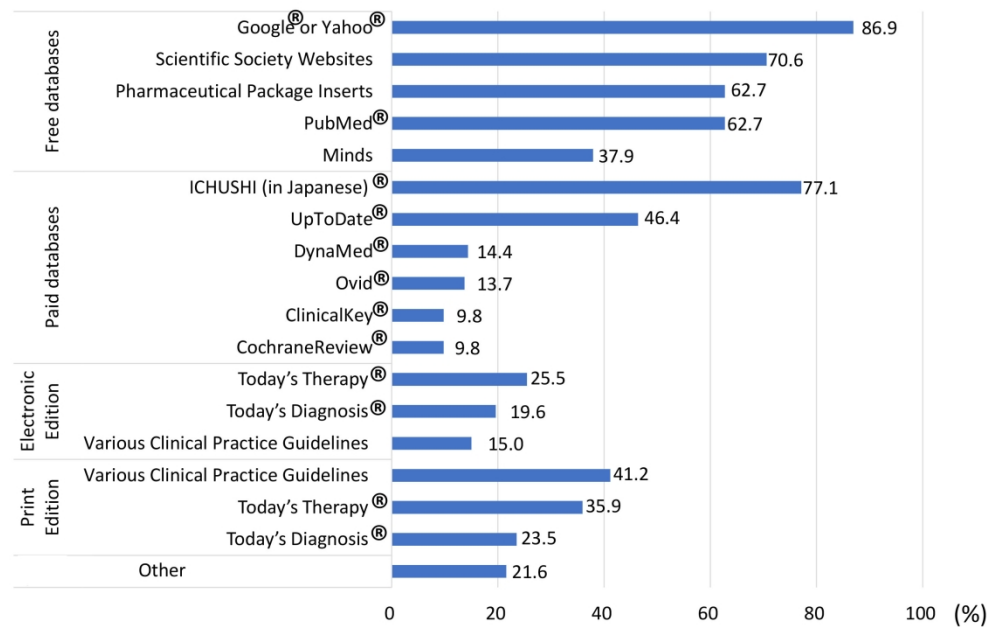
254x190mm (300 x 300 DPI)

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

245x158mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

QI score

Node 0
Mean 81.1
SD 17.4
n(%)=153 (100)

P=0.002,F=9.604
df1=1, df2=151

Hospital size and teaching status

≤ 500-bed teaching
> 500-bed teaching/non-teaching

≤500-bed non-teaching

Node 1
Mean 83.3
SD 13.4
n(%)=119 (77.8)

Node 2
Mean 73.1
SD 25.9
n(%)=34 (22.2)

P=0.011,F=6.688
df1=1, df2=117

Paid medical databases

Japanese and/or English DBs

Node 3
Mean 84.5
SD 10.0
n(%)=104 (68.0)

Node 4
Mean 75.1
SD 26.4
n(%)=15 (9.8)

P=0.050**,F=3.937
df1=1, df2=102

Accessibility to the Internet including LAN availability

0-2*

3*

Node 5
Mean 83.1
SD 10.8
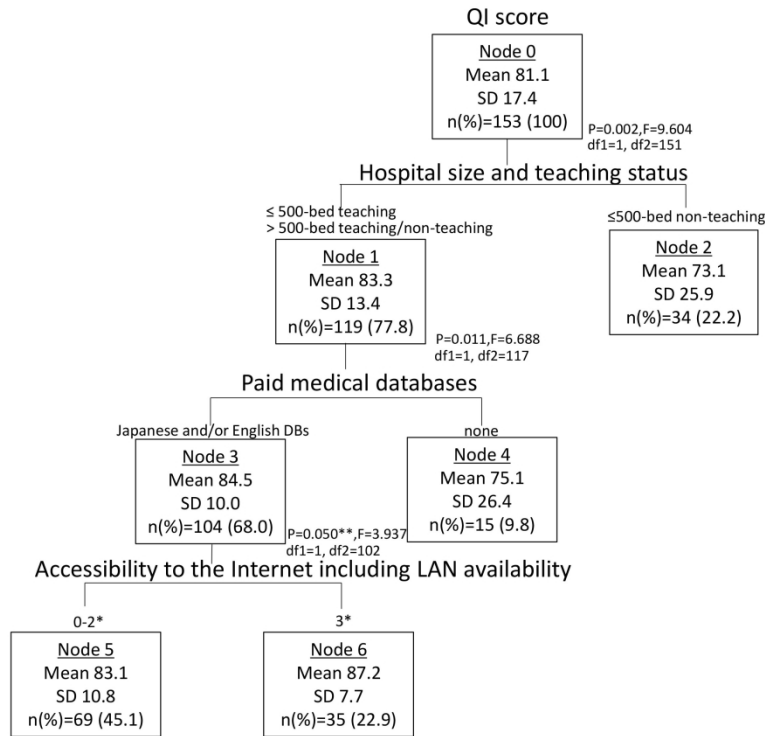n(%)=69 (45.1)

Node 6
Mean 87.2
SD 7.7
n(%)=35 (22.9)

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)

31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Appendix_Table. Original Questions

Q1-1. Does your hospital have an explicit policy to enhance IT infrastructure in order to improve accessibility to medical information?
  □ Yes   □ No   □ Other

Q1-2. What information sources are available in your hospital? (Please choose all options that would apply)
  □ 1. PubMed □2. Google/Yahoo □3. Pharmaceutical Package Inserts □ 4. Pharmaceutical Interview Forms
  □ 5. Scientific Society Websites □ 6. MINDS
  □ 7. *Igaku Chuo Zasshi* (ICHUSHI) Medical Literature Database [**Hospital** Subscription]
  □ 8. *Igaku Chuo Zasshi* (ICHUSHI) Medical Literature Database [**Medical Office** Subscription]
  □ 9. UpToDate [**Hospital** Subscription] □ 10. UpToDate [**Medical Office** Subscription]
  □ 11. Cochrane Review   □ 12. ClinicalKey   □13. Ovid   □ 14. DynaMed
  □ 15. *Today's Diagnosis* [**Electronic Edition**]   □ 16. *Today's Therapy* [**Electronic Edition**]
  □ 17. Various Clinical Practice Guidelines [**Electronic Versions**]
  □ 18. *Today's Diagnosis* [**Print Edition**]   □ 19. *Today's Therapy* [**Print Edition**]
  □ 20. Various Clinical Practice Guidelines **[Print Versions**]   □21. Other

Q2-1. 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 own computers to access the Internet.
  □ EHRs are not available.
  □ Other

Q2-2. Is *wireless* LAN available in your hospital?
  □Yes, available with no limitations.   □Yes, with limited access points.   □ No, not available.

Q2-3. Where are the major locations in your hospital for Internet use with *wired* LAN access? *(Multiple answers allowed)*
  □ Outpatient clinics   □ Wards   □ Medical offices   □ Libraries
  □ Other

Q3-1. How many librarians are there in your hospital?
  □ Full-time: □ Part-time:

Q3-2. Does your hospital provide an intranet homepage with user-friendly interface?
  □ Yes   □ No   □ Other

Q3-3. Which applies to your hospital regarding medical library activities? *(Multiple answers allowed)*
  □ 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

Q4. Do you have an explicit recommendation for the utilization of evidence-based medicine in your hospital?
  □ Yes   □ No   □ Other

Q5. Do you have an explicit recommendation for adherence to clinical practice guidelines in your hospital?
  □ Yes   □ No   □ Other

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

Section/Topic	Item #	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	2,7-11
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 modifiers. Give 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 groupings 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	*
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11, Fig1.
		(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 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 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, 17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	4,13-18
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 the 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 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.