PEER REVIEW HISTORY

ARTICLE DETAILS

TITLE (PROVISIONAL)	Does Hospital Information Technology Infrastructure Promote the Implementation of Clinical Practice Guidelines? A Multicenter Observational Study of Japanese Hospitals
AUTHORS	Sasaki, Noriko; Yamaguchi, Naohito; Okumura, Akiko; Yoshida, Masahiro; Sugawara, Hiroyuki; Imanaka, Yuichi

VERSION 1 – REVIEW

REVIEWER	Jon Wardle University of Technology Sydney
REVIEW RETURNED	05-Aug-2018

GENERAL COMMENTS	Thank you for the opportunity to review this manuscript, which reports on an area of consequence and importance to health care delivery, planning and policy. Overall the paper is well-written, largely methodologically sound and of interest to the BMJ OPEN readership. The manuscript will require a thorough English review proof-read before resubmission, as there are some areas where language is cumbersome or not clearly articulated. There are some specific comments I would like to make: INTRODUCTION: P5 L7: The introduction sentence is not academic tone and is too journalistic (this is an issue in other sections of the manuscript too). Instead of “Due to a flood of…” a more appropriate statement would be “Due the growth of…” P5 L35: Rather than state that CPGs are underused in developed countries, a more appropriate statement would be that they are underused in countries even where CPGs are well developed (some of these countries are not developed countries, and some developed nations have very poor CPG development). P5 L43: Rather than use the term treatments I would use the term “care”. Some CPGs advocate for no treatment (e.g. watchful waiting) as unnecessary treatment can introduce harms P6 L6: It should be “there are no clear data” or “there is no clear evidence” P6 L13: This sentence is confusing. Are the IT studies growing or is IT implementation growing. Are the positive effects from the IT implementation? P6 L40: More detail on the determinants (and why they have been chosen) would be useful METHODS: P7 L35: More detail on the Minds-QIP project would be useful – is it a government initiative, an industry collaboration? P8 L3: The authors mention that a literature review informed their survey design – does this mean any questions were based o previous surveys?

	P8 L12: It is now standard practice to include a survey in the appendices, I would recommend the authors provide an English translation P8 L22: It is important to note that “enhancing IT” and “promoting evidence-based practice” are not necessarily the same thing, but this is how this statement comes across. A better way of phrasing would be something along the lines of “In order to identify whether hospital’s were using IT as a part of their promotion of evidence-based practice”. I cannot see where the explicit link is made in the survey to comment further. P9 L26: There are always appropriate exceptions in clinical practice – was there a way to account for these? P9 L26: Also, databases such as the DPC often have inbuilt variability due to the systems and capacity of those entering data in different institutions. Is there any data on the reliability or consistency of this database for research purposes? I think it is an appropriate data source for this topic, but it may have some limitations which should be discussed here or in the limitations section P10 L29: Again, the implementation of IT infrastructure is conflated with policies to implement evidence-based practice (which are likely to extend beyond IT). P11 L11: Was there ethics approval for this project? It needs to be included or a statement as to why it wasn’t deemed necessary provided. RESULTS: P11 L22: Were there any known differences between responders and non-responders? P11 L24: As only 153 of the 239 hospitals had adequate QI data – were there any known differences between the 153 who had data and the 86 who didn’t? P12 L10: It would be useful to know a little more about the Japanese databases – are these providing language summaries of English research, or are they similar to databases such as MEDLINE but limited to Japanese language sources? P13 L9: Could the lower scores/differences in QI score in hospitals also be related to their lack of IT infrastructure? For example, could they be inaccurately reporting due to inadequate systems? DISCUSSION: P14 L40: Could it be possible that the “teaching” nature of the institutions themselves makes them more committed to evidence-based initiatives – i.e. teaching and research is part of their culture of practice. Resources are likely to certainly be a big part of their increased participation, but there may be a cultural element too. P15 L32: Some hospitals have policies in place to access research via inter-library services, partnerships with academic institutions or policies for ad-hoc access to research (e.g. pay per paper). Were these examined? P15 L46: It would be good to overtly discuss where these previous studies were from (to show that these results mirror those seen internationally). P16 L38: This paragraph seems based on the erroneous notion that if the IT is taken care of that clinicians will use CPGs – this is not necessarily the case. A more critical discussion of IT not being the solution (but being PART of a solution is warranted). Additionally, the fact that the authors identified that only 41% of hospitals even had access to printed CPGs suggests that better IT itself may not mean that the infrastructure will be used in the way it should. IT can stifle innovation as much as encourage it, if not implemented appropriately. I think there needs to be a more critical

	discussion of how IT fits in the broader scheme of things is required in this discussion. P17 L13: The self-reported nature of the data needs to be discussed as a potential limitation P17 L35: Given the findings, the authors should make a comment about the potential barriers to implementation of IT that exist (or state whether this is worth more detailed examination).

REVIEWER	Professor Robin Gauld Otago Business School, University of Otago
REVIEW RETURNED	23-Aug-2018

GENERAL COMMENTS	This is an interesting and useful study. It's well constructed, and the article draft is well written and clear. In some ways, the findings are quite routine and do not necessarily tell us much that is new. However, the study does add weight to a growing field of research into the impact of general quality improvement efforts on health care quality. In this regard, I believe that it is publishable. What it needs is a stronger linking into other work in the field beyond IT. There are a series of studies into QI efforts and clinical leadership that show efforts to put standardised processes in place produce better financial and quality outcomes - examples are work by John Van Reenen and colleagues, and Amanda Goodall, published in the early 2010s. This study could usefully reference this line of work, which generally shows that if investments are made in improving organisational operational excellence, which includes IT system investments, better performance can be expected. Short of this, the study shows a link but does not explain it or place it in context as well as it could.

REVIEWER	Xiaolin Xu University Of Queensland, Australia
REVIEW RETURNED	23-Jan-2019

GENERAL COMMENTS	This paper reports a descriptive analysis of the present state of IT infrastructure provided in acute care hospitals in Japan and related factors of healthcare quality. I was asked for a statistical review and I interpret that to include aspects of the design and conduct of the study. Here are my comments: 1. Statistical analysis: please specify the CHAID test is one-side or two-side, and P value is at 0.05 level or other levels. 2. Page 10, line 19: we usually don't say "Statistical computations were conducted…". 3. Page 11, lines 15-17: please be careful when using "limited" and "only in a minority…" to describe the degree of frequency. For example, I would not think 71.9% and 54.9% are "limited". 4. Table 1: the authors treated hospital size as a categorical (e.g., >500 or ≤500) variable in the analysis, but describes them as continuous variables in the Table 1. Characteristics of the hospitals and respondents. I would suggest to describe them as both continuous and categorical variables. 5. Figure 1: Please specify the difference between 'QI' and 'target QI', I can't find related information in the notes of the Figure and the main context. 6. Figure 2: Please specify the meanings of 'df1' and 'df2'. 7. Figure 2: I think the authors should be careful when using 'determinants' to describe these included factors. My

	understanding is 'determinants' usually are well defined and established causes, e.g., social determinants of health. 8. Following Point 4, I would suggest the authors revise the objectives as: to describe the present state of IT infrastructure provided in acute care hospitals across Japan and to investigate its association with healthcare quality (page 2).

VERSION 1 – AUTHOR RESPONSE

Reviewer #1

We are very grateful for the reviewer's thoughtful and inspiring suggestions and questions. We revised our manuscript based on the reviewer's comments where possible. The details are shown below.

(We used the line numbers displayed in the Word file for convenience.)

1. Introduction

As per the reviewer's suggestion within the box, we revised the manuscript as below (red text).

- P5 L7: The introduction sentence is not academic tone and is too journalistic (this is an issue in other sections of the manuscript too). Instead of "Due to a flood of…" a more appropriate statement would be "Due the growth of…"
- P5 L35: Rather than state that CPGs are underused in developed countries, a more appropriate statement would be that they are underused in countries even where CPGs are well developed (some of these countries are not developed countries, and some developed nations have very poor CPG development).
- P5 L43: Rather than use the term treatments I would use the term "care". Some CPGs advocate for no treatment (e.g. watchful waiting) as unnecessary treatment can introduce harms
- P6 L6: It should be "there are no clear data" or "there is no clear evidence"
- P6 L13: This sentence is confusing. Are the IT studies growing or is IT implementation growing. Are the positive effects from the IT implementation?

Page 5, Line 2

Due to the growth of renewed medical information and ….

Page 5, Line 12

CPGs continue to be underused even in countries even where CPGs are well developed…

Page 5, Line 14

…can lead to the provision of substandard or potentially harmful care to patients

Page 6, Line 1

Furthermore, there is no clear evidence….

Page 6, Line 4-7

On the other hand, research related to the adoption of health information technology at the organizational level is growing, and a number of studies have reported positive effects on quality, safety and efficiency

P6 L40: More detail on the determinants (and why they have been chosen) would be useful

Thank you for your comment. Regarding the comments also from reviewer #3, we decided *not* to use the word 'determinants' and revised the related sentences as below:

Page 2, Line 5

The objectives of this study were to describe….and to investigate its association with healthcare quality.

Page 6, Line 14-16

This multicenter study aimed to describe the present state of IT infrastructure provided in Japanese acute care hospitals and to investigate its association with healthcare quality, taking into account hospital size, hospital policies promoting evidence-based practice.

The reason why we chose 'hospital size' and 'policies promoting evidence-based practice' is from our assumption that larger hospitals tend to possess much resources including IT infrastructure and that the hospital policies may affect adoption of updated IT infrastructure. However, because of the readability, we dare not to include these in the above sentences.

2. Methods

P7 L35: More detail on the Minds-QIP project would be useful – is it a government initiative, an industry collaboration?

As per the reviewer's suggestion, we revised the related sentences as follows (red text):

Page 6, Line 11 *over 180 evidence-based CPGs have been assessed and disseminated by the government-funded Medical Information Network Distribution Service (Minds) Guideline Center*

Page 7, Line 12

The Minds-QIP project, as a part of activities of the Minds Guideline Center, was initiated…

P8 L3: The authors mention that a literature review informed their survey design – does this mean any questions were based o previous surveys?

We did not intend to indicate that the questionnaire was developed based on a single specific survey. Rather it was based on multiple literature reviews as well as discussions and interviews with related experts and administrators. Therefore, no question is exactly the same as in previous studies. We revised the manuscript as below so as not to mislead readers:

Page 8, Line 1

The questionnaire was developed based on literature reviews, discussions with experts,….

P8 L12: It is now standard practice to include a survey in the appendices, I would recommend the authors provide an English translation

As per the reviewer's suggestion, we attached the appendix table showing the original survey questions in English (Appendix_Table).

P8 L22: It is important to note that "enhancing IT" and "promoting evidence-based practice" are not necessarily the same thing, but this is how this statement comes across. A better way of phrasing would be something along the lines of "In order to identify whether hospitals were using IT as a part of their

promotion of evidence-based practice". I cannot see where the explicit link is made in the survey to comment further.

Thank you for pointing this out. We completely agree with your opinion that IT use (even if it is enhanced) is not the only element that promotes evidence-based practice. We need to consider the multifaceted aspects of implementing the recommendations of CPGs to promote evidence-based practice.

We attempted to adopt your recommended expression, but it appeared to be tautological and did not fit well in this context. Therefore, we did not change the sentence here, but added the paragraph below in the 'Discussion' section, which incorporates the reviewer's opinion; we revised the body of the manuscript (red text) and added the references [37-40]:

Page 17, Line 6-17

In a broader context, barriers to implementing CPG recommendations in daily practice vary greatly at the individual level of specialists and physicians (e.g.perception, education, incentives, professional autonomy), the institutional level (e.g., physician leadership, hospital policies, finance, institutional culture, teamwork, IT infrastructure), national level (e.g., policies to promote CPG use, hospital accreditation) and the societal level (e.g.a culture of shared-decision making with patients, information derived from mass media) [37,38,39]. Yet, given the growing importance of IT use in an innovative society, the impact of IT adoption on healthcare quality warrants far more consideration of the types of relationships that were revealed in this study. According to previous research, IT itself needs to be understood as having two distinct components—information technology and communication technology— and these differently affect the autonomy of workers [40]. Further examination is needed to clarify these issues in order to implement IT in practice settings.

References:

[37] *Ministerio de Salud y Protección Social. Implementation manual for evidence-based clinical practice guidelines in health institutions in colombia.2014. http://gpc.minsalud.gov.co/recursos/Documentos%20compartidos/Implementation_guide_ingles.pdf (accessed 13 February 2019)*

[38] *Hamilton AB, Mittman BS.Implementation science in health care. In:Brownson RC, et al, editor.Dissemination and implementation research in health:translating science into practice.2nd ed.New York: Oxford University Press; 2018. p. 385-400.*

[39] *Goodall AH. Physician-leaders and hospital performance: is there an association? Soc Sci Med. 2011;73:535-539.*

[40] *Bloom N, Garicano L, Sadun R,Van Reenen J.The distinct effects of information technology and communication technology on firm organization. Management Science.2014;60:2859-2885.*

P9 L26: There are always appropriate exceptions in clinical practice – was there a way to account for these?

Yes, there are always appropriate exceptions in clinical practice, but we mainly focused on compliance with the recommendation of specific CPGs. Since we are using administrative claims data, we cannot know in detail the reason why specific individual patient received a practice other than the recommended practice. However, we have an interactive relationship with attending hospitals in the QIP, and we usually have a chance to ask specific hospitals why the QIs are so low or so high in some cases. Based on the reviewer's opinion, we added the sentences in the limitation section as below:

Page 18, Line 9-12

Fourth, as we used administrative claims data, we could not know the clinical information in detail including appropriate exceptions in clinical practice. However, in this study, we focused on perioperative antibiotic prophylaxis of the 11 surgeries, which we could identify accurately based on the information of surgical procedure and drug use from the database.

P9 L26: Also, databases such as the DPC often have inbuilt variability due to the systems and capacity of those entering data in different institutions. Is there any data on the reliability or consistency of this database for research purposes? I think it is an appropriate data source for this topic, but it may have some limitations which should be discussed here or in the limitations section

In Japan, the Ministry of Health, Labour and Welfare (MHLW) is in charge of managing the DPC system, including collecting hospital data and qualifying them.[1] Readers can find hundreds of articles published elsewhere in clinical journals and in health service research journals that are internationally peer reviewed. We can introduce some of them here.[2-5]

Indeed, the DPC data has weak points related to administrative claims data such as lacking clinical information data in detail including laboratory exam results, accuracy of naming of the disease, and so on. However, in this study, we focused on perioperative antibiotic prophylaxis of the 11 surgeries, which we could identify accurately based on the information of surgical procedure and drug use from the database.

As per the reviewer's suggestion, we added the sentences in the limitation section as below:

Page 18, Line 9-12

Fourth, as we used administrative claims data, we could not know the clinical information in detail including appropriate exceptions in clinical practice. However, in this study, we focused on perioperative antibiotic prophylaxis of the 11 surgeries, which we could identify accurately based on the information of surgical procedure and drug use from the database.

References :

1) OECD, World Health Organization. Case-based Payment Systems for Hospital Funding in Asia An Investigation of Current Status and Future Directions: An Investigation of Current Status and Future Directions. OECD Publishing, 2015; page63.
2) Sasaki N, Lee J, Park S, et al. Development and Validation of an Acute Heart Failure-Specific Mortality Predictive Model Based on Administrative Data. Can J Cardiol 2013; 29:1055-61
3) Hamada H, Sekimoto M, Imanaka Y. Effects of the per diem prospective payment system with DRGlike grouping system (DPC/PDPS) on resource usage and healthcare quality in Japan. Health Policy. 2012;107:194-201
4) Fukuhara, T., & Hori, Y. Prefectural difference in spontaneous intracerebral hemorrhage incidence in Japan analyzed with publically accessible diagnosis procedure combination data: possibilities and limitations. Epidemiology and health.2016;38, e2016028. doi:10.4178/epih.e2016028
5) Kunisawa, S., Fushimi, K., Imanaka, Y.,. Reducing Length of Hospital Stay Does Not Increase Readmission Rates in Early-Stage Gastric, Colon, and Lung Cancer Surgical Cases in Japanese Acute Care Hospitals. PloS one, 2016;11(11), e0166269.

P10 L29: Again, the implementation of IT infrastructure is conflated with policies to implement evidence-based practice (which are likely to extend beyond IT).

Since we are explaining the independent variables here, we cannot change the wording. However, based on the reviewer's opinion, we added the paragraph below (in red text) in the 'Discussion' section (before the limitations) along with corresponding references [37-40]:

Page 17, Line 6-17

In a broader context, barriers to implementing CPG recommendations in daily practice vary greatly at the individual level of specialists and physicians (e.g.perception, education, incentives, professional autonomy), the institutional level (e.g., physician leadership, hospital policies, finance, institutional culture, teamwork, IT infrastructure), national level (e.g., policies to promote CPG use, hospital accreditation) and the societal level (e.g.a culture of shared-decision making with patients, information derived from mass media) [37,38,39]. Yet, given the growing importance of IT use in an innovative society, the impact of IT adoption on healthcare quality warrants far more consideration of the types of relationships that were revealed in this study. According to previous research, IT itself needs to be understood as having two distinct components—information technology and communication technology— and these differently affect the autonomy of workers [40]. Further examination is needed to clarify these issues in order to implement IT in practice settings.

References:

[37] Ministerio de Salud y Protección Social. Implementation manual for evidence-based clinical practice guidelines in health institutions in colombia.2014. http://gpc.minsalud.gov.co/recursos/Documentos%20compartidos/Implementation_guide_ingles.pdf (accessed 13 February 2019)

[38] Hamilton AB, Mittman BS.Implementation science in health care. In:Brownson RC, et al, editor.Dissemination and implementation research in health:translating science into practice.2nd ed.New York: Oxford University Press; 2018. p. 385-400.

[39] Goodall AH. Physician-leaders and hospital performance: is there an association? Soc Sci Med. 2011;73:535-539.

[40] Bloom N, Garicano L, Sadun R,Van Reenen J.The distinct effects of information technology and communication technology on firm organization. Management Science.2014;60:2859-2885.

P11 L11: Was there ethics approval for this project? It needs to be included or a statement as to why it wasn't deemed necessary provided.

The ethics approval appears on page 20. However, we added sentences that were accidentally dropped from the previous draft during the submission process:

Page 20, Line 9-13

Informed consent was received from all participants prior to the survey, and they were also informed that the data was being collected for research purposes. Regarding the DPC data, we collect anonymous data based on a process designated by the ethics guideline from the Japanese government, and the consent to participate from each patients was omitted.

3. Results

P11 L22: Were there any known differences between responders and non-responders? P11 L24: As only 153 of the 239 hospitals had adequate QI data – were there any known differences between the 153 who had data and the 86 who didn't?

Thank you for your questions. Hospitals that responded to our questionnaires are assumed to be highlymotivated compared to those that did not. Further, while QIP member hospitals voluntarily submit

data for analysis, some hospitals do not necessarily submit their data regularly and thus may fall outside the 239 hospitals. In addition, since we focused on the QI of adherence to CPGs for perioperative antibiotic prophylaxis of 11 surgeries such as gastrectomy, prostate cancer surgery and so on (i.e., target QI), hospitals that do not perform index surgeries may have been dropped during the selection process.

P12 L10: It would be useful to know a little more about the Japanese databases – are these providing language summaries of English research, or are they similar to databases such as MEDLINE but limited to Japanese language sources?

'ICHUSHI-Web' is a search system which contains bibliographic citation, abstracts and publications published in Japan (https://www.jamas.or.jp/english/).

This database is similar to MEDLINE and contains mainly Japanese language sources published mostly by Japanese researchers, including abstracts in Japanese. Some articles in English are returned when the search is conducted with English words.

P13 L9: Could the lower scores/differences in QI score in hospitals also be related to their lack of IT infrastructure? For example, could they be inaccurately reporting due to inadequate systems?

Yes, we also checked the QI mean score differences between hospitals with and without each specific IT infrastructure. We found that the mean QI scores of hospitals that lacked 'charged databases' (Japanese DBs / English DBs), 'wireless LAN', or 'the hospital provision of an intranet homepage with user-friendly interface' were lower by about 5 to 8 points compared with hospitals that had these IT infrastructures (75-80 points vs 83-84 points). We believe inaccurate reporting is a separate issue since we used administrative claims data.

4. Discussion

P14 L40: Could it be possible that the "teaching" nature of the institutions themselves makes them more committed to evidence-based initiatives – i.e. teaching and research is part of their culture of practice. Resources are likely to certainly be a big part of their increased participation, but there may be a cultural element too.

Yes, we do think that it would be highly possible that the "teaching" nature of the institutions themselves makes them more committed to evidence-based thinking and practices. In the Japanese context, highly motivated teaching staffs tend to gather in large-scale teaching hospitals such as tertiary hospitals including university hospitals. Therefore, we set the variable "hospital size and teaching status." We do feel that cultural elements derived from the motivation of staff affect the promotion of evidence-based practice, and this variable may include some part of cultural elements.

P15 L32: Some hospitals have policies in place to access research via inter-library services, partnerships with academic institutions or policies for ad-hoc access to research (e.g. pay per paper). Were these examined?

Based on information from our semi-structured face-to-face interviews with several hospital administrators and IT managers from five major teaching hospitals prior to the questionnaire survey,

we asked questions Q1-2,Q3-2, Q3-3 of the original questions (see Appendix_Table), which partly include the mentioned topics.

P15 L46: It would be good to overtly discuss where these previous studies were from (to show that these results mirror those seen internationally).

Thank you for your suggestion. As per the reviewer's suggestions, we revised the sentence as below:

Page 16, Line 1

Thirdly, the importance of Internet accessibility (including LAN availability) to healthcare quality has been similarly observed in previous studies from the US and UK [1,21,30].

P16 L38: This paragraph seems based on the erroneous notion that if the IT is taken care of that clinicians will use CPGs – this is not necessarily the case. A more critical discussion of IT not being the solution (but being PART of a solution is warranted). Additionally, the fact that the authors identified that only 41% of hospitals even had access to printed CPGs suggests that better IT itself may not mean that the infrastructure will be used in the way it should. IT can stifle innovation as much as encourage it, if not implemented appropriately. I think there needs to be a more critical discussion of how IT fits in the broader scheme of things is required in this discussion.

Thank you for your comments. We should have mentioned the potential barriers to implementing not only IT but also the recommendations of the CPGs in order to promote evidence-based practice.

As per the reviewer's suggestion, we added the following paragraph (red text) in the 'Discussion' section (before discussing limitations) and added the corresponding references [37-40]:

Page 17, Line 6-17

In a broader context, barriers to implementing CPG recommendations in daily practice vary greatly at the individual level of specialists and physicians (e.g.perception, education, incentives, professional autonomy), the institutional level (e.g., physician leadership, hospital policies, finance, institutional culture, teamwork, IT infrastructure), national level (e.g., policies to promote CPG use, hospital accreditation) and the societal level (e.g.a culture of shared-decision making with patients, information derived from mass media) [37,38,39]. Yet, given the growing importance of IT use in an innovative society, the impact of IT adoption on healthcare quality warrants far more consideration of the types of relationships that were revealed in this study. According to previous research, IT itself needs to be understood as having two distinct components—information technology and communication technology—and these differently affect the autonomy of workers [40]. Further examination is needed to clarify these issues in order to implement IT in practice settings.

References:

[37] Ministerio de Salud y Protección Social. Implementation m anual for evidence-based clinical practice guidelines in health institutions in colombia.2014. http://gpc.minsalud.gov.co/recursos/Documentos%20compartidos/Implementation_guide_ingles.pdf (accessed 13 February 2019)

[38] Hamilton AB, Mittman BS.Implementation science in health care. In:Brownson RC, et al, editor.Dissemination and implementation research in health:translating science into practice.2nd ed.New York: Oxford University Press; 2018. p. 385-400.

[39] Goodall AH. Physician-leaders and hospital performance: is there an association? Soc Sci Med. 2011;73:535-539.

[40] Bloom N, Garicano L, Sadun R,Van Reenen J.The distinct effects of information technology and communication technology on firm organization. Management Science.2014;60:2859-2885.

P17 L13: The self-reported nature of the data needs to be discussed as a potential limitation

Thank you for pointing this out. Yes, the survey data could be exaggerated or may be affected by social desirability bias, and the result could be overestimated because of its self-reported nature. However, we did not just use this data but rather aggregated it with the DPC/PDPS administrative data, which are more objective. This may decrease the bias from self-reported data.

As per the reviewer's suggestions, we added the sentence in the limitation part as below:

Page 18, Line 1-3

In addition, as this was a self-reported survey, the possible presence of social desirability bias may have caused these respondents to underestimate the barriers being investigated.

P17 L35: Given the findings, the authors should make a comment about the potential barriers to implementation of IT that exist (or state whether this is worth more detailed examination).

Thank you for your comment. Again, we should have mentioned the potential barriers to implementing not only IT but also the recommendations of the CPGs in order to promote evidence-based practice. Given our findings, we believe that in the Japanese context, the possible major barriers to implementing appropriate IT infrastructure would be the issues of cost and investment to adopt updated IT infrastructures, including charged medical databases and Internet accessibility. Hospital leadership of physicians or not, information technology as well as communication technology should be examined further.

As per the reviewer's suggestion, we added the paragraph below (red text) in the 'Discussion' section (before the limitations) stating that more detailed studies are required. We also added corresponding references [37-40]:

Page 17, Line 6-17

In a broader context, barriers to implementing CPG recommendations in daily practice vary greatly at the individual level of specialists and physicians (e.g.perception, education, incentives, professional autonomy), the institutional level (e.g., physician leadership, hospital policies, finance, institutional culture, teamwork, IT infrastructure), national level (e.g., policies to promote CPG use, hospital accreditation) and the societal level (e.g.a culture of shared-decision making with patients, information derived from mass media) [37,38,39]. Yet, given the growing importance of IT use in an innovative society, the impact of IT adoption on healthcare quality warrants far more consideration of the types of relationships that were revealed in this study. According to previous research, IT itself needs to be understood as having two distinct components—information technology and communication technology—and these differently affect the autonomy of workers [40]. Further examination is needed to clarify these issues in order to implement IT in practice settings.

References:

[37] Ministerio de Salud y Protección Social. Implementation manual for evidence-based clinical practice guidelines in health institutions in colombia.2014. http://gpc.minsalud.gov.co/recursos/Documentos%20compartidos/Implementation_guide_ingles.pdf (accessed 13 February 2019)

[38] Hamilton AB, Mittman BS.Implementation science in health care. In:Brownson RC, et al, editor.Dissemination and implementation research in health:translating science into practice.2nd ed.New York: Oxford University Press; 2018. p. 385-400.
[39] Goodall AH. Physician-leaders and hospital performance: is there an association? Soc Sci Med. 2011;73:535-539.
[40] Bloom N, Garicano L, Sadun R,Van Reenen J.The distinct effects of information technology and communication technology on firm organization. Management Science.2014;60:2859-2885.

Reviewer #2

This is an interesting and useful study. It's well constructed, and the article draft is well written and clear. In some ways, the findings are quite routine and do not necessarily tell us much that is new. However, the study does add weight to a growing field of research into the impact of general quality improvement efforts on health care quality. In this regard, I believe that it is publishable. What it needs is a stronger linking into other work in the field beyond IT. There are a series of studies into QI efforts and clinical leadership that show efforts to put standardised processes in place produce better financial and quality outcomes - examples are work by John Van Reenen and colleagues, and Amanda Goodall, published in the early 2010s. This study could usefully reference this line of work, which generally shows that if investments are made in improving organisational operational excellence, which includes IT system investments, better performance can be expected. Short of this, the study shows a link but does not explain it or place it in context as well as it could.

We thank the reviewer very much for reading our manuscript and giving us these valuable and inspiring suggestions and comments.

Thank you, too, for introducing us to important studies that bridge healthcare quality and organization management. We re-examined our study in the context of improving organizational operational excellence, which includes IT system investments, and added the paragraph below (red text) in the 'Discussion' section (before the limitations) and added the index references [37-40]:

Page 17, Line 6-17

In a broader context, barriers to implementing CPG recommendations in daily practice vary greatly at the individual level of specialists and physicians (e.g.perception, education, incentives, professional autonomy), the institutional level (e.g., physician leadership, hospital policies, finance, institutional culture, teamwork, IT infrastructure), national level (e.g., policies to promote CPG use, hospital accreditation) and the societal level (e.g.a culture of shared-decision making with patients, information derived from mass media) [37,38,39]. Yet, given the growing importance of IT use in an innovative society, the impact of IT adoption on healthcare quality warrants far more consideration of the types of relationships that were revealed in this study. According to previous research, IT itself needs to be understood as having two distinct components—information technology and communication technology—and these differently affect the autonomy of workers [40]. Further examination is needed to clarify these issues in order to implement IT in practice settings.

References:

[37] Ministerio de Salud y Protección Social. Implementation manual for evidence-based clinical practice guidelines in health institutions in colombia.2014. http://gpc.minsalud.gov.co/recursos/Documentos%20compartidos/Implementation_guide_ingles.pdf

(accessed 13 February 2019)
[38] Hamilton AB, Mittman BS.Implementation science in health care. In:Brownson RC, et al, editor.Dissemination and implementation research in health:translating science into practice.2nd ed.New York: Oxford University Press; 2018. p. 385-400.
[39] Goodall AH. Physician-leaders and hospital performance: is there an association? Soc Sci Med. 2011;73:535-539.
[40] Bloom N, Garicano L, Sadun R,Van Reenen J.The distinct effects of information technology and communication technology on firm organization. Management Science.2014;60:2859-2885.

Reviewer #3

We are very grateful to the reviewer for reading our manuscript and providing valuable comments and suggestions. We revised our manuscript based on the reviewer's questions and comments where possible. The details are shown below.

1. Statistical analysis: please specify the CHAID test is one-side or two-side, and P value is at 0.05 level or other levels.

We applied the exhaustive CHAID algorithm, using the alpha-levelα_{split} =0.10. [29,a] As a result, hospitals with a high level of access to paid databases (p=0.049908) and Internet (p=0.010935) were strongly associated with increased care quality in larger or teaching hospitals.

Since our dependent variable (i.e., QI score) was continuous, it is first transformed into an ordinal predictor before the rest of the exhaustive CHAID algorithm proceeded. The algorithm performs an ANOVA F test that tests whether the means of the QI scores for the different categories of X are the same. This ANOVA F test calculates the F-statistic and derives the p-value such as below:

$$F = \frac{\sum_{i=1}^{I}\sum_{n\in D} w_n f_n I(x_n = i)(\bar{y}_i - \bar{y})^2/(I-1)}{\sum_{i=1}^{I}\sum_{n\in D} w_n f_n I(x_n = i)(y_n - \bar{y}_i)^2/(N_f - I)},$$

$$p = \Pr\left(F(I-1, N_f - I) > F\right),$$

where

$$\bar{y}_i = \frac{\sum_{n\in D} w_n f_n y_n I(x_n = i)}{\sum_{n\in D} w_n f_n I(x_n = i)},\quad \bar{y} = \frac{\sum_{n\in D} w_n f_n y_n}{\sum_{n\in D} w_n f_n},\quad N_f = \sum_{n\in D} f_n,$$

'One-side (benefit only) or two-side' does not fit in this context. We could not find any related previous study using CHAID analysis that mentioned this point.

As per the editor's and reviewer's suggestion, we revised the related part as follows (red text) and added reference #29:

Page 2, Line 17-19

The CHAID analysis showed that hospitals with a high level of access to paid databases ($p<0.05$) and Internet ($p<0.05$) were strongly associated with increased care quality in larger or teaching hospitals.

Page 10, Line 19- Page 11, Line 2

We used the exhaustive CHAID algorithm, a modified version of the basic algorithm that performs a more thorough merging and testing of independent variables [29]. References:

[29] Robert Nisbet, John Elder, Gary Miner.Handbook of Statistical Analysis and Data Mining Applications.Academic Press, 2009/05/14

[a] IS BY BIGGS, CHAID, et al. CHAID and Exhaustive CHAID Algorithms. ftp://java.sdu.edu.tr/SPSS%20ve%20AMOS/SPSS%2013.0.1/Algorithms/TREE-CHAID.pdf Page 3-4.

2. Page 10, line 19: we usually don't say "Statistical computations were conducted…".

Thank you for pointing this out. As per the reviewer's suggestion, we changed the sentence as below:

Page 11, Line 2-3

Statistical calculations were performed using SPSS 20.0J software and….

3. Page 11, lines 15-17: please be careful when using "limited" and "only in a minority…" to describe the degree of frequency. For example, I would not think 71.9% and 54.9% are "limited".

Thank you for your comments. Indeed, these words should be used with caution, as the impression and interpretation would vary among readers. However, since we discuss this topic later in the context of the importance of Internet accessibility (including LAN availability) in the 'Discussion' section (Page 15, Line 19- Page 16, Line 7), we decided not to change the wording at this time.

4. Table 1: the authors treated hospital size as a categorical (e.g., >500 or ≤500) variable in the analysis, but describes them as continuous variables in the Table 1. Characteristics of the hospitals and respondents. I would suggest to describe them as both continuous and categorical variables.

Thank you for pointing this out. We clarified the nature of the categorical variable (e.g., >500, ≤500) in Table 1.

5. Figure 1: Please specify the difference between 'QI' and 'target QI', I can't find related information in the notes of the Figure and the main context.

Thank you for pointing this out. We focused on the QI of adherence to CPGs for perioperative antibiotic prophylaxis of the 11 surgeries such as gastrectomy, prostate cancer surgery and so on (i.e., target QI), which were explained in "the QI of interest" (Page 9 Line 11-16).

As per the reviewer's suggestion, we revised the sentence and the figure, and added the figure legends as below:

Page 9, Line 13

The QI of interest for this study was…., and was aggregated from the results of the following 11 surgical types (i.e., target QI in Fig.1): evacuation of intracranial hematoma, gastrectomy, …benign ovarian tumor surgery, and ovarian cancer surgery.

Page 27, Line 3-4（Figure legends of Figure 1）

**Target QI indicates QI of perioperative antibiotic prophylaxis of the 11 surgical procedures mentioned in the manuscript.*

6. Figure 2: Please specify the meanings of 'df1' and 'df2'.

Since our dependent variable (i.e., QI score) was continuous, it is first transformed into an ordinal predictor before the remainder of the exhaustive CHAID algorithm proceeds. The algorithm performs an ANOVA F test that tests whether the means of the QI scores for the different categories of X are the same. This ANOVA F test calculates the F-statistic and derives the p-value as below:

$$F = \frac{\sum_{i=1}^{I}\sum_{n\in D} w_n f_n I(x_n = i)(\bar{y}_i - \bar{y})^2/(I-1)}{\sum_{i=1}^{I}\sum_{n\in D} w_n f_n I(x_n = i)(y_n - \bar{y}_i)^2/(N_f - I)},$$

$$p = \Pr\left(F(I-1, N_f - I) > F\right),$$

where

$$\bar{y}_i = \frac{\sum_{n\in D} w_n f_n y_n I(x_n = i)}{\sum_{n\in D} w_n f_n I(x_n = i)},\quad \bar{y} = \frac{\sum_{n\in D} w_n f_n y_n}{\sum_{n\in D} w_n f_n},\quad N_f = \sum_{n\in D} f_n,$$

$F(I-1,N_f-I)$ is a random variable following an F-distribution with degrees of freedom, df1 and df2, i.e., F(df1, df2). References:

IS BY BIGGS, CHAID, et al. CHAID and Exhaustive CHAID Algorithms. ftp://java.sdu.edu.tr/SPSS%20ve%20AMOS/SPSS%2013.0.1/Algorithms/TREE-CHAID.pdf Page 3-4.

7. Figure 2: I think the authors should be careful when using 'determinants' to describe these included factors. My understanding is 'determinants' usually are well defined and established causes, e.g., social determinants of health.

As per the reviewer's suggestion, we changed 'determinants' in the body of the manuscript to 'correlates' so as not to exaggerate the nuance of the meaning.

8. Following Point 4, I would suggest the authors revise the objectives as: to describe the present state of IT infrastructure provided in acute care hospitals across Japan and to investigate its association with healthcare quality (page 2).

As per the reviewer's suggestion, we changed the related sentences as below:

Page 2, Line 5-6

The objectives of this study were to describe….and to investigate its association with healthcare quality.

Page 6, Line 14-16

This multicenter study aimed to describe the present state of IT infrastructure provided in Japanese acute care hospitals and to investigate its association with healthcare quality, taking into account hospital size, hospital policies promoting evidence-based practice.

VERSION 2 – REVIEW

REVIEWER	Xiaolin Xu University Of Queensland
REVIEW RETURNED	28-Feb-2019

GENERAL COMMENTS	The authors have addressed all my concerns.