PEER REVIEW HISTORY

ARTICLE DETAILS

TITLE (PROVISIONAL)	Efficiency evaluation of public hospitals in Saudi Arabia: An application of Data Envelopment Analysis
AUTHORS	Alatawi, Ahmed; Niessen, Louis; Khan, Jahangir

VERSION 1 - REVIEW

REVIEWER	Zhang Xing Health Program group, MetLife Japan
REVIEW RETURNED	26-Jun-2019

GENERAL COMMENTS	Dear Editor, Thank you very much for the opportunity to review this manuscript. The paper analyzed the efficiency of public hospitals in Saudi Arabia using DEA approach. I have following major concerns about the paper, thus I suggest a major revise. Here are major concerns: First, authors need to consider the international readership BMJ open, it is important draw better conclusions for an international audience, largely outside of Saudi Aribia. Instead of plain description of efficiency scores, tell audience how your paper informs the international research and policy communities, in terms of: (1) the usefulness and generalizability of your findings; and/or (2) the implications for policy makers who must design hospital efficiency improvement program. Second, authors need to perform deeper discussion by taking local health policy and functions of hospitals into consideration, which will make your recommendation more practical. My experience tells me most policy suggestions drawn from mathematical models do not work in the real world. Third, orientation of the DEA model. In the introduction section, authors pointed out the health system facing a considerable shortage in hospital bed. It is possible that patients are not able to access to adequate healthcare services because of short in supply. Thus, output oriented model might be more proper. The government is facing increase of supply issue. Or it may draw contradictory conclusions. Minor concerns, 1. Strength and limitations in Abstract section. I am not convinced by the listed 4 strength, instead, many issues remain arguable. For example, with my limited knowledge, I didn't see any paper shows the hospital efficiency research community or DEA community reach agreement on criteria of variable selection for hospital efficiency study. Quite the contrary, many dimensions remains

	controversial, like quality of the service, the complexity of the service, the way to deal with the negative output (mortality you used in this research. It's not a strength, you need to justify it not only from model construction, but also from more basic rationale whether mortality rate can truly reflect the quality the service). On the other hand, the limitations of this study are far from being stated. 2. For the method part, you need to justify your method by your study design, objective, and your data. For example, a) both DEA and SFA have pros and cons, they are widely used in different settings serve different purposes. It inconvincible to justify your DEA choice by comparing which method is more frequently used by research papers. b) You need to give more explain about your output variables, "intermediate" outputs like radiological tests, surgical operations, etc. The final "products" of a hospital are treated patients, all the intermediate outputs serve the final treated patients, they are highly correlated, what is your explanation of including both. 3. In the discussion part, the limitation of DEA approach in hospital efficiency study should be well realized and admitted before give any policy suggestion. You always need to reference the "Newhouse critique" about the quality and complexity of healthcare service. Following articles address this issue very well. Considering the limitations, I would suggest not give advice purely based on you model, like full time physicians are 20% excess, increase inpatient by 12% etc. You don't know whether these are feasible if no real-world factors are considered. Instead, I suggest to explore the pattern and trend of the efficiency of the hospitals and investigate the causes of these pattern. Please refer to the third paper as well about how to generalize the local findings. □ Newhouse, J. P. 1994. "Frontier estimation: how useful a tool for health economics?" J Health Econ 13(3): 317-22. □ Hussey, P. S., H. de Vries, J. Romley, M. C. Wang, S. S. Chen, P. G. Shekelle, and E. A. McGlynn. 2009. "A systematic review of health care efficiency measures." Health Serv Res 44(3): 784-805. □ Zhang, X., Tone, K. and Lu, Y., 2017. Impact of the Local Public Hospital Reform on the Efficiency of Medium-Sized Hospitals in Japan: An Improved Slacks-Based Measure Data Envelopment Analysis Approach. Health Services Research.

REVIEWER	MONICA GIANCOTTI MAGNA GRAECIA UNIVERSITY, CATANZARO
REVIEW RETURNED	04-Jul-2019

GENERAL COMMENTS	TITLE: Efficiency evaluation of public hospitals in Saudi Arabia: An application of Data Envelopment Analysis Journal: BMJ Open Manuscript ID bmjopen-2019-031924 Overall impression: In my opinion the paper present a potential relevant contribution. The topic is interesting and relevant. The title is appropriate. However, the study requires revisions in order to improve the quality of the paper.

	Therefore, I invite authors to respond to my comments and revise their manuscript. Here are my key observations on the content and quality of the manuscript. ABSTRACT: The section “Strengths and limitations of this study” should not be inserted in the abstract INTRODUCTION: In the first place, the suggestion is to revisit the introductory section: please provide proper background and motivation of the study, considering the international context, including a clear Statement of the Problem. In particular, spending more effort in describing what is known about hospitals efficiency and factors that affect hospitals’ performance could add to the paper’s positioning in the research stream and increase its international relevance. METHOD: The methodological section’s structure could perhaps be slightly revisited in order to describe clearly how the various research questions are being addressed. Also, please offer proper justification of why the DEA technique is better suited for this case. CONCLUSIONS: The manuscript lacks discussion on how other countries could benefit from this research. In particular, in describing a case study, it’s important from the authors to offer a detailed discussion and / or enunciation of (a) lessons learned in applying a certain technique/method, (b) how the experience of the localized case study be replicated to another entity in other parts of the world to enhance its broader impact. Some part s of the manuscript may be in need of a linguistic revision. This reviewer wishes the authors good luck with the publication of their work!

VERSION 1 – AUTHOR RESPONSE

Reviewer #1:

Thank you very much for the opportunity to review this manuscript.

The paper analyzed the efficiency of public hospitals in Saudi Arabia using DEA approach. I have following major concerns about the paper, thus I suggest a major revise.

Comment 1: First, authors need to consider the international readership BMJ open, it is important draw better conclusions for an international audience, largely outside of Saudi Aribia. Instead of plain description of efficiency scores, tell audience how your paper informs the international research and policy communities, in terms of: (1) the usefulness and generalizability of your findings; and/or (2) the implications for policy makers who must design hospital efficiency improvement program.

Response: We thank the reviewer for the comments. We updated discussion sections accordingly (page 19 and 20). In recent years, KSA has been facing the global trends of rising healthcare costs in addition to high growth rate of population and high prevalence of chronic diseases. The government thus realized that the existing healthcare financing system with oil revenue is unsustainable. It thus can be argued that optimum use of existing health resources, which is a fundamental requirement for

achieving universal health coverage as advised by the World Health organization can appropriately be applied for KSA. An application of these findings is useful for high income, and Gulf countries in particular, which have the same health financing systems and comparable demand for health services. Our findings from this current analysis of KSA public hospitals indicated that there is large scope for improving efficiency in utilizing healthcare resources. We recommend the policy-makers to consider the appropriate use of resources within hospitals as well as reallocate resources across hospitals, given the findings of this research. Thus, to meet the efficient use of health resources to ensure the maximum value for money, which is expected to contribute significantly towards achieving universal health coverage in KSA.

Comment 2: Second, authors need to perform deeper discussion by taking local health policy and functions of hospitals into consideration, which will make your recommendation more practical. My experience tells me most policy suggestions drawn from mathematical models do not work in the real world.

Response: We revised the discussion of the findings, which based in light of the health policies in KSA in pages 18 and 19.

Comment 3: Third, orientation of the DEA model. In the introduction section, authors pointed out the health system facing a considerable shortage in hospital bed. It is possible that patients are not able to access to adequate healthcare services because of short in supply. Thus, output oriented model might be more proper. The government is facing increase of supply issue. Or it may draw contradictory conclusions.

Response: We aimed to estimate the optimal levels of the resources without deteriorating the levels of the health services that the hospitals provide. In this way, we provide the central authorities with the potential savings that could be made in the health sector. Performance analysis have argued that hospitals have relatively little control over their outputs (for example, expanding surgical operations), but more control over the inputs (e.g. medical devices), where they have the social responsibility to provide medical treatment through the public hospitals in general (see Jacobs, 2006). Thus, we adopt input orientation for efficiency assessment of the hospitals. However, did not apply output-oriented DEA models because outputs of different type than the ones used in the current study (public hospitals) would need to be available.

Comment 4: Strength and limitations in Abstract section. I am not convinced by the listed 4 strength, instead, many issues remain arguable. For example, with my limited knowledge, I didn't see any paper shows the hospital efficiency research community or DEA community reach agreement on criteria of variable selection for hospital efficiency study. Quite the contrary, many dimensions remains controversial, like quality of the service, the complexity of the service, the way to deal with the negative output (mortality you used in this research. It's not a strength, you need to justify it not only from model construction, but also from more basic rationale whether mortality rate can truly reflect the quality the service). On the other hand, the limitations of this study are far from being stated.

Response: We updated the strength and limitation section accordingly. It has been argued by Jacobs, et al. in 2006 about the dimensions of the selected variables in performance assessment of health care models, which we met in this study. Similar arguments we observed in Hollingworth 2003; 2008, inputs are capital, labour and consumable resources; whereas outputs are health services and health outcomes, (page 8). We included the mortality rate as an indicator of health service quality, however, reduction in the mortality rate and increase quantity of life signify an improvement in the health outcomes of the public hospital of investigation. Therefore, mortality rate could be a proxy for a weighted health quality measure in this analysis.

Comment 5: For the method part, you need to justify your method by your study design, objective, and your data. For example, a) both DEA and SFA have pros and cons, they are widely used in

different settings serve different purposes. It inconvincible to justify your DEA choice by comparing which method is more frequently used by research papers. b) You need to give more explain about your output variables, “intermediate” outputs like radiological tests, surgical operations, etc. The final “products” of a hospital are treated patients, all the intermediate outputs serve the final treated patients, they are highly correlated, what is your explanation of including both.

Response: We revised the contents of the method section, (pages 6;12). A) We applied DEA since it does not require any a prior specification of the underlying functional form that relates the inputs with the outputs. Usage of DEA is also justified by its ability to incorporate multiple inputs and outputs in different units of assessment, (page 9). In addition, DEA is the predominant method of public hospital efficiency assessment as observed in many publications. B) In our study “aimed to assess the performance” we expanded the selection of the hospital outputs to cover a broad range of health services provided by public hospitals, for accurate assessment (Jacobs, 2006). All the included outputs (health services) are dependent on the selected inputs (health resources), as DEA requirements, however, it is expected (and required) that these variables to be correlated (see Luo, et al. 2012). For instance, radiology technicians are included in allied health personnel (input variable), so we have to include radiological tests, given the definition of performance assessment (Cooper, et. Al, 2007). Finally, the selected four inputs and six outputs were chosen based on the availability of the data in KSA context. However, we incorporate the variables that could answer the research questions and requirements of the DEA model, which were rationally approved in previous theoretical and empirical studies.

Comment 6: In the discussion part, the limitation of DEA approach in hospital efficiency study should be well realized and admitted before give any policy suggestion. You always need to reference the "Newhouse critique" about the quality and complexity of healthcare service. Following articles address this issue very well. Considering the limitations, I would suggest not give advice purely based on you model, like full time physicians are 20% excess, increase inpatient by 12% etc. You don’t know whether these are feasible if no real-world factors are considered. Instead, I suggest to explore the pattern and trend of the efficiency of the hospitals and investigate the causes of these pattern. Please refer to the third paper as well about how to generalize the local findings.

 Newhouse, J. P. 1994. “Frontier estimation: how useful a tool for health economics?” J Health Econ 13(3): 317-22.

 Hussey, P. S., H. de Vries, J. Romley, M. C. Wang, S. S. Chen, P. G. Shekelle, and E. A. McGlynn. 2009. “A systematic review of health care efficiency measures.” Health Serv Res 44(3): 784-805.

 Zhang, X., Tone, K. and Lu, Y., 2017. Impact of the Local Public Hospital Reform on the Efficiency of Medium-Sized Hospitals in Japan: An Improved Slacks-Based Measure Data Envelopment Analysis Approach. Health Services Research.

Response: We thank the reviewer for the suggestions. We updated these sections accordingly. In the current time, we are conducting allocative efficiency analysis considering the health policies and strategic plans in KSA. In addition, we estimating through utilization analysis of health services in each hospital to understand the patterns and demand for the services in the sample hospitals.

Reviewer #2:

Overall impression: In my opinion the paper present a potential relevant contribution. The topic is interesting and relevant. The title is appropriate.

However, the study requires revisions in order to improve the quality of the paper.

Therefore, I invite authors to respond to my comments and revise their manuscript.

Here are my key observations on the content and quality of the manuscript.

ABSTRACT

Comment 1: The section “Strengths and limitations of this study” should not be inserted in the abstract

Response: We thank the reviewer for this comment. We followed the BMJ-open’s guidelines to include “Strength and limitation” section after the Abstract part. See the following link; https://bmjopen.bmj.com/pages/authors/

INTRODUCTION

Comment 2: In the first place, the suggestion is to revisit the introductory section: please provide proper background and motivation of the study, considering the international context, including a clear Statement of the Problem. In particular, spending more effort in describing what is known about hospitals efficiency and factors that affect hospitals’ performance could add to the paper’s positioning in the research stream and increase its international relevance.

Response: We updated the introduction accordingly. Please see the related section (page 4, 5 & 6).

METHOD

Comment 3: The methodological section’s structure could perhaps be slightly revisited in order to describe clearly how the various research questions are being addressed. Also, please offer proper justification of why the DEA technique is better suited for this case.

Response: We revised the order and contents of the method’s sub-headings, (pages 6;12). We applied DEA since it does not require any a prior specification of the underlying functional form that relates the inputs with the outputs. Also, use of DEA is justified by its ability to incorporate multiple inputs and outputs in different units of assessment, (page 9)

CONCLUSIONS

Comment 4: The manuscript lacks discussion on how other countries could benefit from this research.

In particular, in describing a case study, it’s important from the authors to offer a detailed discussion and / or enunciation of (a) lessons learned in applying a certain technique/method, (b) how the experience of the localized case study be replicated to another entity in other parts of the world to enhance its broader impact.

Response: We thank the reviewer for the comments. We updated the related sections accordingly (page 20, 2nd and 3rd para).

VERSION 2 – REVIEW

REVIEWER	Zhang Xing Health Program Group, MetLife Japan.
REVIEW RETURNED	05-Sep-2019

GENERAL COMMENTS	Here are my comments on the revised version. Major comments 1. The model you build contradicts to your statement made in the introduction. The problem you pointed out is insufficient health resources. But the model you built is based on keeping supply constant while reduce the health resource. As a fundamental issue, my third comment is not well responded. The argument “hospitals have relatively little control over their outputs” is questionable in a different unit of analysis and policy settings. In public financed healthcare system, the policymakers are able to increase the output by increase medical students and hospitals. ...the number of hospital beds is considerably lower. 3,109 Just 2.7 hospital beds per 1,000 people are allocated in KSA, whereas the average corresponding figure in other high-income countries is 8.9.3,109 A previous study suggested that demand for healthcare services in KSA would increase by 145% by 2025 and require twice the number of hospital beds Although much has been done to promote the efficient use of resources, this has proven insufficient to meet the rising health expenditure and demand for healthcare in KSA. Providers seem to find it very challenging to deliver adequate provision using current resources.4 There seems to be an imbalance between health service availability and health spending, so better use of resources is necessary if KSA is to have an efficient and appropriate health system. Is it an issue of efficiency or shortage of resource or both?? Referring to my comments, what is the proper model to address the issue? I don’t quite get the explanation “because outputs of different type than the ones used in the current study (public hospitals) would need to be available.” Could you explain little more? 2. Regarding previous Comment 4, you need to be very cautious to use mortality as a proxy variable for quality measurement. As you mentioned, the complexity and severity of patients, which may lead to higher mortality, are missing in your study. Usually, large hospitals handle more severe cases, which could possibly be a reason they have lower efficiency in your study. 3. In the discussion session, some policy implications are stated in a very assertive way, I am concerned whether it is proper by leaving many other factors unevaluated, which may influence the efficiency as well. I suggest authors soften the tone, in a position that provide more information for policy-makers from DEA efficiency perspective of view, constructively suggest them taking the findings of this study into their consideration as one of many factors when they make the health policies. Minor comments 1. You need to reduce the length of your introduction, it should be done within one page, at most one and half. 2. You may want to start the method session with Data Envelopment Analysis (in 9 page), and take the DEA related

	paragraph in the introduction session to here as well. It will be easier to read. 3. On page 16, “In terms of input, results show that an excess of physicians was the main cause of inefficiencies in public hospitals.” 2% more reduction than other inputs does not seemingly make the physicians the main cause of inefficiency. Would the findings suggest that the inputs should be reduced proportionally?? 4. On page 17, “This indicated that inefficiency was due to administrative failure to overcome external environmental factors and inability to manage internal operations in the hospitals.” I would not make such a strong assertion unless all other possibilities causing inefficiency are carefully examined. 5. On page 18, the paragraph “this study found that 61.5%.... which reported the lowest efficiency scores, were operating on DRS”. It is obvious to downsize the DMUs on DRS and expand those on IRS based on DEA model. But when it comes to policy implications, it deserves a deeper discussion by considering broader settings, especially potential public functions they are undertaking. How these functions influence the efficiency. Is the public interest is hurt if you cut the resources? 6. On page 18, the first argument about the reason for lower efficiency in the west region. I can understand that case-mix can create efficiency difference between small and large hospitals. But I have some hard time to image location difference caused by mix case. Could you check the size of hospitals in the western region? Or IS it because of incapability of handling complicating medical conditions in these western region hospitals, patients prefer to go to other hospitals for better treatment? Or would you examine the demand side factors, like the density of population, or some geographic barriers that make patients difficult to access to hospitals? 7. On page 19, second paragraph, “… the number of full-time physicians was the most notable reason…” the same comment as 5. 8. On Page 20, second paragraph, argument about orient of your model. I am not saying you should do the output orientation model, I suggest that your model should serve the logic of your paper. Please refer to comment 2 above. 9. The conclusion is too long, please keep it one paragraph.

REVIEWER	MONICA GIANCOTTI MAGNA GRAECIA UNIVERSITY
REVIEW RETURNED	27-Aug-2019

GENERAL COMMENTS	Manuscript ID bmjopen-2019-031924.R1 Title Efficiency evaluation of public hospitals in Saudi Arabia: An application of Data Envelopment Analysis Overall impression: My comments have been addressed by the authors. Now the paper is well written, with clear structure and careful explanations, enabling others to replicate these techniques if desired. The quality of experimental data is convincing and the conclusions appear to be reliable. I have just a few small comments on the text, which the authors may wish to address: Pag 6, Line 13-28: please justify the text;

	Pag 11, line 55: please check the sequence of numbered points, number one is not formatted in bold, like points 2 and 3; Pag 13, line 5: please insert the point at the end of the sentence: "Table 3 presents the results of DEA models, summary statistics of average technical (CRS and VRS) efficiency, and scale (SE) efficiency scores, as well as concerning the return to scale." Pag 19-20, from line 58(pag 19) to line 23 (Page 20): please justify the text; Pag 25, line 40-44: please check the spaces; This reviewer wishes the authors good luck with the publication of their work!

VERSION 2 – AUTHOR RESPONSE

Reviewer #1:

Here are my comments on the revised version.

Major comments

Comment 1: The model you build contradicts to your statement made in the introduction. The problem you pointed out is insufficient health resources. But the model you built is based on keeping supply constant while reduce the health resource. As a fundamental issue, my third comment is not well responded.

The argument "hospitals have relatively little control over their outputs" is questionable in a different unit of analysis and policy settings. In public financed healthcare system, the policymakers are able to increase the output by increase medical students and hospitals.

...the number of hospital beds is considerably lower. 3,109 Just 2.7 hospital beds per 1,000 people are allocated in KSA, whereas the average corresponding figure in other high-income countries is 8.9.3,109 A previous study suggested that demand for healthcare services in KSA would increase by 145% by 2025 and require twice the number of hospital beds

Although much has been done to promote the efficient use of resources, this has proven insufficient to meet the rising health expenditure and demand for healthcare in KSA. Providers seem to find it very challenging to deliver adequate provision using current resources.4 There seems to be an imbalance between health service availability and health spending, so better use of resources is necessary if KSA is to have an efficient and appropriate health system.

Is it an issue of efficiency or shortage of resource or both??

Referring to my comments, what is the proper model to address the issue?

I don't quite get the explanation "because outputs of different type than the ones used in the current study (public hospitals) would need to be available." Could you explain little more?

Response: We thank the reviewer for the comments. The problem addressed in this paper deals with inefficient usage of health resources, indicating the increase of health expenditure in general in the country as well as the increased spending in the public hospitals, (Introduction, page 3, para 2& 3).

In public hospital context, which have social responsibility to provide medical care to all population in need in the catchment area and beyond, it is challenging to control the level of supply (output or production of health services) since many factors play important roles (like demand for medical care, social characteristics of those patients who seek health services) in determining the production level of a hospital. In addition, the factors inside the hospitals (like health human resources) are important inputs of the production process and their level of performance is not always predictable.

This uncertainty in production process along with the demand for medical care and social characteristics in the catchment areas might be argued for applying input-orientation as a more appropriate one than the output-oriented approach (please see Methods in page 10, para 2). We employ an input-oriented DEA model that seeks for potential improvements in hospitals by reducing their input levels while their levels of outputs are kept unchanged. This notion is clearly depicted in the envelopment form (dual) of model (2), which is a minimization problem.

On the contrary, if we would analyse the efficiency of factories that solely use machines for production where doubling of machine doubles the production, then output-orientation would be more appropriate approach of analysis. Based on the similar arguments, several previous studies adopted input-orientation in their public hospital efficiency assessments (Cooper W, 2007; O'Neill L, 2008; Varabyova Y, Müller JM; 2016; Pelone F, 2015; Chuang CL, 2010). In sum, since hospital is a labour-intensive production process unlike many other capital-intensive ones (like, computer production), input-orientation appears to be a more appropriate approach of efficiency analysis in public hospitals.

Comment 2: Regarding previous Comment 4, you need to be very cautious to use mortality as a proxy variable for quality measurement. As you mentioned, the complexity and severity of patients, which may lead to higher mortality, are missing in your study. Usually, large hospitals handle more severe cases, which could possibly be a reason they have lower efficiency in your study.

Response: We included the mortality rate as an indicator of health service quality, since reduction in the mortality rate and increase in quantity of life (longevity) signify an improvement in the health outcomes of the public hospitals under investigation (page 8, para 2). Therefore, we adopted mortality rate as a proxy for a weighted health quality measure in this analysis (Ahmed et al. 2019). We are aware that the severity of treated cases and case-mix would be a good indicator of quality. But we lack relevant data, while the data on mortality was available in the study hospitals. We have included this limitation in the discussion section (page 20, Para 2).

Comment 3: In the discussion session, some policy implications are stated in a very assertive way, I am concerned whether it is proper by leaving many other factors unevaluated, which may influence the efficiency as well. I suggest authors soften the tone, in a position that provide more information for policy-makers from DEA efficiency perspective of view, constructively suggest them taking the findings of this study into their consideration as one of many factors when they make the health policies.

Response: We made it clear that the policy recommendations are based on our findings from the analysis and tried to soften the language. Please see page 19, paragraph 3. In the limitations, we brought the issue that all factors could not be included in the analysis due to unavailability of data though we are aware of their importance (please see page 20, paragraph 3).

Minor comments

Comment 1: You need to reduce the length of your introduction, it should be done within one page, at most one and half.

Response: We thank the reviewer for the comment. The introduction is now less than 2 pages. We kept the description of KSA health system under a new sub-heading. This new section is necessary to understand the context of this study and we didn't breach the word limit. We provided an overview of health system in KSA, indications on inefficient utilization of health resources in public hospital sector, literature reviews of main research conducted in this context and methods that commonly used, that led us to investigate the current state of hospital efficiency (study aim).

Comment 2: You may want to start the method session with Data Envelopment Analysis (in 9 page), and take the DEA related paragraph in the introduction session to here as well. It will be easier to read.

Response: We read through the text and found that the description of the sample and the variables used in the analysis, followed by the estimation technique (DEA) and related assumptions appear to be a common order of presenting in the papers for a good flow in reading. We have also followed some previous studies in this area of research which used the same order of presentation. The reader will be able to understand the methodology techniques, orientation of analysis and performance assumptions after they finished reading the relevant parts of sample/ variable descriptions.

Comment 3: On page 16, "In terms of input, results show that an excess of physicians was the main cause of inefficiencies in public hospitals." 2% more reduction than other inputs does not seemingly make the physicians the main cause of inefficiency. Would the findings suggest that the inputs should be reduced proportionally??

Response: We suggested that all four inputs should be reduced proportionally according to the percentages in table 5, (page 16, 2nd para), without giving any emphasis on physician reduction.

Comment 4: On page 17, "This indicated that inefficiency was due to administrative failure to overcome external environmental factors and inability to manage internal operations in the hospitals." I would not make such a strong assertion unless all other possibilities causing inefficiency are carefully examined.

Response: We revised by softening the language as ''This indicated that inefficiency might be due to administrative gaps to overcome external environmental factors, and limitations in managing internal operations in the hospitals''. In the limitations under discussion, we have brought the issue of missing factors in the analysis (page 19 & 20).

Comment 5: On page 18, the paragraph “this study found that 61.5%.... which reported the lowest efficiency scores, were operating on DRS”. It is obvious to downsize the DMUs on DRS and expand those on IRS based on DEA model. But when it comes to policy implications, it deserves a deeper discussion by considering broader settings, especially potential public functions they are undertaking. How these functions influence the efficiency. Is the public interest is hurt if you cut the resources?

Response: In this analysis, we aimed to assess efficiency of public hospitals and provide recommendations for decision-makers in this context, which we answered in the paper. Also, we suggested that the prevailing ability of patients to access health services should not be compromised while reallocating the resources of some hospitals to the other hospitals until Pareto optimality is achieved. In addition, health regulators and decision makers should assess the legal conditions and regulations of MoH before taking any practical actions (page 19 para 1 & 3).

Comment 6: On page 18, the first argument about the reason for lower efficiency in the west region. I can understand that case-mix can create efficiency difference between small and large hospitals. But I have some hard time to image location difference caused by mix case. Could you check the size of hospitals in the western region? Or IS it because of incapability of handling complicating medical conditions in these western region hospitals, patients prefer to go to other hospitals for better treatment? Or would you examine the demand side factors, like the density of population, or some geographic barriers that make patients difficult to access to hospitals?

Response: We thank the reviewer for the question. Actually 5 out of 8 large size hospitals that were included in our analysis are located in the west region. In addition, west region hospitals treating different severities that include accidents during pilgrimage trip and infectious diseases of pilgrims and visitors from all over the globe in the Hajj season every year. Such treatment of the different cases in severity require comprehensive care for each case, consume more resources depend on severity of the case. On the other hand, the government of KSA allocate more health resources for the whole year in these hospitals to meet that aim, although pilgrimage season lasts for two weeks to one month. Thus, we provided the arguments in page 18.

Comment 7: On page 19, second paragraph, “… the number of full-time physicians was the most notable reason…” the same comment as 5.

Response: Given the findings of slack analysis, and policy implications and related recommendation, it should start dealing with physicians numbers, especially that they are the highest salaries in MOH. However, that doesn’t omit dealing with slacks of other inputs. We changed the wording in the manuscript as: “The analysis showed that the number of full-time physicians was slightly larger notable reason for inefficiency than the other factors, with an average excess of 22.4%, from an input perspective”. (page 19, para 2).

Comment 8: On Page 20, second paragraph, argument about orient of your model. I am not saying you should do the output orientation model, I suggest that your model should serve the logic of your paper. Please refer to comment 2 above.

Response: We have revised the text accordingly. Please see page 20, paragraph 2.

Comment 9: The conclusion is too long, please keep it one paragraph.

Response: We thank the reviewer for the comment. We shortened the conclusion to one paragraph (page 21).

Reviewer #2:

Overall impression: My comments have been addressed by the authors.

Now the paper is well written, with clear structure and careful explanations, enabling others to replicate these techniques if desired. The quality of experimental data is convincing and the conclusions appear to be reliable.

I have just a few small comments on the text, which the authors may wish to address:

Pag 6, Line 13-28: please justify the text;

Pag 11, line 55: please check the sequence of numbered points, number one is not formatted in bold, like points 2 and 3;

Pag 13, line 5: please insert the point at the end of the sentence: “Table 3 presents the results of DEA models, summary statistics of average technical (CRS and VRS) efficiency, and scale (SE) efficiency scores, as well as concerning the return to scale.”

Pag 19-20, from line 58(pag 19) to line 23 (Page 20): please justify the text;

Pag 25, line 40-44: please check the spaces;

This reviewer wishes the authors good luck with the publication of their work!

Respond: We thank the reviewer for these comments. We updated the related sections accordingly.

VERSION 3 - REVIEW

REVIEWER	Xing Zhang Health Program Group, MetLife, Japan.
REVIEW RETURNED	17-Nov-2019

GENERAL COMMENTS	The reviewer completed the checklist but made no further comments.

REVIEWER	MONICA GIANCOTTI MAGNA GRAECIA UNIVERSITY, ITALY
REVIEW RETURNED	23-Oct-2019

GENERAL COMMENTS	My minor comments have been addressed by the authors. Basically, the paper has a good potential and a clear structure. The language is fluent and it is easy to read. I recommend publication and I'm looking forward to read your next paper. This reviewer wishes the authors good luck with the publication of their work!