PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	A multicenter methodological study to create a publicly available score of hospital financial standing in the United States
AUTHORS	Zinoviev, Radoslav; Krumholz, Harlan; Ciccarone, Richard; Antle, Rick; Foreman, Howard

VERSION 1 – REVIEW

REVIEWER	Katarzyna Dubas-Jakóbczyk Uniwersytet Jagiellonski w Krakowie Collegium Medicum
REVIEW RETURNED	06-Jan-2021

GENERAL COMMENTS	The manuscript is focused on an important and valid issue. Yet, there are some issues to be addressed by the authors: • Both the article's title and abstract should indicate the country of the research. It's quite important from an international reader perspective. In other countries the availability of similar data might be limited, which strongly impacts the findings generalizability. This also should be discussed in the study limitations description (see further comments) • p.7. lines 27-32: references are required for such a normative statements • p.9. lines 22 – 27: the 'open discussion in the medical and business communities' and 'solicited open feedback' as a part of the study methods must be described in details – who, when, how was asked opinion? Was a qualitative methods used (focus group, in depth interview) or quantitative – survey? Depending on the answer – the process of data gathering and analysis must be described. • p. 9, line 41: authors write that they 'studied the financial analysis literature and identified 232 financial metrics that describe all aspects of hospital operations' – this process also need to be described in more details. How was the literature identified, what criteria were to select this original group of 232 metrics. Even though the literature review was not systematic, some kind of criteria must have been applied? • P.10, lines 26: some more details about these 1075 hospitals? Some basic descriptive statistics (private/public; for/non-profit; size). • p.13, line 6: 'perfect model' does not exists… models don't not need to be 'perfect' rather as accurate as possible • p.13, line 6-8: authors write that they 'undertook a systematic approach' - for that to be confirmed, the details of the methods applied (as listed above) should be provided • The current Discussion section seem more like repetition of Methods and Results – suggest to rewrite the text, that it covered only short summary of the results followed by more extended comparison to the literature. The is an abundance of literature on US hospitals financial standing, actually majority of the literature on 'hospitals financial standing' refers to the US market, so the

Discussion might be extended.
• In the Implication section, the authors mention only the limitation of their final results – the YHFS. What about the limitation of the study itself? Limitations related to the data and methods applied. What is the findings generalizability potential, also from an international perspective?
• Most of the Conclusion section seems to refer once again to repeating the Methods applied.

In general, I'm not sure whether the current manuscript version fits the BMJ Open readers' profile.

REVIEWER	Vivian Valdmanis
	Western Michigan University
REVIEW RETURNED	29-Jan-2021

GENERAL COMMENTS	Well written and thorough
	I enjoyed reading this paper
	Good jo

REVIEWER	Tiago Magalhães
	Universidade Federal de Juiz de Fora
REVIEW RETURNED	01-Apr-2021

| GENERAL COMMENTS | The paper creates a scoring procedure (the Yale Hospital Financial Score, YHFS) that provides an assessment of the financial health of a hospital. This manuscript includes results that are worthy of publication. However, I have some concerning about the statistical methodology.

Referee report on manuscript   A publicly available score for evaluating hospital
  nancial standing   ; BMJ: bmjopen-2020-046500

The paper creates a scoring procedure (the Yale Hospital Financial Score, YHFS) that provides an assessment of the   nancial health of a hospital. This manuscript includes results that
are worthy of publication. However, I have some concerning about the statistical methodology.
Guidelines are listed below.

1. Page 8. Will the dataset be available?

2. Page 9.
(a) Please, specify the page where the   nancial ratio standard equations is in the GAAP
reference.
(b) Why is the value 10% for validation, instead of, for instance, 25% or 33%? Did you
perform some kind cross-validation study?
(c) What was the motivation for the use of the PCoA and PCA? LASSO and Ridge
regression are quite useful for selection and/or solve the problem of collinearity.
(d) The last paragraph must be rewritten. For a non-quantitative readers, it is hard to
understand. Additionally, a detailed description (like an algorithm, if you prefer) of
this procedure should be in the Appendix. |

	3. Page 10. (a) The OLS equation should be presented in the Appendix. (b) The OLS was performed without an intercept? 4. Page 11. The multivariate OLS equation should be presented in the Appendix. 5. In the general. (a) The YHFS for a hospital i is YHFSi = 19 × Pro t Margini + 7 × Current Debt Service Coveragei + · · · + 1 × Salaries & Bene tsi , am I right? In any case, the main contribution of the manuscript, the YHFS, must be more emphasized. (b) The score was based on a dataset from 2017. How is the performance for more recently data?

VERSION 1 – AUTHOR RESPONSE

Reviewer: 1

Dr. Katarzyna Dubas-Jakóbczyk, Uniwersytet Jagiellonski w Krakowie Collegium Medicum

We would like to express our gratitude to Dr. Dubas-Jakóbczyk for her review of our manuscript and for her recommendations. We have made edits to our study in accordance to her recommendations. Detailed responses to her comments are given below.

Comments to the Author:

The manuscript is focused on an important and valid issue. Yet, there are some issues to be addressed by the authors:

- Both the article's title and abstract should indicate the country of the research. It's quite important from an international reader perspective. In other countries the availability of similar data might be limited, which strongly impacts the findings generalizability. This also should be discussed in the study limitations description (see further comments)

We appreciate this insight given the international scope of our target audience. This score was created using financial data in the United States and this is an excellent point that the country of origin should be clearly stated. We have added "in the United States" to our title and to the abstract, and we have expanded the limitations at the end of the Discussion section to reflect that this data may not be available in other countries:

"Fourthly, we used financial data from hospitals in the United States in creating the YHFS. Because hospitals in other countries face different financial stressors, this score will need to be further validated using country-specific financial data prior to use in another region."

- p.7. lines 27-32: references are required for such a normative statements

We have added references to this statement as requested by the reviewer.

- p.9. lines 22 – 27: the 'open discussion in the medical and business communities' and 'solicited open feedback' as a part of the study methods must be described in details – who, when, how was asked opinion? Was a qualitative methods used (focus group, in depth interview) or quantitative – survey? Depending on the answer – the process of data gathering and analysis must be described.

The Patient and Public Involvement statement was moved to a separate section preceding the Introduction in accordance to the recommendations by the editor. In response to the feedback from Dr. Dubas-Jakóbczyk, we have significantly expanded this section from two sentences into two paragraphs detailing community involvement into our process. We detailed the timing, methods and groups with whom this discussion was held. We specified that qualitative methods were used and described these methods. We added specifics regarding our process of recruitment and how these interviews affected our process. We named the industry experts who were recruited to the study as a result of our open discussions. We specified how these individuals and groups affected the process of data gathering and analysis.

- p. 9, line 41: authors write that they 'studied the financial analysis literature and identified 232 financial metrics that describe all aspects of hospital operations' – this process also need to be described in more details. How was the literature identified, what criteria were to select this original group of 232 metrics. Even though the literature review was not systematic, some kind of criteria must have been applied?

Thank you for this comment. This list of 232 financial metrics is in fact the list of metrics that can be calculated using the data reported by hospitals in their annual financial report. We obtain this list through our partnership with Merritt Research Services LLC. We used then confirmed that these ratios are inclusive of all metrics used by financial analysts through our review of literature. One our main sources was the book of most commonly used United States Generally Accepted Accounting Principles which is referenced in the next paragraph, and the studies of hospital financial standing referenced throughout the manuscript. We have rephrased this text as follows and added citations for the references using in our literature analysis:

"Through our partnership with Merritt Research Services LLC, we obtained a comprehensive list of 232 financial metrics that can be calculated using the data reported by hospitals in their annual financial reports. We studied the financial analysis literature to assure that these metrics describe all aspects of hospital operations."

- P.10, lines 26: some more details about these 1075 hospitals? Some basic descriptive statistics (private/public; for/non-profit; size).

We have expanded this section to include a description of the hospitals used in the study, including hospital type, size, and share of Medicare patients with the following text:

"Our sample consisted of 1,075 US hospitals reporting financial data in 2017. This sample comprised of general acute care and teaching hospitals (535), health systems (301), hospital districts (102), critical access hospitals (93), children's hospitals (32), and other hospital types (12). These hospitals had an average of 265 beds, average total annual discharges of 12,714 patients of whom an average of 37% were Medicare patients."

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- p.13, line 6: 'perfect model' does not exists… models don't not need to be 'perfect' rather as accurate as possible

We agree with the reviewer's comment and have changes the text to read: "There is currently no systematically validated model for evaluating the financial standing of hospitals."

- p.13, line 6-8: authors write that they 'undertook a systematic approach' - for that to be confirmed, the details of the methods applied (as listed above) should be provided

Thank you for this feedback. In response to this and the previous comments by Dr. Dubas-Jakóbczyk, we have expanded the description of our methodology. This includes:

1. *A detailed discussion of our work with academic and industry experts detailed in the Patient and Public Involvement section.*
2. *An expansion of how and why the initial 232 ratios were selected in the Methods section.*
3. *Further description of the hospital sample used in the study.*

We hope that these details make clear the steps that were taken in creating the YHFS. We would be glad to add more details if there is any area that remains unclear as our hope is to produce a fully transparent methodology.

- The current Discussion section seem more like repetition of Methods and Results – suggest to rewrite the text, that it covered only short summary of the results followed by more extended comparison to the literature. The is an abundance of literature on US hospitals financial standing, actually majority of the literature on 'hospitals financial standing' refers to the US market, so the Discussion might be extended.

We appreciate the feedback from Dr. Dubas-Jakóbczyk regarding our discussion. However, we were unsure of what specific edits Dr. Dubas-Jakóbczyk is asking for as we had intended to do just as she had suggested. Because we are presenting a methodology paper for the creation of a novel financial score, we felt that a discussion of the significance behind our variable selection is pertinent and have tried to present it in a way that does not simply repeat the Methods and Results. We have drawn from existing literature on financial standing in the United States whenever possible. We acknowledge our limitations in recognizing shortcomings in this approach and aspire to present a comprehensive report. We would gladly work with the editors to eliminate any redundancies but would appreciate more guidance in what parts felt to be restating the previous sections and are appropriate for elimination. Furthermore we would be glad to add more references to published literature if we could ask for guidance in what specific parts of the study can be supported further. It is our intent to present a clear discussion that describes the significance of our work and draw on existing literature on financial standing in healthcare organizations, and we would be grateful for any further instruction in how we may do so.

- In the Implication section, the authors mention only the limitation of their final results – the YHFS. What about the limitation of the study itself? Limitations related to the data and methods applied. What is the findings generalizability potential, also from an international perspective?

Thank you for this comment – this concern was also raised by the editor. We have added a paragraph at the end of the Discussion section expanding on the limitations of the study including the limitation of generalizability from an international perspective.

- Most of the Conclusion section seems to refer once again to repeating the Methods applied.

As with the comments regarding the Discussion, we kindly ask for any specifics that Dr. Dubas-Jakóbczyk feels are redundant and what we may do to strengthen our Discussion and Conclusion sections.

In general, I'm not sure whether the current manuscript version fits the BMJ Open readers' profile.

Reviewer: 2

Dr. Vivian Valdmanis, Western Michigan University

Comments to the Author:

Well written and thorough

I enjoyed reading this paper

Good jo

We would like to thank Dr. Valdmanis for her time in reviewing our manuscript and for her feedback.

Reviewer: 3

Prof. Tiago Magalhães, Universidade Federal de Juiz de Fora

Comments to the Author:

The paper creates a scoring procedure (the Yale Hospital Financial Score, YHFS) that provides an assessment of the financial health of a hospital. This manuscript includes results that are worthy of publication. However, I have some concerning about the statistical methodology. Guidelines are listed in a attached file.

We would like to thank Prof. Magalhães for his thoughtful consideration of our manuscript. We have made changes to the manuscript in accordance with his recommendations. These changes are detailed below:

1. Page 8. Will the dataset be available?

Our goal is for the methodology of this study to be readily and easily reproducible. The dataset used in calculating the YHFS is cited in the methods section and is publicly available. If this is the dataset referred to by Prof. Magalhães, this dataset should be freely downloadable from the CMS website listed under our reference. If Prof. Magalhães was referring to the final calculated hospital scores, we

had not planned to post the final dataset online, but would be glad to share these with individual researchers.

2. Page 9.
(a) Please, specify the page where the financial ratio standard equations is in the GAAP reference.

Thank you – the page numbers have been added to the reference (because we calculated multiple ratios whose formulae are dispersed throughout the book, we provided a broad range that included all formulae rather than referencing 30 individual pages).

(b) Why is the value 10% for validation, instead of, for instance, 25% or 33%? Did you perform some kind cross-validation study?

We concur that the choice of 10% rather than a different value is arbitrary. We reviewed financial modeling literature and did not find a specific recommendation on what size sample should be reserved for validation. During our discussion with the statisticians and financial modeling experts listed in our Patient and Public Involvement, 10% appeared to be a reasonable size sample to reserve for validation.

We apologize that our text was unclear: the aim of reserving a 10% sample was indeed for cross-validation. We have changed the text in the Abstract, Methods, Results and Discussion sections to specify that this was used for cross-validation.

(c) What was the motivation for the use of the PCoA and PCA? LASSO and Ridge regression are quite useful for selection and/or solve the problem of collinearity.

Thank you for this feedback. We (the authors) had experience with the use of PCoA and PCA analysis in this context. We had successfully used in prior similar projects and felt that it was appropriate for this study. We hired an independent biostatistics consultant, Dr. Gayane Yenokyan, at the Johns Hopkins Bloomberg School of Public Health Biostatistics Center who confirmed that this is an appropriate method to use in solving our problem with collinearity.

(d) The last paragraph must be rewritten. For a non-quantitative readers, it is hard to understand. Additionally, a detailed description (like an algorithm, if you prefer) of this procedure should be in the Appendix.

Thank you for pointing out that this part of the methods section was unclear. We have completely rewritten the entire paragraph pointed out by this reviewer to make our process more clear and understandable. We have simplified the language whenever possible and added more text to clarify what was done in each step and what was the rational for each process.

*We appreciate the recommendation for creating a visual algorithm for this process to better illustrate the methodology. Following this recommendation, we have created a flow chart **Appendix Figure 1** to visualize the procedure followed in creating our score.*

3. Page 10.
(a) The OLS equation should be presented in the Appendix.

*As requested, we have included the OLS model as **Appendix Figure 2.***

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(b) The OLS was performed without an intercept?

Yes, the OLS regression was performed without an intercept. We had extensive discussions regarding this process with our statistical consultants, Dr. Gayane Yenokyan, at the Johns Hopkins Bloomberg School of Public Health Biostatistics Center, and ultimately decided not to include an intercept. The rationale for our choice was that we had performed this OLS regression to calculate coefficients for the variables used in the YHFS by using their relative weights in the model. Including an intercept would affect the weights of each coefficient as they relate to each other. We therefore chose not to include an intercept into the equation.

4. Page 11. The multivariate OLS equation should be presented in the Appendix.

*As requested, we have included the multivariate OLS outputs as **Appendix Figure 3**.*

5. In the general.
(a) The YHFS for a hospital i is YHFSi = 19 Prot Margini + 7 Current Debt Service Coveragei + + 1 Salaries & Benetsi; am I right? In any case, the main contribution of the manuscript, the YHFS, must be more emphasized.

Yes, the equation listed by Prof. Magalhães is correct. We have revised the manuscript to increase the emphasis on the YHFS per the recommendations of Prof. Magalhães.

(b) The score was based on a dataset from 2017. How is the performance for more recently data?

There is a delay in the submission and release of hospital financial data which prompted us to use 2017 data at the time of this study in 2019-2020. To assess the validity of our model over time, we also computed the YHFS score for hospitals in 2014 and included this data in our discussion. The point raised by Prof. Magalhães is an important one and we are very interested in seeing how our model holds up over time. We intend to re-assess our model's performance as more current financial data becomes available in the next 1-2 years. Of particular interest would be the impact of the COVID-19 pandemic on hospital financial performance, though this data would unfortunately not be available for at least another year. While we are unable to calculate the YHFS in real-time from the publicly available databases used in this study, we hope that the retrospection to 2014 demonstrates the stability of our model.

VERSION 2 – REVIEW

REVIEWER	Katarzyna Dubas-Jakóbczyk Uniwersytet Jagiellonski w Krakowie Collegium Medicum
REVIEW RETURNED	23-May-2021

| GENERAL COMMENTS | The manuscript has been substantially improved and the authors provided comprehensive answers to the first round of reviews. I have only two additional, minor comments:

• As the 'patient and public involvement' statement has been extended and moved into separate section I suggest to further revise it according to the journal standards: using GRIPP2 reporting checklists: https://www.bmj.com/content/358/bmj.j3453 |

	• The Discussion section still seems mostly focused on repeating the methods stages and results. I'm missing here some more emphasis 'why it is important to have such a composite score'? The authors mention only 2 studies on relationship between hospital financial standing and the quality of care, yet there is so much more on this topic… (there are studies which e.g. measure the associations between patients satisfaction, readmissions, adverse events, staff skills/ratios etc. and profits, as well as studies that show that composite financial performance metrics are better than using multiple indicators in such studies: e.g. Akinleye DD, McNutt LA, Lazariu V, McLaughlin C. Correlation between hospital finances and quality and safety of patient care. PLoS One 2019,14(8):e0219124). However, I accept the authors comments on the profile of 'methodological paper'.

REVIEWER	Tiago Magalhães Universidade Federal de Juiz de Fora
REVIEW RETURNED	08-Jun-2021

GENERAL COMMENTS	I am satisfied with the modifications. However, it will be very interesting if you add: (i) the sentence which is in the report (the motivation for the use of the PCoA and PCA) in the main article: "We had successfully used in prior similar projects and felt that it was appropriate for this study" or something like it. (ii) An Excel file with the 10 or the 30 variables (plus the response) available as a supplementary file in BMJ webpage will attract statisticians (or data scientists) to your paper, because the impletation of the OLS.

VERSION 2 – AUTHOR RESPONSE

Reviewer: 1

Dr. Katarzyna Dubas-Jakóbczyk, Uniwersytet Jagiellonski w Krakowie Collegium Medicum

Comments to the Author:

The manuscript has been substantially improved and the authors provided comprehensive answers to the first round of reviews. I have only two additional, minor comments:

- As the 'patient and public involvement' statement has been extended and moved into separate section I suggest to further revise it according to the journal standards: using GRIPP2 reporting checklists: https://www.bmj.com/content/358/bmj.j3453

This was an important comment as we wish to highlight the role that PPI played in our research. We have revised the PPI portions of the manuscript to ensure compliance with the GRIPP2 reporting checklist.

Section and topic	*Item*	*Reported on page No*
1: Aim	*Report the aim of PPI in the study*	*6*

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2: Methods	Provide a clear description of the methods used for PPI in the study	6
3: Study results	Outcomes—Report the results of PPI in the study, including both positive and negative outcomes	6
4: Discussion and conclusions	Outcomes—Comment on the extent to which PPI influenced the study overall. Describe positive and negative effects	6
5: Reflections/critical perspective	Comment critically on the study, reflecting on the things that went well and those that did not, so others can learn from this experience	6

- The Discussion section still seems mostly focused on repeating the methods stages and results. I'm missing here some more emphasis 'why it is important to have such a composite score'? The authors mention only 2 studies on relationship between hospital financial standing and the quality of care, yet there is so much more on this topic… (there are studies which e.g. measure the associations between patients satisfaction, readmissions, adverse events, staff skills/ratios etc. and profits, as well as studies that show that composite financial performance metrics are better than using multiple indicators in such studies: e.g. Akinleye DD, McNutt LA, Lazariu V, McLaughlin C. Correlation between hospital finances and quality and safety of patient care. PLoS One 2019,14(8):e0219124). However, I accept the authors comments on the profile of 'methodological paper'.

Thank you for this comment. We very much agree that there are many reasons why the understanding of hospital financial standing is very important. We felt limited in that this is a methodological paper, as Dr. Dubas-Jakóbczyk mentions, and we wished to highlight the development of the score as the central theme of our paper. We had limited the emphasis on such a score's importance to the introduction, without mentioning this in the discussion. We have now expanded the introduction section to further detail the importance of such a score for both the medical and business communities. We then added a new paragraph at the start of the discussion to bring focus back on the importance of this score's creation.

Reviewer: 3

Prof. Tiago Magalhães, Universidade Federal de Juiz de Fora

Comments to the Author:

I am satisfied with the modifications. However, it will be very interesting if you add:

(i)   the sentence which is in the report (the motivation for the use of the PCoA and PCA) in the main article: "We had successfully used in prior similar projects and felt that it was appropriate for this study" or something like it.

Per Prof. Magalhães's request, we have added the sentence in our "Response to reviewers" to the main article. The methods section now reads:

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"We used Principal Coordinate Analysis (PCoA) to examine trends in the dataset. This method was selected because it was felt to be best suited for analysis of this dataset and was one that the authors had most experience using."

(ii)   An Excel file with the 10 or the 30 variables (plus the response) available as a supplementary file in BMJ webpage will attract statisticians (or data scientists) to your paper, because the impletation of the OLS.

We would be more than happy to collaborate with researchers who wish to share our data and are open and willing to provide these on request.