Author's response to reviews

Title: The relationship between number of primary health care visits and hospitalisations: evidence from linked clinic and hospital data for remote Indigenous Australians

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Author's response to reviews: see over
ATTENTION:
Executive Editor
BMC Health Services Research

Dear Editor,

RE: The relationship between number of primary health care visits and hospitalisations: evidence from linked clinic and hospital data for remote Indigenous Australians

Attached please find our above titled article revised for publication in BMC Health Services Research. We have revised this article including the title according to referees’ comments. A point-by-point response to referees’ comments is attached. A copy of revised article with track changes is also provided. We look forward to hearing from you soon.

Thank you and best regards.

Yours sincerely

Yuejen Zhao (Corresponding author)
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Point to point response to reviewers’ comments

Title: The relationship between number of primary health care visits and hospitalisations: Evidence from linked clinic and hospital data for remote Indigenous Australians

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Reviewer 1

1. This study is an important one using a unique data set that links primary care visits with hospitalisations for Aboriginal residents of remote communities. Primary care and hospitalisations have a complex relationship and although primary health care advocates would love to demonstrate that primary care reduces hospitalisations, the reality is that the relationship is inconclusive. This paper is one attempt to decompose the complexity, by demonstrating that the relationships between hospitalisations and primary care visits are not linear.

Noted
- no revision required.

2. The explanation of the data and methodologies are fairly clear, but more details would give greater confidence in the findings.

Agreed
- More details of methods and results have been added to the respective sections of the manuscript.

3. The conclusions, as tentative as they are, have important policy implications. More primary care may lead to more hospitalisations, but so does too little.

Noted and revised
- The first paragraph of the Discussion has been revised to reinforce this central result of the study - Discussion (P11).

DISCRETIONARY REVISIONS

4. I take exception to the equation of access and utilization. This study does not measure access to primary care, only numbers of visits.

Agreed and revised
- The title of the article has been changed to “The relationship between number of primary health care visits and hospitalisations: evidence from linked clinic and hospital data for remote Indigenous Australians” to avoid confusion between access and utilisation.
- A sentence has been added in the second paragraph of Background “Access to PHC may be measured in...” (P4)

5. It does seem strange that 37% of the people in the study had zero clinic visits per year over four years. I think that this demonstrates less about the lack of access to care or even lack of utilization but rather a failure to match patients’ primary care and hospitalisation experience.
Even if zero visits includes everyone with less an average number of visits of less than one a year (for example, 3 visits in four years), it does seem a very high figure and suggests a problem with linking patients to communities and the clinics that serve them. People living in remote communities are very mobile and do not always stay, or get care from those 52 clinics under the same name. It may be difficult to accurately match their experience in the primary care system with their hospitalisations. If many of the hospital patients were not matched to primary care visits then there would certainly be a U-shaped relationship because those with very few visits would be disproportionately made up of people who had missing visits but who had been hospitalised. Only new analysis with this data set and others will be able to confirm if my hypothesis is true but it should be raised as a potential methodological limitation.

**Noted and further detail provided**

- Add at the end of the first paragraph of Methods “Shared by Caresys and PCIS, HRN is a unique patient identifier developed and used in the NT for more than 20 years and has been demonstrated to be highly reliable with accuracy rates for Indigenous status 98%, sex 99%, year of birth 91% and locality 88% [19]. The HRN has also been used for eHealth records so that healthcare providers, including non-DoH providers, can retrieve clinical information on shared clients [20]” (P6). Add “who were recorded as residing in the catchment areas of the 54 DOH clinics, …” in the second sentence of Paragraph 1 of Results (P7).

6. The discussion of limitations touches on many important points. But would like to see more detailed discussion on how the study’s design may have influenced the results. In particular, I would like to see: • A more detailed discussion of the extent of matching errors and the potential biases this could introduce.

**Note and revised**

- Added on P13 “There is an ongoing program of consolidation and validation to maintain the quality of HRN, with the accuracy of patient demographic information in public hospital records recently reported as around 95% [19]. There have also been clinical audits, which have confirmed the quality of data collections [19, 36]. Deterministic linkage is simple but considered a more reliable linkage strategy, when coding errors of HRN are minimal [37].”

7. Advantages and disadvantages of using an average over four years rather than four separate observations per person of average number of visits in each year.

**Note and revised**

- Revised the first sentence of Paragraph 3 in Method to “The average numbers of PHC visits and hospital admissions per person per year (person-year), and average length of hospital stay were analysed by age group, sex and disease groups to summarize the relations between PHC and hospital care.” (P6) Add “… this study did not control individual level variation and …. More research is needed to further explore this topic. Multilevel analysis … may be a useful tool [38]” (PP13-4).
8. Use of length of stay (number of days hospitalised per year) rather than number of hospital admissions/discharges as an indicator. (I suspect that good primary care may reduce LOS through earlier admission and earlier discharge to competent primary care.)

Accepted and revised

- In Table 2, add results of average length of stay and 95% confidence intervals (P20).
- Revise the first sentence of the third paragraph in Methods “The average numbers of …and average length of hospital stay were analysed by age group, sex and disease groups to summarise the relation between PHC and hospital care.” (P6)
- Add two sentences in the first paragraph of Result “This U-shaped association was also evident for hospital bed-day utilisation (Table 2), patients with zero PHC visits stayed in hospital 2.52 days on average, whereas those with four PHC visits stayed 1.95 days and those with 12 PHC visits and more stayed an average of 3.29 days.” (P8)
- In Discussion, revised the sentence, in the first paragraph “This study demonstrates that too little PHC may lead to an increase in both hospitalisations and length of hospital stay, but so does too much, with people who receive either less or more than the optimal level of PHC have a marked increase in number and length of hospitalisations” (P11).

MAJOR COMPULSORY REVISIONS:

9. Table 3 presents the estimates of clinic visits associated with the lowest rates of hospitalisations. There is a very large difference in the figures for the first categories (total, female, older adults and potentially avoidable hospitalisations) for the ‘spline’ and ‘simple’ equations. The differences are also fairly large for child health conditions, but much closer for adults with specific diseases. If the spline quadratic model produce a better estimate, I would like an explanation of why that model was not used for the models graphed in Figure 2.

Accepted with further detail provided

- Added explanation with Figure 2 (now Figure 3) “Figure 3 uses simple quadratic regression lines to compare the impacts of key demographics, chronic diseases and child health conditions on the PHC-hospital relationship”(P9).
- Add “… the simple quadratic model is more robust and more readily interpretable, making it useful for comparisons within a family of U-curves” (P13).
- Add “For clarity, spline quadratic models and 95% confidence intervals for demographics, chronic diseases and child health conditions were omitted from Figure 3.” in the last paragraph of Results. (P10)

10. In addition, I would like to have some measure of the statistical significance of the differences in the curves for the different groups and a measure of the goodness of fit. The authors demonstrate in Figure 1 that there is increasing heterogeneity in the association between primary care visits and hospitalisations as the average number of primary care visits increase. The authors haven’t given me enough information to determine if the curves in Figure 2 represent real differences.

Agreed and revised
Reviewers

Reviewer 2

I find this study to be quite interesting. It describes an analysis of the association between Primary Health Care Services and hospitalisation rates in a large population cohort of indigenous Australian living in 54 remote Northern Territory communities in Australia. I would like to acknowledge that I have no research experience using primary health care data. I would like to suggest the following:

MAJOR COMPULSORY REVISIONS

1. Background: It would be helpful if the authors could define what they mean by remote area of NT (bottom paragraph page 4). For people not familiar with the NT it might be helpful to put it into context of the entire indigenous population. That is to say, of the 64,000 Indigenous residents living in NT, 51,000 live in these remote areas.
   
   Agreed, additional detail provided
   
   o Two sentences added to the last paragraph of P4 “The NT is a federal territory of Australia, occupying much of the centre and top end of the continent. According to the Australian Statistical Geography Standard, 99.8% of the NT is classified as either a Remote or Very Remote (hereafter called remote) area” with new reference [16].
   
   o Modify the next sentence by adding “80% of the total NT Indigenous population.”

2. Background: Could the authors clarify the total number of PHC providers? It is not clear whether the 40 medical practitioners are all qualified physicians (general practitioners) or include nurses and Aboriginal health workers discussed in the following sentence. It would be clearer if the authors stated the overall total of PHCs and then broke down the categories (i.e. Of the X PHCs in remote NT, X% were general practitioners, X% were nurses and X% were Aboriginal health workers).
   
   Agreed, additional detail provided
   
   o Revise Background paragraph 3 by adding details in the sentence “The majority of PHC providers are nurses (approximately 400) and Aboriginal health workers (200) [18], employed by…” (P4).

3. Method: Could the authors give some examples of “other types PHC providers” working in remote NT? Are physiotherapists, psychologists, occupational therapists, dietitians working in these remote areas? Could they have examined rate of hospitalisations by type of PHC professional?

Add new Figure 2 to compare the spline quadratic model with the simple quadratic model and display the confidence intervals of group means (additional file for new Figure 2). The title is on P19.

Revised the last 2 sentences of the first paragraph of Results “Figure 2 …” (P8). Add the goodness-of-fit statistic to Table 2 (P20).

Revise the text in Results accordingly. Insert “The goodness-of-fit statistic shows that …” in the second paragraph of Results (P9).
Noted, detail added

- Add a sentence in the first paragraph on P4 “Few PHC services are provided by allied health professionals.”
- We could not analyse hospitalisation rate by PHC professions due to data inadequacies.

4. Method: Please clarify if the truncation of “individuals with clinic visits greater than 200 times” is 200 times per year or 200 times in the four year study period. What percentage of patients had more than 200 clinic visits? What type of PHCs were they accessing so frequently? Are they dialysis patients?

Agreed, detail added

- Revision to second last paragraph in Methods by adding “… over the four-year study period (1.43% of total patients).” (P7)
- Insert in the last paragraph in Results “Further analysis revealed that these truncated patients were more likely to have one or more chronic conditions (50.1% diabetes, 20.5% IHD, 23.0% renal disease, compared with 5.1%, 3.0% and 3.3% respectively in the total), and more likely to be older (23.6% aged 60 and older vs 5.3%) and female (64.5% vs 52.4%).” (P10)

5. Method: Could the authors please clarify in the methods section what they mean by “Sensitivity analysis was undertaken to test the alternative assumptions”.

Noted, details added

- The statement is clarified by adding “…such as free or fixed knot of spline quadratic models, different age grouping and truncating criteria of clinic visits.” (P7)

6. Results: I think table 2 could benefit by having a column percentage of people (rather than just having the frequency counts) and state the total number of people in the study population.

Agreed

- Percentages added in Table 2 (P20).
- Add a sentence in the first paragraph of Results “Over one-third (37%) of patients visited PHC clinics less than once a year on average during the four years.” (P8)

7. Results: The Figure legends are inconsistent. While the Figure 2 legend states how they were estimated (ie, …using quadratic modelling…) the Figure 1 legend does not.

Agreed

- Figure 1 legend changed to “Average hospitalisations per person-year by average clinic visits for the remote Indigenous patients, estimated using spline quadratic models, Northern Territory, Australia, 2007-2011” (see P20).
- All headings of Figures and Tables have been amended for consistency

8. Results: The lines in the figures are difficult to follow. I think if they were in colour it would be much clearer.
Agreed

- Both patterns and colours have now been added to distinguish graph lines in Figures 1, 2 and 3 (additional Figure files).

9. Results: There were 52,739 patients using hospital services, slightly more than the estimated indigenous population referenced in the background. Would the authors care to comment on the 100+% capture rate? Did they anticipate every indigenous person would have at least one contact with the linked health services used in this study?

Noted, with further explanation

- Revise the second sentence in Results as “There was a total of 52 739 patients in the linked data (48% male, 52% female), who were recorded as residing in the catchment areas of the 54 DOH clinics. This indicates that the majority (82%) of the NT Indigenous population had a remote area address and used a DOH service, at least once, during the study period” (P7).

- Add in limitations (P14) “Additionally PHC data were incomplete due to high population mobility, unclear clinic catchments and the availability of alternate non-DOH PHC services. While this incompleteness may lead to an underestimate of the optimal number PHC services for the population, it is unlikely to change the general pattern of the U-curve association between PHC and hospitalisations.”

10. Results: I do not understand how inspecting Figure 2 panel a can be interpreted as showing me that the proportion of PAH decreased from 59% for those with no PHC visits to 28% when 15 PHC visits were provided. There is no reference to any percentage in Figure 2. Could the authors please clarify how they estimate that 75% of PAHs could be avoided by providing adequate level of PHC? By definition, shouldn’t all PAHs be avoidable?

Agreed, text revised

- Revise the second sentence of the last paragraph in Results (PP9-10) as “Inspecting panel a in Figure 3, we see that PAH (short green dashes) decreased from 0.7 to 0.2 hospitalisations per person-year when PHC visits increased from 0 to 15 visits annually. In other words, at least two-thirds of PAHs may potentially be avoided by providing adequate levels of PHC. By comparing with the total hospitalisations (solid black curve), this difference was equivalent to a reduction of PAHs from 59% to 28% of the total hospitalisations.”

- Revise Figure 3 by using coloured curves, new legend and new abbreviations (P19 and Figure 3 file).

11. Results: Correction, page 9. First sentence “Panel a in Figure 2 also compares the PHC-hospital relations by key demographics and major disease groups” please note that the major disease groups are in panel b.

Agreed, text revised

- Delete “and major disease groups” (P10).

12. Discussion: I think the use of the word vertex in the second sentence of the discussion “This study demonstrates that people receiving the vertex level of PHC use the lowest amount of
hospital care” is not particularly informative. While the term vertex is “sort of” defined in the methods section on page 6, “The spline quadratic model glues two simple quadratic models together through a free knot at the vertex” the meaning of the term will be lost on readers who skipped the statistical methods section. The third sentence again refers to the vertex level of PHC and is not interpreting the data for the reader.

Agreed, text revised

- Revise the second and the third sentences in Discussion to “This study demonstrates that too little PHC may lead to an excess of both hospitalisations and length of hospital stay, but so does too much, with people who receive either less or more than the optimal level of PHC having a marked increase in number and length of hospitalisation.” (P11)
- Delete the word “vertex” at L13, P10.

13. Discussion: The authors refer to the Figure 1 and Table 3 in the first paragraph of the discussion and then again later in the discussion. This is quite unorthodox. I think it best that reference to particular figures and table be removed from the discussion.

Agreed and revised.

- Delete “(Figure 1)” at L13, P11, “(Table 3)” at L14 P11, “in Figure 1” at L-4 P12, “(Figure 3)” at L-6, P13 in Discussion.

14. Discussion: The sentence “The U-shaped distribution provides an explanation to why PHC activity is not a consistent linear predictor of hospitalisation” is incorrect. This is a poorly phrased sentence. To my mind the u-shaped distribution provided evidence for an association rather than an explanation for an association.

Agreed and revised

Revise the first sentence of Paragraph 2 in Discussion to “The U-shaped distribution provides evidence for a non-linear association between PHC activity and hospitalisation, and…” (P11)

15. Discussion: Can the authors re-write the sentence “Residents living close to or further away from hospital both had higher hospitalisation rates.” so that it means something.

Agreed and revised

- Revised to “Living either closer to (<35 kms) or further from a hospital (>50 kms) was associated with higher hospitalisation rates.” (P11)

16. Discussion: The authors have acknowledged that distance from hospitals affect hospitalisation rates yet have not linked this fact to their study. I realise that remote communities are, by definition, far away (> 50kms) from hospital but I believe it would be helpful to give a few details as to how far the remote communities are from the closest hospital. Did the authors examine distance as a confounder? Were some communities 3000kms from hospital and others only 400kms? Did this affect hospitalisation rates? Or rates of PHC use?

Noted, and revised

- Revise the last sentence of the third paragraph in Introduction (PP4-5), “…(Alice Springs Hospital, Gove District Hospital, Katherine Hospital, Royal Darwin Hospital and Tennant
Creek Hospital). The median distance from the remote Indigenous communities to nearest hospital was 275 kilometres (kms) ranging from 87 to 700 kms.

- At L-1 P11, add “In this study the communities were all located far from a hospital (>87 kms).”
- In limitations, we acknowledge “Secondly, this study did not control individual level variation and potential confounders such as types of PHC, professions of PHC providers and distance to hospital. More research is needed to further explore this topic. Multilevel analysis and multivariate adaptive regression splines may be a useful tool [38].” (PP13-4)

17. Discussion: Can the authors please reference the sentence “Absence of PHC leads to increased false negative and delayed diagnoses, acute evacuation and hospitalisation”

**Agreed, references added**

- Revise the sentence to “Low levels of PHC may lead to increased false negative and delayed diagnoses, acute evacuation and hospitalisation.” Add two references here ([30, 31], P12).

18. Discussion: The authors quite correctly point out that “This study is neither longitudinal nor experimental, which limits the extent to which a causal relation can be drawn and generalized” yet the authors appear to infer a causal relationship which is a little strong.

**Agreed**

- Revised the last two sentence of Abstract (PP2-3) as “Under the conditions of remote Indigenous Australians, there may be an optimal level of PHC at which hospitalisations are at a minimum. The authors propose that the effectiveness of a health system may hinge on a refined balance, rather than a straight-line relationship between primary health care and tertiary care.”
- Revise the last two sentences in Conclusions “The results of this study demonstrate … PHC and tertiary care.” (P14).

19. Discussion: Perhaps this has already been done, but I would have been interested to see the relationship between type of PHC service provides and hospitalisation rates.

**Noted**

- In limitations, we acknowledge “This study did not control multiple potential confounders such as type of PHC, professions of PHC provider, and distance to hospital. More research is needed to further explore this topic.” (PP13-4)

20. Did the authors consider statistical methods to adjust for confounders?

**Noted**

- In limitations, we acknowledge “Secondly, this study did not control individual level variation and potential confounders such as types of PHC, professions of PHC providers and distance to hospital. More research is needed to further explore this topic. Multilevel analysis and multivariate adaptive regression splines may be a useful tool” with new reference [38] (PP13-4).
21. The discussion is generally difficult for me to follow and in my opinion requires a bit more work so that it can contribute better to our understanding of this area of health service need.

**Noted**

- Revised (see PP11-14). In particular, at L7, P11, “The U-shape relationship is also consistent across various population sub-groups including: people over 40, females, and those with chronic conditions.”, At L-8, P11 “This study supports an argument that providing an optimal level of PHC in remote Indigenous communities may reduce hospitalisations, although the optimal levels of PHC service may vary with age, gender and disease.”

**Reviewer 3**

**MAJOR COMPULSORY REVISIONS:** No major compulsory revisions.

**MINOR ESSENTIAL REVISIONS:**

1. The article is entitled: “The relationship between access to primary care and hospitalisations …”. While access to Primary Health Care is being addressed in the Discussion the main focus of the article seems to be the relationship between the number of PHC visits and hospitalisations. I suggest changing the title to “The relationship between number of primary health care visits and hospitalisations …” or something similar.

**Suggestion accepted.**

- Change the title of the article to “The relationship between number of primary health care visits and hospitalisations: evidence from linked clinic and hospital data for remote Indigenous Australians”

2. I suggest choosing either American or British spelling throughout the article page 8, 2nd paragraph - “minimized” page 12, 1st paragraph - “generalized”

**Suggestion accepted.**

- See changes made on P12. Searches are performed for other editing changes.

3. [Results – last paragraph] I believe that it should say “(Insert table 3 and figure 2 here)’.

**Agreed**

- Changes made (see P9).

4. [Discussion] The authors mention that the current level of access to PHC for Indigenous residents in remote areas is inadequate compared with the national average. I believe that the authors should elaborate more on this and also mention the importance of culturally appropriate services.

**Suggestion accepted**

- Revise the first sentence of the third paragraph in Discussion by adding “…and the need for culturally appropriate services [34].” Add Reference [34] (P12).
5. [Discussion] I suggest adding the heading “Limitations” to the last paragraph.

**Suggestion accepted**
- Added a heading for last paragraph in Discussion (P13).
- At L1 P13, add a sentence “There are also a number of limitations.” And then use a structured format to list the limitations: Firstly, … Finally, …

6. [Conclusion] I believe that it should say “…and support an argument that remote Indigenous people …” instead of “…and support am argument that remote Indigenous people …”.

**Accepted**
- Corrected (see P14).

7. Figure 1 and Figure 2 are missing a title.

**Noted**
- The legends of the figures can be found on P19.

**DISCRETIONARY REVISIONS:**

8. Overall, I would suggest using either “hospital admissions” or “hospitalisations” throughout the article.

**Agreed and revised**
- Changed to hospitalisation throughout manuscript – note the track changes (PP2-14).

**Reviewer 4**

**MAJOR COMPULSORY REVISIONS**

1. A1) Figure 1 provides a strong rationale for why spline regression would provide significant improvements over quadratic regression for the aggregate data. However despite this in Figure 2 quadratic regression is used throughout. I would either (a) use spline regression in Figure 2, or (b) use quadratic regression but explain why quadratic regression had to be used within this Figure and what weaknesses might be present through the use of quadratic regression.

**Agreed and revised.**
- Add a new Figure 2 to compare spline and simple quadratic models (P19).
- Revise the first paragraph in “Strengths and limitations” (P13) by adding: “The spline quadratic model fits the aggregate data better than the simple quadratic model, but does so at the expense of robustness and parsimony.” Further explain “The spline regression model provides the advantage that being more sensitive to the data is more useful when deriving vertex values. On the other hand the simple quadratic model is more robust and more readily interpretable making it useful when making comparisons between a family of U-curves.”
MINOR ESSENTIAL REVISIONS

2. B1) I am unfamiliar with "bubble diagrams". I would give a one-sentence explanation of these diagrams within the caption for this graph, and would cite a textbook discussing these diagrams within the main text.

Agreed and revised.
- Add in Methods at L-3 P6 "...to depict three-dimensional information [24] with bubble area representing population size" and a new reference [24].
- Add under Figure 1 title “Note: The size of bubbles denotes the number of patients. (P19)"

3. B2) At the bottom of page 8 comments are made that percentages are shown in Figure 2, however the Figure shows PAH in person-year not percentages. Hence the discussion on percentages was confusing. I would quote PAH values within the main text (eg. such as 1.5 PAH per person-year for females at 0 clinic visits). In addition percentages could then be quoted within the main text if the corresponding PAH values were also given (eg. 1.5 PAH person-year which equates to 59% of the total PAH).

Accepted and revised
- Revised this section “Inspecting panel a in Figure 3, we see that PAH (short green dashes) decreased from 0.7 to 0.2 hospitalisations per person-year when PHC visits increased from 0 to 15 visits annually. In other words, at least two-third of PAHs could be potentially avoided by providing adequate level of PHC. By comparing with the total hospitalisations (black solid line), this difference was equivalent to a reduction of PAHs from 59% to 28% of the total hospitalisations.” (see P9)

4. B3) I was unsure why there were no captions for the Figures.

Noted
- The captions for the figures are listed on P19.

5. B4) I found the line markings in Figure 2 hard to distinguish (eg. the dashed and dotted lines appeared almost identical to me). I would strongly recommend that line markings with a more visible distinction be used (again this is a comment on the visual appearance of the graph rather than the data itself). Again I would congratulate the authors on the fine work in their report.

Agreed and revised.
- Both patterns and colours have now been used to distinguish different groups (see Figure 3).