PEER REVIEW HISTORY

ARTICLE DETAILS

TITLE (PROVISIONAL)	What is the major driver of China's hospital medical expenditure growth? A decomposing analysis
AUTHORS	Yan, Xiaoling; Liu, Yuanli; Rao, Keqin; Li, Jinlei

VERSION 1 – REVIEW

REVIEWER	Zang, Xiao Brown University, Epidemiology
REVIEW RETURNED	08-Feb-2021

GENERAL COMMENTS	This study provided a decomposition analysis of the medical expenditure growth among public hospitals in China to identify primary drivers for this growth. The study question is interesting and important and can be very informative for the medical reform that is ongoing in China. The conclusion is that expenditure growth (in total and per capita) is attributable majorly to increase in service use (in total and per capita). The authors provided excellent discussion on what may contributed to the service use growth in the last decade but how the findings of this study may inform health policy is lacking. While the writing should be improved (see my minor comments) and the methods section needs elaboration, I have some major comments on this study and concerns over the methods. Major: 1. The authors claimed that this was the first paper to use the decomposing method in the analysis of Chinese health expenditure growth but apparently it is not. They cited papers using a similar method on a similar topic. Although it may be true if this claim is restricted to post-reform era, I don't think this should be highlighted anywhere in this manuscript since the methods are not renovative nor the study question. 2. The introduction should provide more contextual information for why identifying the major drivers of medical cost growth is important. Same for discussion, how can the findings of this study help future medical policy reform? 3. The authors have clearly realized the importance of population aging, but why was this factor not included in the analysis? Instead, the authors chose a simpler model with only two factors in both analyses, based on which the implications can be limited. For example, we can't tell whether the increase in service use is due to poorer health (e.g. higher prevalence of chronic diseases) or aging. This information should be available in the statistical yearbook and should be included. A prior study (https://doi.org/10.1186/s12913-017-2119-1) has considered five factors in their analysis.

	4. Details regarding the methods should be provided while some phrases are confusing. First, the authors analyzed decomposed expenditure growth in both total and per capita medical cost, but only the equations for the total were provided. Second, according to my understanding, the decomposition method (referred as Das Gupta) used data from two time points (or two populations), but what two years of data were used for this analysis was unclear. Third, in page 8 line 40, the authors defined service volume as the number of people receiving inpatient or outpatient care, which diverged from what they described in Table 1 (as visits). Number of visits and number of persons should differ in valuation for the same population and I am wondering how the authors reconciled this difference. Forth, in page 8 line 48, the authors said they have adjusted for population growth, but how the population growth was adjusted was unreported. 5. Most importantly, I think there are major flaws in their analysis methods. Although I am no expert in decomposition analysis, I did spend some time reading Das Gupta's papers and other methodological manuscripts, and I found the approach the authors used in appendix did not seem to concur with Das Gupta's original ones, but please correct me if I am wrong. The authors incorrectly parsed out the two effects by two equations (for Va and Pa), but according to the original paper, these two effects are not separable and should be included in one equation (Va + Pa = …). The analysis for each individual effect should then be performed by creating counterfactual scenarios (no growth in service volume but with growth in service price and intensity, and vice versa) rather than directly computing the values. Minor: 1. Page 3, line 17, remove "both" 2. Page 4, line 12, 17, "explored" instead of "explores", "focused" instead of "focus", "two" instead of "2" (numbers under 10 should be spelled out) 3. Page 4, line 22: the authors said no consensus on the drivers of US health spending growth but in the previous sentence they extracted a few factors from previous literature, which made me confused. Are you suggesting no consensus on the "primary" factor(s)? Also I am curious why the authors chose to start a manuscript on a Chinese question with theories/evidence for the US. 4. Page 4, line 30: "obtained" to "revealed" 5. Page 5, line 4: "and" to "while" 6. Page 5: the authors attempted to create a contrast of this study with prior ones (direct versus indirect approach), but I don't quite see the logic. Prior studies using regression methods examined very different questions (the impact of reforms on expenditure), not the growth of expenditure. The authors need to explain how they define a direct and indirect approach. 7. Page 6, line 14: "These results" to "Results of this study" 8. Page 6, line 32-33, reference is needed for National Health Commission 9. Page 7, line 6: you need to justify why using one-year population size rather than year-specific data. 10. Page 7, line 11-30: service volume does not equal to the annual volume of visits, this is only how you characterized the variable, so you can't say A "was" B. Instead, you can say, service volume was "defined as… in this study" 11. Table 1, the definition for service utilization is very confusing, please rewrite

	12. Page 10, line 48: what do you mean by “tracks”? 13. Page 15, line 7-10: they are not “outliers”, please choose another word, otherwise it is misleading. Also the italics are difficult to recognize in table 3b, please choose another method to highlight those cells (e.g. bold, asteroid) 14. Page 16, line 43: “addressing” to “identifying”, you didn’t do anything to deal with the drivers, you only found them. 15. Page 16, line 43-60: I don’t really think the Moses study is comparable. 16. Page 18, line 35: why should we “improve” unreasonable health demands? Shouldn’t we strive to minimize them?

REVIEWER	Grima, Simon University of Malta
REVIEW RETURNED	7-Apr-2021

GENERAL COMMENTS	I believe that the article flows well and is well written. The problem is well explained and addressed and the method is replicable. The conclusions and significance of the findings are well explained.

REVIEWER	Wieser, Simon Zurcher Hochschule fur Angewandte Wissenschaften, Winterthur Institute of Health Economics
REVIEW RETURNED	11-Jun-2021

GENERAL COMMENTS	REVIEW for BMJ Open (June 2021) What is the major driver of China’s hospital medical expenditure growth: A decomposing analysis Brief summary: The authors estimate the contribution of service use/volume and service price and intensity to the growth of Chinese hospital expenditures between 2008 and 2018. They apply Das Gupta’s decomposition method for aggregate measures and find that total hospital expenditures increased by a factor of 3.6 for inpatient services and by a factor of 2.9 for outpatient services between 2008 and 2018. The increase in service volume was associated with 67.4% of the observed increase in total inpatient expenditures and 57.2% of the increase in total outpatient expenditures. The numbers were very similar when looking at average (per capita) expenditures for both types of care. Broad comments: The findings of the study are relevant but come with many limitations. The most interesting results are the region-specific decomposition rates. Based on the results, it is not easy to draw the right conclusions about what to do. Is the increase in service volume acceptable? When a society gets older, patients need more care quite certainly. This will again increase their life expectancy (hopefully). It would have been very interesting to see if the pattern was the same across different conditions (such as in Dieleman et al. (2020), Zhai et al. (2017) or Stucki (2021)). The way the authors include the factor population growth does not completely make sense (see comments below). Specific comments:

	Introduction: In the first paragraph, why is there only literature from and for the US? Wouldn't it make more sense to start with the evidence on China and then say that a similar methodological approach was also used in other countries (e.g. US, but also others). You mention that the evidence about what factors are associated with rising health expenditures in China (and elsewhere) is mixed. The literature on China seems to have used more detailed data and to have decomposed the growth into more factors. What is your contribution to the literature? Which research gap do you close? Methods: Variable definition: the portion of population that used a service is not necessarily the same as the average per capita number of visits (since some patients will have more than one visit). The method by Das Gupta seems to be an adequate choice for the research question. The section starting on line 40 on page 8 is not clear. The first sentence might even be wrong, as the number of visits (=volume) is not equal to the number of people receiving care. Furthermore, it is not clear how you used the decomposition method for the second part; I suggest you write it down as a formula like for the first analysis. Why did you not include the factor population size as a third factor directly in the specification (like in Dieleman et al. 2017, Zhai et al. 2017 and Stucki 2021)? Results: There are two sub-periods: 2008-2013 and 2013-2018. Which period comprises 2013? Can't you show the results of table 2 in a graph? There are too many numbers to grasp, and you actually only want to show the growth over the study period. Looking at the growth rates of both service volumes and expenditures per admission I might already guess the relative contributions of the two. So, what does the decomposition really add? When you use average per capita expenditure to control for population growth, but a lower share of the population uses public hospitals (as shown in the introduction), then you allocate some of the spending to people who have never been at a public hospital. As a consequence, you don't fully capture the effect of population growth. If population had stayed constant, the number of visits per person had decreased (because it decreased in public hospitals), but this would have resulted in a negative contribution in your analysis, although in reality it would have had to stay constant (=contribution of 0). Discussion: How are the results affected by the fact that the share of public hospitals in the number of visits dropped between 2008 and 2018 (see also last point in Results comments)? Do you assume that the other hospitals treated patients that were comparable to the ones in public hospitals (e.g. with respect to age, conditions etc.)? "unreasonable" (pages 15 and 16) seems to be a strange and not very scientific term. Appendix exhibit 2:

	It is not clear what the percentage numbers in the “service utilization (%)” column refer to Cited literature: Dieleman, Joseph L., et al. "Factors associated with increases in US health care spending, 1996-2013." Jama 318.17 (2017): 1668-1678. Stucki, Michael. "Factors related to the change in Swiss inpatient costs by disease: a 6-factor decomposition." The European Journal of Health Economics 22.2 (2021): 195-221 Zhai, Tiemin, John Goss, and Jinjing Li. "Main drivers of health expenditure growth in China: a decomposition analysis." BMC health services research 17.1 (2017): 1-9.

VERSION 1 – AUTHOR RESPONSE

Reviewer: 1
Dr. Xiao Zang, Brown University

Comments to the Author:
This study provided a decomposition analysis of the medical expenditure growth among public hospitals in China to identify primary drivers for this growth. The study question is interesting and important and can be very informative for the medical reform that is ongoing in China. The conclusion is that expenditure growth (in total and per capita) is attributable majorly to increase in service use (in total and per capita). The authors provided excellent discussion on what may contributed to the service use growth in the last decade but how the findings of this study may inform health policy is lacking. While the writing should be improved (see my minor comments) and the methods section needs elaboration, I have some major comments on this study and concerns over the methods.

Response: We appreciate your kind work on our study. We noted the implications of this study more clearly in the discussion section in our new manuscript (see our response to your second major comment). We improved our writing by adopting your minor suggestions and comments (see our responses to your minor comments). We made extensive modification to improve and clarify our methods in the methods section of the main document and supplementary material (see our responses to your forth major comment). Revisions in the text were marked in red.

Major:
1. The authors claimed that this was the first paper to use the decomposing method in the analysis of Chinese health expenditure growth but apparently it is not. They cited papers using a similar method on a similar topic. Although it may be true if this claim is restricted to post-reform era, I don’t think this should be highlighted anywhere in this manuscript since the methods are not renovative nor the study question.

Response: Thank you for pointing this out. This study extends the existing literature by focusing on the drivers of growth in public hospitals’ medical expenditures during the first decade of the new round of health system reform in China. We focused on the growth of medical expenditures of public hospitals because most medical spending is by public hospitals and because cost containment in public hospitals is the focus of health-care delivery reform across China. One of the main contributions of this study is the provision of the region-specific decomposition rates of 31 provinces, autonomous regions and municipalities in mainland China.

We clarified the strengths and main contributions of this study in the “Strengths and limitations of this study” section and “Introduction” section of our new manuscript more appropriately. The revision was marked in red. We deleted the following sentences: “This is the first paper using the decomposing method to explore the associations of service use, service price and intensity with increases in public hospitals’ total and average medical expenditures in the first decade of the new round of health system reform in China”.

2. The introduction should provide more contextual information for why identifying the major drivers of medical cost growth is important. Same for discussion, how can the findings of this study help future medical policy reform?

Response: Thank you very much for your comments and suggestions. In the introduction section of our new manuscript, we provide more contextual information regarding the initiatives of public hospital reform and monitoring indicators of medical cost control in public hospitals. Based on these monitoring indicators, it seems that the assumption underlying policy decisions was that price and intensity were the primary drivers of medical cost. However, these reforms did not reduce overall medical expenditures. Efforts to contain medical expenditure growth may benefit from a better understanding of the underlying drivers increasing medical costs.

In the discussion section of our new manuscript, we clearly noted the policy implication of our study as follows: “These findings inform health policy makers, whose current cost contains tools mainly to control the cost per visit or per admission,[13] that controlling price and intensity growth are crucial, but their effect on containing medical costs could be limited. In the coming years, health service utilization is likely to increase due to the ageing population and the increased burden of noncommunicable diseases. A study of China’s health expenditure projections showed that the increase in services per case of disease and unit cost would contribute 4.3 and 2.4 percentage points, respectively, of the 8.4% annual average growth rate in health expenditure during the 2015–2035 period.[34] Controlling service utilization growth could be essential through a nationwide effort for a healthy population, which could include disease prevention, healthy ageing, ensuring quality care and minimizing unreasonable healthcare demands.[35,36] Positive incentive mechanisms should be established to enhance an integrated medical and long-term care delivery system, which would be expected to increase growth in outpatient and long-term care in primary facilities and prevent unnecessary hospitalization.”

3. The authors have clearly realized the importance of population aging, but why was this factor not included in the analysis? Instead, the authors chose a simpler model with only two factors in both analyses, based on which the implications can be limited. For example, we can’t tell whether the increase in service use is due to poorer health (e.g. higher prevalence of chronic diseases) or aging. This information should be available in the statistical yearbook and should be included. A prior study (https://doi.org/10.1186/s12913-017-2119-1) has considered five factors in their analysis.

Response: Thank you very much for your comments. This study decomposed growth in medical expenditure into changes in its two primary policy-relevant constituent factors, i.e., service volume and service price and intensity, to determine how much of the growth in the real total medical expenditure was attributable to changes in service use versus service price and intensity. The results directly respond to the current cost containment policies of controlling the service volume and price and intensity.

In our new manuscript, we also explored the impact of changes in subcomponent factors of the service volume, i.e., population size, hospital utilization rates, and share of public hospitals’ utilization, on the growth in public hospitals’ real total medical expenditure by developing a four-factor decomposition model.

However, due to the lack of data regarding service volume and price and intensity of public hospitals' inpatient and outpatient care for disease conditions in the base year and the lack of age-sex price and intensity of public hospitals' inpatient and outpatient care for disease conditions in both the base year and end year in the China Health Statistical Yearbooks, this study did not consider changes in types of conditions prompting people to visit hospitals and the ageing of the population.

4. Details regarding the methods should be provided while some phrases are confusing. First, the authors analyzed decomposed expenditure growth in both total and per capita medical cost, but only the equations for the total were provided. Second, according to my understanding, the decomposition method (referred as Das Gupta) used data from two time points (or two populations), but what two years of data were used for this analysis was unclear. Third, in page 8 line 40, the authors defined service volume as the number of people receiving inpatient or outpatient care, which diverged from what they described in Table 1 (as visits). Number of visits and number of persons should differ in valuation for the same population and I am wondering how the authors reconciled this difference. Forth, in page 8 line 48, the authors said they have adjusted for population growth, but how the population growth was adjusted was unreported.

Response: Thank you very much for your comments and suggestions.

Response to the first comment: In our new manuscript, we included the population size, hospital utilization rate, and share of public hospitals' utilization, which are the three subcomponent factors of service volume, in the decomposition model to replace the two-factor decomposition model of per capita medical cost, which aimed to adjust for population growth but did not consider the lower share of the population using public hospitals' service pointed out by reviewer 3. The four-factor decomposition equation was provided in the main document, and a more detailed description of the four-factor decomposition method was provided in Appendix exhibits 1.2.

Response to the second comment: The time points of the decomposition analysis are described in the data source section in our new manuscript. The text was modified as follows:
"We chose 2008 as the base year for the nationwide analysis and 2011 as the base year for the provincial analysis because the earliest available years of nationwide and provincial public hospitals' service volume and price and intensity data were 2008 and 2011, respectively. Additionally, there were significant policy changes in 2009 and 2012 as mentioned above, rendering 2008 and 2011 appropriate as base years. The year 2018 was selected as the end date for both the nationwide and provincial analyses because the latest data we could obtain during our study period was 2018, which was also the period of the first decade of new round health system reform."

Response to the third comment: We recognize the difference between the number of visits and the number of people who received inpatient or outpatient care since some patients have more than one visit. In this study, the service volume was defined as the annual volume of visits or admissions to public hospitals (as described in Table 1). We revised the incorrect description of the service volume on page 8 line 40 in our previous draft and provided a new expression of the service volume, i.e., the service volume can be expressed as the product of the population size, hospital inpatient or outpatient utilization rate, and share of public hospitals' utilization (the share of public hospitals in the number of hospital visits or admissions).

Response to the forth comment: We noted the flaw in the method of adjusting for population growth, as mentioned in the above response to your first comments. Therefore, we include the factor population size as one of the four factors in the decomposition model to replace adjusting for population growth. The four-factor decomposition equation was provided in the main document, and a

more detailed description of the four-factor decomposition method was provided in Appendix exhibits 1.2.

5. Most importantly, I think there are major flaws in their analysis methods. Although I am no expert in decomposition analysis, I did spend some time reading Das Gupta's papers and other methodological manuscripts, and I found the approach the authors used in appendix did not seem to concur with Das Gupta's original ones, but please correct me if I am wrong. The authors incorrectly parsed out the two effects by two equations (for Va and Pa), but according to the original paper, these two effects are not separable and should be included in one equation (Va + Pa = …). The analysis for each individual effect should then be performed by creating counterfactual scenarios (no growth in service volume but with growth in service price and intensity, and vice versa) rather than directly computing the values.

Response: Thank you very much for your comments. We used the decomposition-standardization method described by Das Gupta to determine the additive contributions of the effects of the differences in the compositional factors to the difference in their overall expenditures in two years. Our approach concurs with Das Gupta's original approach.

To enhance clarity, we added detailed descriptions of the decomposition-standardization methods in Appendix exhibit 1 in the new draft, including the standardized steps and the decomposition steps.

Va is the difference in the total medical expenditures associated with the difference in the service volume in counterfactual scenarios if the price and intensities were identical (standardized) in the two years; Pa is the difference in the total medical expenditures associated with the difference in the service price and intensity in counterfactual scenarios if the service volumes were identical (standardized) in the two years. Then, we obtain the identity , which is completely additive and does not involve any residual terms.

Minor:

1. Page 3, line 17, remove "both"

Response：Thank you for your suggestion. We removed "both" in the new draft.

2. Page 4, line 12, 17, "explored" instead of "explores", "focused" instead of "focus", "two" instead of "2" (numbers under 10 should be spelled out)

Response：Thank you very much for your suggestion. We used "explored" instead of "explores", "while focusing" instead of ", which also focus", and "two" instead of "2" in the new draft.

3. Page 4, line 22: the authors said no consensus on the drivers of US health spending growth but in the previous sentence they extracted a few factors from previous literature, which made me confused. Are you suggesting no consensus on the "primary" factor(s)? Also I am curious why the authors chose to start a manuscript on a Chinese question with theories/evidence for the US.

Response: Thank you very much for your comments and suggestions. We stated "no consensus on the factors driving increased US health spending" to indicate "no consensus on the major factors driving increased US health spending". In our new manuscript, to enhance clarity, we started by providing evidences from China. We added two new studies using a similar methodological approach to study spending increases in Switzerland and Brazil. We identified two primary factors (quantity and price) for the decomposing analysis of growth in spending from these existing studies.

4. Page 4, line 30: "obtained" to "revealed"

Response：Thank you very much for your suggestion. We used “revealed” instead of “obtained”.

5. Page 5, line 4: “and” to “while”

Response：Thank you for your suggestion. We used “while” instead of “and”.

6. Page 5: the authors attempted to create a contrast of this study with prior ones (direct versus indirect approach), but I don’t quite see the logic. Prior studies using regression methods examined very different questions (the impact of reforms on expenditure), not the growth of expenditure. The authors need to explain how they define a direct and indirect approach.

Response：Thank you for your suggestion. We agree with your opinion that the problem of decomposing the increase in medical expenditure into several additive effects differs from the problem of a regression analysis of the impact of reforms on expenditure. We referred to prior studies that used regression methods to suggest that the reforms of public hospitals did not reduce public hospitals’ total medical expenditures but not to compare the two approaches. Therefore, we deleted the “direct approach” and “indirect approach” discussion in our new manuscript to avoid confusing readers.

7. Page 6, line 14: “These results” to “Results of this study”

Response：Thank you for your suggestion. We used “Results of this study” instead of “These results”.

8. Page 6, line 32-33, reference is needed for National Health Commission

Response：Thank you very much for your suggestion. For the National Health Commission (originally called the Ministry of Health), we referred to the state council institutional reform plan released by Xinhua News Agency and Yip et al.’s article. Cited these two references in the reference list as follows:
4. Yip WN, Fu HQ, Chen AT, et al. 10 years of health-care reform in China: progress and gaps in Universal Health Coverage. Lancet 2019;394(10204):1192-204.
16. Xinhua News Agency. The state council institutional reform plan 2018 [Available from: http://www.gov.cn/xinwen/2018-03/17/content_5275116.htm accessed Jun 25 2021.

9. Page 7, line 6: you need to justify why using one-year population size rather than year-specific data.

Response：Thank you very much for your suggestion. The 2019 China Statistical Yearbook includes nationwide and provincial population size data from 2008 to 2018. According to the National Bureau of Statistics on demographic data in the Statistical Yearbook of 2019, demographic data from some years were revised based on the 2010 census data since the population data from non-census years were extrapolated from the annual population sample survey. To adopt more accurate population size data, we used population size data from 2008 to 2018 from the 2019 China Statistical Yearbook rather than year-specific Statistical Yearbook. We also added “in specific years between 2008 and 2018” to the new manuscript to ensure that readers understand the population size data more clealy.

10. Page 7, line 11-30: service volume does not equal to the annual volume of visits, this is only how you characterized the variable, so you can’t say A “was” B. Instead, you can say, service volume was “defined as… in this study”

Response：Thank you for noting our incorrect presentation. We adopted your suggestion and used ”was defined as…in this study” instead of “was” in the definitions of the service volume, utilization, price and intensity.

11. Table 1, the definition for service utilization is very confusing, please rewrite

Response：Thank you for noting our incorrect presentation. In table 1 in our new manuscript, the utilization rate was defined as annual hospital visits or admissions per capita, including public and private hospital visits or admissions.

12. Page 10, line 48: what do you mean by “tracks”?

Response：We use "tracks" to express that the increases in medical expenditures shown in the figure represent the additive increase of 10 years from 2008 to 2018. In conducting the study, we decomposed the increases in medical expenditures in each contiguous two-year period from 2008 to 2018. To enhance clarity, we used “reveals” instead of “tracks”.

13. Page 15, line 7-10: they are not “outliers”, please choose another word, otherwise it is misleading. Also the italics are difficult to recognize in table 3b, please choose another method to highlight those cells (e.g. bold, asteroid)

Response： Thank you for noting our incorrect presentation. We chose to use an asterisk to highlight those cells, and reframed them as ” *The exception of provinces where increases in price and intensity accounted for the largest increases in the real total medical expenditures of public hospitals”.

14. Page 16, line 43: “addressing” to “identifying”, you didn’t do anything to deal with the drivers, you only found them.

Response： Thank you very much for your suggestion. We used “Our findings also suggest that most of the service volume effect is due to an increase in the hospital utilization rate. Our findings closely parallel Moses et al.’s[24] results.” instead of “Addressing drivers of the increase in service volume” in our new manuscript.

15. Page 16, line 43-60: I don’t really think the Moses study is comparable.

Response：Thank you very much for your comment. The cause of your doubt may be that we misplaced Moses’ study in the paragraph comparing our study with the other two references. We referred to the results of Moses’ study to identify the factors that drove the increases in the volume of outpatient visits and inpatient admissions in China. In the new manuscript, we referred to the results of Moses’ study in a new paragraph discussing factors relevant for health service utilization in China.

16. Page 18, line 35: why should we “improve” unreasonable health demands? Shouldn’t we strive to minimize them?

Response： Thank you very much for your suggestion. We used “minimizing” instead of “improving” in our new manuscript.

Reviewer: 2
Dr. Simon Grima, University of Malta

Comments to the Author:
I believe that the article flows well and is well written. The problem is well explained and addressed and the method is replicable. The conclusions and significance of the findings are well explained.

Response： Thank you very much for your comments.

Reviewer: 3
Dr. Simon Wieser, Zurcher Hochschule fur Angewandte Wissenschaften

Comments to the Author:
Brief summary: The authors estimate the contribution of service use/volume and service price and intensity to the growth of Chinese hospital expenditures between 2008 and 2018. They apply Das Gupta's decomposition method for aggregate measures and find that total hospital expenditures increased by a factor of 3.6 for inpatient services and by a factor of 2.9 for outpatient services between 2008 and 2018. The increase in service volume was associated with 67.4% of the observed increase in total inpatient expenditures and 57.2% of the increase in total outpatient expenditures. The numbers were very similar when looking at average (per capita) expenditures for both types of care.

Broad comments:
- The findings of the study are relevant but come with many limitations.

Response: We appreciate your kind work on our study. Based on your comments and suggestions, we made extensive modification on the original manuscript. We hope this revision can make our manuscript more acceptable. The revised text was marked in red.

- The most interesting results are the region-specific decomposition rates.

Response: Thank you very much for your comments. We enhanced the clarity of one of our contributions that we provided region-specific decomposition rates of 31 provinces, autonomous regions and municipalities in mainland China.

- Based on the results, it is not easy to draw the right conclusions about what to do. Is the increase in service volume acceptable? When a society gets older, patients need more care quite certainly. This will again increase their life expectancy (hopefully). It would have been very interesting to see if the pattern was the same across different conditions (such as in Dieleman et al. (2020), Zhai et al. (2017) or Stucki (2021)).

Response: Thank you for your excellent question and comments. To enhance clarity, we introduced your question "Is the increase in service use acceptable?" directly into the discussion section in our new manuscript. Referring to existing studies on factors determining health service utilization and statistic data on population ageing, increased prevalence of chronic diseases in people aged 65 and above, soaring real gross domestic product and declining share of out-of-pocket spending on health services, It is plausible that rising hospital service utilization is related to the increase in the underlying need for and improvements in access to hospital services. Because underutilization was a concern before the health system reform initiated in 2009, the increase in hospital service utilization currently represents as improvements in access. Therefore, the increase in service use is acceptable.

However, due to the lack of data regarding service volume and price and intensity of public hospitals' inpatient and outpatient care for disease conditions in the base year and the lack of age-sex price and intensity of public hospitals' inpatient and outpatient care for disease conditions in both the base year

and end year in the China Health Statistical Yearbooks, this study did not consider changes in types of conditions prompting people to visit hospitals and the ageing of the population.

- The way the authors include the factor population growth does not completely make sense (see comments below).

Response: Thank you very much for noting the flaw in the method of adjusting for population growth. The response to this concern is provided in the response to your forth comment in result section.

Specific comments:

Introduction:

- In the first paragraph, why is there only literature from and for the US? Wouldn't it make more sense to start with the evidence on China and then say that a similar methodological approach was also used in other countries (e.g. US, but also others).

Response: Thank you very much for your comments and suggestions. In our new manuscript, to enhance clarity, we started by providing evidences from China. We added two new studies using a similar methodological approach to study spending increases in Switzerland and Brazil. We identified two primary factors (quantity and price) for the decomposing analysis of growth in spending from these existing studies.

- You mention that the evidence about what factors are associated with rising health expenditures in China (and elsewhere) is mixed. The literature on China seems to have used more detailed data and to have decomposed the growth into more factors. What is your contribution to the literature? Which research gap do you close?

Response: Thank you very much for your comments and questions. The existing literature used a decomposition method to examine two or five components of health expenditure growth in China from the perspectives of the cost of healthcare or disease. However, studies focusing on decomposing analysis of growth in public hospitals' medical expenditure are lacking, and the region-specific decomposition rates of sources of the growth in public hospitals' medical expenditure in 31 provinces, autonomous regions and municipalities in mainland China are unclear.

This study extends the existing literature by focusing on the drivers of growth in public hospitals' medical expenditure during the first decade of the new round of health system reform in China. We focused on the growth in medical expenditure of public hospitals because most medical spending is by public hospitals and because cost containment in public hospitals is the focus of health-care delivery reform across China. One of the main contributions of this study is the provision of the region-specific decomposition rates of 31 provinces, autonomous regions and municipalities in mainland China.

However, due to the lack of data regarding the service volume and price and intensity of public hospitals' inpatient and outpatient care for disease conditions in the base year and the lack of data regarding age-sex price and intensity of public hospitals' inpatient and outpatient care for disease conditions in both the base year and end year, this study did not consider changes in types of conditions prompting people to visit the hospitals and the ageing of the population.

Methods:

- Variable definition: the portion of population that used a service is not necessarily the same as the average per capita number of visits (since some patients will have more than one visit).

Response: Thank you very much for noting our incorrect presentation. We recognize the difference between the number of visits per capita and the portion of people who used a service. We revised the incorrect description of the definition of service utilization. In our new manuscript, we included three subcomponent factors of the service volume to the decomposition model, i.e., population size, hospital utilization rate, and share of public hospitals' utilization. Hospital utilization rate was defined as annual hospital visits or admissions per capita, which includes public and private hospital visits or admissions. The share of public hospitals' utilization was defined as the share of public hospitals in the number of hospital visits or admissions.

- The method by Das Gupta seems to be an adequate choice for the research question.

Response: Thank you very much for your comments.

- The section starting on line 40 on page 8 is not clear. The first sentence might even be wrong, as the number of visits (=volume) is not equal to the number of people receiving care. Furthermore, it is not clear how you used the decomposition method for the second part; I suggest you write it down as a formula like for the first analysis.

Response: Thank you very much for your comments and suggestions.
Response to your first comment: We revised the incorrect description of the serve volume in our previous manuscript, and provided a new expression of the service volume, i.e., the service volume can be expressed as the product of the population size, hospital utilization rate, and share of public hospitals' utilization in our new manuscript. The definitions of hospital utilization rate and share of public hospitals' utilization were provided in the variable definition section in our new manuscript.

Response to your second suggestion: A four-factor decomposition model for the second part was provided in our new main manuscript, and a more detailed description of the four-factor decomposition method was given in Appendix exhibit 1.2.

- Why did you not include the factor population size as a third factor directly in the specification (like in Dieleman et al. 2017, Zhai et al. 2017 and Stucki 2021)?

Response: Thank you very much for your suggestion. This study decomposed growth in medical expenditure into changes in its two primary policy-relevant constituent factors, i.e., service volume and service price and intensity, to determine how much of the growth in the real total medical expenditure was attributable to changes in service use versus service price and intensity. The results directly respond to the current cost containment policies of controlling the service volume and price and intensity.

In the second part of our new manuscript, we include the factor population size as one of the three subcomponent factors of the service volume, i.e., population size, hospital utilization rates, and share of public hospitals' utilization, and explored the relative effect of each factor on the growth in public hospitals' real total medical expenditure by developing a four-factor decomposition model.

Results:

- There are two sub-periods: 2008-2013 and 2013-2018. Which period comprises 2013?

Response: Thank you for your comments. Both sub-periods comprise 2013. We calculated the annual growth rates every five years. For the 2008-2013 sub-period, 2013 was the end date. For the 2013-2018 sub-period, 2013 was the base year.

- Can't you show the results of table 2 in a graph? There are too many numbers to grasp, and you actually only want to show the growth over the study period.

Response: Thank you very much for your comments. Table 2 shows not only the growth trend of real total medical expenditure, expenditure per admission/visit, and admission/visit over the study period but also the values of the factors included in the decomposition analysis. Because of the different units of measurement of medical expenditure (Chinese yuan) and service volume (million visits or admissions), and the very different magnitudes of total medical expenditure and expenditure per visit/admission (million yuan Vs yuan), it is not appropriate to represent these data in a graph.

- Looking at the growth rates of both service volumes and expenditures per admission I might already guess the relative contributions of the two. So, what does the decomposition really add?

Response: Thank you very much for your excellent question. The decomposition in this study was performed to quantify how much of the growth in total medical expenditure was attributable to changes in the service volume versus price and intensity (expenditure per admission or visit).

- When you use average per capita expenditure to control for population growth, but a lower share of the population uses public hospitals (as shown in the introduction), then you allocate some of the spending to people who have never been at a public hospital. As a consequence, you don't fully capture the effect of population growth. If population had stayed constant, the number of visits per person had decreased (because it decreased in public hospitals), but this would have resulted in a negative contribution in your analysis, although in reality it would have had to stay constant (=contribution of 0).

Response: Thank you very much for your elaboration and for noting the flaw in the method of adjusting for population growth. Adopting your above suggestion of including the population size factor, we included the population size, hospital utilization rate, and share of public hospitals' utilization, which are the three subcomponent factors of service volume, in the decomposition model to replace the two-factor decomposition model of per capita medical cost, which aimed to adjust for population growth but did not consider the lower share of the population using public hospitals' service. Results show that population growth was associated with a slight increase in inpatient (4.2%) and outpatient (4.8%) total medical expenditure, while a lower share of public hospitals' utilization(the share of public hospitals in the number of admissions or visits to) was associated with a slight reduction in inpatient (10.9%) and outpatient (8.1%) real total medical expenditure.

Discussion:

- How are the results affected by the fact that the share of public hospitals in the number of visits dropped between 2008 and 2018 (see also last point in Results comments)? Do you assume that the other hospitals treated patients that were comparable to the ones in public hospitals (e.g. with respect to age, conditions etc.)?

Response: Thank you very much for your excellent questions. Since we are not sure that patients treated in the private hospitals are comparable to the ones treated in public hospitals, we included the population size, hospital utilization rate, and share of public hospitals' utilization, which

are the three subcomponent factors of service volume, in the decomposition model to replace the two-factor decomposition model of per capita medical cost. Results show that a lower share of public hospital utilization (the share of public hospitals in the number of admissions or visits) was associated with a slight reduction in inpatient (10.9%) and outpatient (8.1%) total medical expenditure; Population growth was associated with a slight increase in inpatient (4.2%) and outpatient (4.8%) total medical expenditure; The increase in utilization rate contributed 73.7% of the growth in the real total medical expenditure on inpatient care, and 60.3% of the growth in the real total medical expenditure on outpatient care. These findings suggest that most of the service volume effect is due to an increase in the hospital utilization rate.

- "unreasonable" (pages 15 and 16) seems to be a strange and not very scientific term.

Response: Thank you for your comments. We used "excess" instead of "unreasonable" in our new manuscript.

Appendix exhibit 2:

- It is not clear what the percentage numbers in the "service utilization (%)" column refer to

Response: Thank you for your comments. In the previous Appendix exhibit 2, the percentage numbers in the "service utilization (%)" column referred to the number of public hospitals' visits or admissions per capita, and its calculation formula is admission or visit volume divided by the population size. In our new appendix, this exhibit was removed.

Cited literature:

- Dieleman, Joseph L., et al. "Factors associated with increases in US health care spending, 1996-2013." Jama 318.17 (2017): 1668-1678.
- •Stucki, Michael. "Factors related to the change in Swiss inpatient costs by disease: a 6-factor decomposition." The European Journal of Health Economics 22.2 (2021): 195-221
- • Zhai, Tiemin, John Goss, and Jinjing Li. "Main drivers of health expenditure growth in China: a decomposition analysis." BMC health services research 17.1 (2017): 1-9.

Response: Thank you very much for recommending the latest studies. Our previous draft already cited Dieleman's and Zhai's articles. The latest Stucki's study that you suggested is very useful to read, and referencing it added greater relevance to our introduction. We cited Stucki's latest study in the introduction section in our new draft.

VERSION 2 – REVIEW

REVIEWER	Zang, Xiao Brown University, Epidemiology
REVIEW RETURNED	02-Aug-2021

GENERAL COMMENTS	The revised manuscript is much improved and I think is acceptable for publication. I only have a few minor suggestions: 1. Page 21, Line 45-46: add "may" between "findings" and "inform"; what do you mean by "cost contains tools"? 2. Page 22, Line 14-15: "can" instead of "could" 3. Page 22, Line 14-15: "heathier" instead of "healthy" 4. Page 22, Line 27-28: just "increase outpatient and long-term..." 5. Page 22, limitation paragraph: limitation of not including aging as factor in analysis "due to data unavailability" should be mentioned

REVIEWER	Wieser, Simon Zurcher Hochschule fur Angewandte Wissenschaften, Winterthur Institute of Health Economics
REVIEW RETURNED	22-Oct-2021

GENERAL COMMENTS	1. On page 12 the authors state: “The sum of the contributions of the changes in the population size, utilization rate, and share of public hospitals’ utilization was equal to the contribution of the changes in the service volume in the above two-factor decomposition. “ That is not fully correct. As we can see in tables 3a and 3b, the sum of the three factors is not exactly the same as the value for service volume (inpatient: 73.7+4.2-10.9=67.0 < 67.4). This is, however, not a problem, as the four factor decomposition naturally leads to slightly different contributions as the two factor decomposition. I would just change the sentence and state that the shares are approximately the same. 2. Figures 1 and 2: It would be great if the graphs did not only show the absolute increase but also the relative (%) contributions of each factors. Could you provide a similar graph with bars showing the relative (in %) contributions or just include the relative contributions as an additional label in the existing graphs? 3. Figure 2: “Factor” instead of “fator” in the caption. Moreover, the authors should improve on the readability of the bar labels (the label for public hospitals utilization is hardly readable). 4. Page 21/22: The authors addressed the issue if the observed increase in spending is acceptable (as suggested in the reviewer’s comments). They were not supposed to provide an answer (“Therefore, the increase in service use is acceptable.”) to that, but only to discuss the issue. I suggest to delete this sentence and to discuss the fact that the increase in spending might be desired. A definite answer to the complex issue would be beyond the scope of the study.

VERSION 2 – AUTHOR RESPONSE

Response to review comments

Reviewer: 1

Dr. Xiao Zang, Brown University
Comments to the Author:

The revised manuscript is much improved and I think is acceptable for publication. I only have a few minor suggestions:

Response: Thank you very much for your suggestions and comments. We are grateful to you for your hard work on our manuscript.

1. Page 21, Line 45-46: add "may" between "findings" and "inform"; what do you mean by "cost contains tools"?

Response: We have added "may" between "findings" and "inform" in page 21, line 48. We used "cost contains tools" to mean the policy instruments used by health policy makers to contain medical cost. To make it more clearly, we have used “policy instruments” instead of “tools” in page 21, line 48-51 in the new manuscript.

2. Page 22, Line 14-15: "can" instead of "could"

Response: We have used "can" instead of "could" in page 22, line 17-18 in the new draft.

3. Page 22, Line 14-15: "heathier" instead of "healthy"

Response: We have used "healthier" instead of "healthy" in page 22, line 19-20 in the new manuscript.

4. Page 22, Line 27-28: just "increase outpatient and long-term..."

Response: We have deleted “growth in” and just kept "increase outpatient and long-term..." in page 22, line 30-32.

5. Page 22, limitation paragraph: limitation of not including aging as factor in analysis "due to data unavailability" should be mentioned

Response: We have add “due to the lack of age-specific price and intensity of public hospitals’ inpatient and outpatient care for disease conditions in both base year and end year, this study did not consider changes in types of conditions prompting people to visit the hospitals and the aging of the population.” to the limitation paragraph in page 22, line 48-59 in the new manuscript.

Reviewer: 3

Dr. Simon Wieser, Zurcher Hochschule fur Angewandte Wissenschaften

Response: Thank you very much for your suggestions and comments. We are grateful to you for your hard work on our manuscript.

Comments to the Author:

1. On page 12 the authors state: “The sum of the contributions of the changes in the population size, utilization rate, and share of public hospitals’ utilization was equal to the contribution of the changes in the service volume in the above two-factor decomposition. “ That is not fully correct. As we can see in tables 3a and 3b, the sum of the three factors is not exactly the same as the value for service volume (inpatient: 73.7+4.2-10.9=67.0 < 67.4). This is, however, not a problem, as the four factor decomposition naturally leads to slightly different contributions as the two factor decomposition. I would just change the sentence and state that the shares are approximately the same.

Response: Thank you for pointing this out. We have used “approximately the same as” instead of “equal to” in page 12, line 9-10 in the new manuscript.

2. Figures 1 and 2: It would be great if the graphs did not only show the absolute increase but also the relative (%) contributions of each factors. Could you provide a similar graph with bars showing the relative (in %) contributions or just include the relative contributions as an additional label in the existing graphs?

Response: Thank you for your suggestions. We provide two panels in both figure 1 and 2 in the new draft: (A) The first panel shows the absolute contribution (billion yuan) of each factor; (B) The second panel shows the relative contribution (%) of each factor.

3. Figure 2: “Factor” instead of “fator” in the caption. Moreover, the authors should improve on the readability of the bar labels (the label for public hospitals utilization is hardly readable).

Response: We have used "factor" instead of "fator" in the caption. To improve on the readability of our manuscript, we have used "share of service utilization in public hospitals" instead of "share of public hospitals' utilization" in the bar labels and caption of figure 2, as well as in the new main document.

4. Page 21/22: The authors addressed the issue if the observed increase in spending is acceptable (as suggested in the reviewer’s comments). They were not supposed to provide an answer (“Therefore, the increase in service use is acceptable.”) to that, but only to discuss the issue. I suggest to delete this sentence and to discuss the fact that the increase in spending might be desired. A definite answer to the complex issue would be beyond the scope of the study.

Response: Thank you very much for your suggestions. We have deleted the sentence “Therefore, the increase in service use is acceptable.” in page 21 in the new draft. In the paragraph of addressing the issue if the increase in service use is acceptable in page 20/21, we have discussed the fact that rising hospital service utilization is related to the increase in the underlying need for and

improvements in access to hospital services. Because underutilization was a concern before the health system reform initiated in 2009, the increase in hospital service utilization after the health system reform represents as improvements in access. That is to say, the increase in service use in the context of concerning underutilization is expected by healthcare reform.