PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Factors driving computed tomography utilisation in tertiary hospitals: a decomposition analysis using linked administrative data in Western Australia
AUTHORS	Ha, Ninh; Maxwell, Susannah; Bulsara, Max; Doust, Jenny; Mcrobbie, Donald; O'Leary, Peter; Slavotinek, John; Moorin, Rachael

VERSION 1 – REVIEW

REVIEWER	Mathews, John University of Melbourne
REVIEW RETURNED	22-Sep-2021

GENERAL COMMENTS	This is a potentially important paper analyzing linked health records to identify the factors that predict changes in CT scanning rates over time in hospitals in Western Australia. There are some ambiguities. • Because of the multi-disciplinary nature of the work, the potential target audience is broad, so that readers from some disciplines (eg radiology, epidemiology) will struggle with some of the terminology and concepts used. • The definitions of "secondary" and tertiary hospital are not given, but as there were only three tertiary, we can perhaps assume that all other hospitals are secondary. The sentence "our data did not fully capture the use of CT in all secondary hospitals hence this study was limited to tertiary…" could be read to suggest that the distinction between secondary and tertiary was somewhat arbitrary. • To understand what the results mean in terms of overall community exposures to CT scans, it would have been helpful to have a concise explanation of how CT scans in WA tertiary hospitals relate to CT scans in secondary hospitals and in ambulant patients (ie Medicare subsidized scans delivered by private radiologists). A comment on the relative frequency of scans outside the tertiary hospital system would have been helpful or a comment based on their earlier paper (29). • The technical details of multivariate decomposition can be accessed through the STATA reference, and do not need to be repeated in detail in the text. However, the paper would be more comprehensible for the general reader if it had explained the methods and the meaning of some results (eg for figures 2 & 3) using simple words in the commentary to get the ideas across. Even the paper abstract is difficult for me to understand without reading the whole paper; this could deter many readers. Perhaps the authors can rewrite the results section of the abstract in a way that will help the general reader to understand. • There are some errors. Table 1 is mis-numbered as Table 2.

	• The % cited in Table 1(2) are somewhat confusing. In the top line the % refers to the proportion of all subjects with or without a scan, whereas in the subsequent lines the % refers to the proportion of all those with (or without) a scan that fall into the relevant category on the LHS. In other words, for the top line, the numbers some to 100% across CT scan status, whereas for subsequent lines they sum to 100% down the subcategories listed for each LH category. Perhaps the Table caption can be improved to explain this. • Figure 2 & Figure 3 are difficult to read. Perhaps they could be rotated through 90% so that the category identifiers could be printed horizontally. • There are some minor issues. The term likelihood is used in its lay sense, meaning "relative probability of this happening", rather than in the technical sense used by statisticians as in maximum likelihood fitting. This is unlikely to cause confusion.

REVIEWER	Shao, Yu-Hsuan Taipei Medical University
REVIEW RETURNED	24-Sep-2021

GENERAL COMMENTS	The aim of this study is to use decomposition analysis to examine factors driving changes in CT use between two periods of time in tertiary hospitals in WA: recent (2013 to 2015) and past (2003 to 2005). Authors claims they conducted a retrospective observational cohort study of CT use in WA between 2003 and 2015 using linkage health administrative data. 1. This is a study comparing results from two time point rather than a cohort study. They are different patients in two time points. 2. Statistical examination on the average of CT scan between the past period and the recent period is needed. 3. Figure 2 and 3 are hard to read. A better presentation will help to understand the results. 4. Besides unplanned admissions explain the increase in the number of CT use. What is the main finding? What is the high-risk group that author referred in the conclusion? 5. Authors may want to explain how aging in the population contribute to the increase in CT number. A huge increase in terms of number of pts aged 75+ receiving CT in the recent period. Is it possible that the increase in CT scans just because of age structure of the population?

VERSION 1 – AUTHOR RESPONSE

Reviewer: 1
Dr. John Mathews, University of Melbourne Comments to the Author:
This is a potentially important paper analyzing linked health records to identify the factors that predict changes in CT scanning rates over time in hospitals in Western Australia. There are some ambiguities:
• Because of the multi-disciplinary nature of the work, the potential target audience is broad, so that readers from some disciplines (eg radiology, epidemiology) will struggle with some of the terminology and concepts used.
AUTHOR RESPONSE:

Thank you for your comments. We have revised some terminology and concepts as per your specific comments bellow.

• The definitions of “secondary” and tertiary hospital are not given, but as there were only three tertiary, we can perhaps assume that all other hospitals are secondary. The sentence “our data did not fully capture the use of CT in all secondary hospitals hence this study was limited to tertiary…” could be read to suggest that the distinction between secondary and tertiary was somewhat arbitrary.

AUTHOR RESPONSE:

Thank you for your comment. We have revised the sentence “our data did not fully capture the use of CT in all secondary hospitals hence this study was limited to tertiary…” now state:

Page 3, lines 77-78: “Our study limited to assess the factors driving the use of CT scanning in tertiary (teaching) hospitals, therefore, caution is needed when generalising the results to other settings”

And we also added more information in the study population section about tertiary hospitals in Western Australia to contextualise the study setting as follow.

Page 5, lines 133-138: “The study population consisted of all hospital admissions in all four tertiary (teaching) hospitals located centrally in Perth, which accounted for nearly 50% of admissions in public hospitals, in WA between 2003 and 2015 inclusive, for people aged 18 years and older. Non-tertiary admissions (i.e. admission from secondary (district general) hospitals) were excluded as CT scans performed in the hospitals are not consistently included in the PACS dataset.”

• To understand what the results mean in terms of overall community exposures to CT scans, it would have been helpful to have a concise explanation of how CT scans in WA tertiary hospitals relate to CT scans in secondary hospitals and in ambulant patients (ie Medicare subsidized scans delivered by private radiologists). A comment on the relative frequency of scans outside the tertiary hospital system would have been helpful or a comment based on their earlier paper (29).

AUTHOR RESPONSE:

Thank you for your suggestion. Using the data available we cannot determine the relative proportion of CT scans performed in secondary vs. tertiary public hospitals because in WA some public secondary hospitals contract out their medical imaging services to private radiology firms and therefore their data are not included in PACS. Overall, in terms of community exposure to CT scans, CT scanning in all public hospitals accounted for 27% of adult CT scans, the rest was performed in private hospitals or standalone private radiology practices.

We have added that information in the discussion section as follows.

Page 12, lines 300: “A recent study examined factors driving the increasing use of CT scan in Australia with a focus on the use of CT outside of the public hospital setting (1), which accounted for 73% of adult CT scans (2).”

• The technical details of multivariate decomposition can be accessed through the STATA reference, and do not need to be repeated in detail in the text. However, the paper would be more comprehensible for the general reader if it had explained the methods and the meaning of some results (eg for figures 2 & 3) using simple words in the commentary to get the ideas across. Even the paper abstract is difficult for me to understand without reading the whole paper; this could deter many readers. Perhaps the authors can rewrite the results section of the abstract in a way that will help the general reader to understand.

AUTHOR RESPONSE:

Thank you for your suggestions. We have shortened the statistical analysis section by reducing the amount of technical detail of multivariate decomposition analysis, revised the results section and the abstract as follows.

Statistical analysis:

Page 7-8, lines 176-197: “Multivariable decomposition for nonlinear response models, an extension of Oaxaca-Blinder decomposition analysis (3), was conducted to decompose the differential rate of CT use between the two study periods into the endowment (distribution of observed patient characteristics) and effect (relative probability of having CT scan) components:

(1) The Endowment component quantifies the amount of the difference in the rate of CT use is explained by the changes in the distribution of observed socio-demographic and clinical characteristics between the two study periods.

(2) The Effect component describes how much of the difference in the rate of CT scanning is explained by a change in the relative probability of having CT across observed characteristics.

We conducted decomposition analyses for all tertiary admissions and for unplanned tertiary admissions separately using STATA SE 14 (3)."

Results:

Page 10-11, lines 239-281: "Over the study period changes in the relative probability of having a CT scan over the observed patient characteristics resulted in a 6.8% increase in the rate of CT scanning, while changes in the distribution of the characteristics of the observed patient characteristics reduced the rate of CT scanning by 2.6%.

Interestingly, the relative probability of having a CT scan for those with young age was significantly lower than in the past period contributing 2.8% reduction in the number of CT scan between the two periods. In addition, the relative probability of having CT was higher for those identified as living in major cities in the recent period compared to the past period, and lower for people from remote/very remote areas in the recent period compared to the past period. The contribution of each component to the difference in the number of CT's per admission between the two periods was 5.5% (p-value=0.02) and -0.8% (p-values<0.001), respectively.

For clinical characteristics, the results indicated a lower relative probability of having a scan during a tertiary admission in the recent period compared with the past period for all the diagnostic groups, with the exception of those admitted for injuries and endocrine disorders. The increase in patients with multi-morbidities (2-5 comorbidities) contributed 3.2% to the difference between the two periods.

For other factors, the relative probability of having a CT scan following transfer from a secondary hospital in the recent period was significantly lower than in the past period, contributing 0.8% reduction to the rate of CT scan between the two periods. A lower relative probability of having a CT scan in the recent period compared with the past period for unplanned admission contributed -4.9% to the difference in CT use between the two periods. Unobserved factors captured in the constant coefficient contributed to 41.8% of the variation in CT usage between the two periods.

Details of decomposition analysis for unplanned tertiary admissions

Similar to all tertiary admissions, the results for unplanned admission (Figure 3) indicated that a substantial proportion of variation in CT use between the two study periods (10.0%) was attributable to changes in the distribution of the observed clinical characteristics including multimorbidity and major diagnostic groups. However, changes in the distribution of the observed demographic characteristics such as age, sex and accessibility between two periods only explained a total of -0.5% the change in CT use.

For the specific effect component, a similar finding was also observed in unplanned admissions. Specifically, a lower relative probability of having a CT scan for those in the youngest age group (18-44 years) was observed in the recent period compared with the past. Likewise, a lower relative probability of having CT scan in the recent period versus the past period was observed among those admitted for condition such as circulatory, cancer, and respiratory; this accounted for -3.8%, -3.7%, and -2.7% of the difference in CT use. The relative probability of having a CT scan after transfer from a secondary hospital in the recent period was lower than in the past, contributing -7.5% to the change in the number of CT scans between the two periods."

Abstract – results:

Page 2, line 48-59: "Results: The rate of CT scanning increased by 112 CT scans per 1000 admissions over the study period. Changes in the distribution of the observed patient characteristics were accounted for 62.7% of the growth in CT use. However, among unplanned admissions, changes in the distribution of patient characteristics only explained 17% of the growth in CT use, the remainder being explained by changes in the probability of having a CT scan. Whilst the relative probability of having a CT scan generally increased over time across most observed characteristics, it reduced in young adults (-2.8%), people living in the rural/remote areas (-0.8%) and people transferred from secondary hospitals (-0.8%).”

• There are some errors. Table 1 is mis-numbered as Table 2.

AUTHOR RESPONSE:

Thank you for your comment. We have made the correction.

• The % cited in Table 1(2) are somewhat confusing. In the top line the % refers to the proportion of all subjects with or without a scan, whereas in the subsequent lines the % refers to the proportion of all those with (or without) a scan that fall into the relevant category on the LHS. In other words, for the top line, the numbers some to 100% across CT scan status, whereas for subsequent lines they sum to 100% down the subcategories listed for each LH category. Perhaps the Table caption can be improved to explain this.

AUTHOR RESPONSE:

Thank you for your comments. We have revised the table by adding the total observations for each sub category (with/without CT scan) in the sub-heading of the table and removing the N line to avoid confusion.

• Figure 2 & Figure 3 are difficult to read. Perhaps they could be rotated through 90% so that the category identifiers could be printed horizontally.

AUTHOR RESPONSE:

Thank you for your suggestions. We have revised the graphs with horizontal display for easy reading.

• There are some minor issues. The term likelihood is used in its lay sense, meaning “relative probability of this happening”, rather than in the technical sense used by statisticians as in maximum likelihood fitting. This is unlikely to cause confusion.

AUTHOR RESPONSE:

Thank you for your suggestion. We have replace the term “likelihood” with the “relative probability of having CT” throughout the text where it is applicable.

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Reviewer: 2

Dr. Yu-Hsuan Shao, Taipei Medical University Comments to the Author:

The aim of this study is to use decomposition analysis to examine factors driving changes in CT use between two periods of time in tertiary hospitals in WA: recent (2013 to 2015) and past (2003 to 2005). Authors claims they conducted a retrospective observational cohort study of CT use in WA between 2003 and 2015 using linkage health administrative data.

1. This is a study comparing results from two time point rather than a cohort study. They are different patients in two time points.

AUTHOR RESPONSE:

Thank you for your comment. We agree this is a repeated cross-sectional study using data from two time periods (2003-2005 and 2013-2015). There would be different patients in two time points. We have revised the text in the methods to be consistent with the abstract as follows.

Page 5, lines 115-116: “We conducted an observational repeated cross-sectional study of CT use in WA in 2003-2005 and 2013-2015 using linked administrative heath data at the individual patient level”

2. Statistical examination on the average of CT scan between the past period and the recent period is needed.

AUTHOR RESPONSE:

Thank you for your suggestions. We have added the statistical examination outputs (95% CI and p-value) for the difference in the average number of CT scans between the two periods in the text as follows.

Page 9, lines 218-221: “The difference in the rate of CT scans between two periods was 112 scans per 1000 admissions (95%CI, 110; 114 per 1000 admissions, p-value <0.001) for all tertiary admission and 116 scans per 1000 admissions (95%CI, 112; 120 per 1000 admissions, p-value <0.001) for unplanned tertiary admissions”

3. Figure 2 and 3 are hard to read. A better presentation will help to understand the results.

AUTHOR RESPONSE:

Thank you for your comment. We have revised the Figures with horizontal display for easier reading.
4. Besides unplanned admissions explain the increase in the number of CT use. What is the main finding? What is the high-risk group that author referred in the conclusion?
AUTHOR RESPONSE:
We found that changes in the distribution of unplanned admissions was the largest driver of the growth in CT use. As mentioned in the first paragraph of the discussion, changes in the distribution of clinical characteristics including major diagnostic groups (i.e. injury) and comorbidies rather than changes of the distribution of demographic characteristic contributed substantially to the variation in CT use between two periods.
We also highlighted key findings in the conclusion as follows.
Page 15-16, line 381-392: "In conclusion, the use of CT in tertiary hospitals increased between the two study periods and this is in keeping with international trends. This is primarily due to changes in the distribution of unplanned admissions and the clinical characteristics of presenting patients rather than changing demographic characteristics. Among unplanned admissions only, changes in the relative probability of scanning were the major drivers of CT use, with the largest component of this relating to unobserved factors. In both results, clinical characteristics appear to be a substantial component driving the growth of CT usage in the tertiary hospital setting while the role of demographic characteristics was minimal. Our study also highlights a potential improvement in practice towards reducing medial radiation exposure through a decrease CTs in subpopulations such as young adults and in those admitted via transfer admission from other hospitals"
5. Authors may want to explain how aging in the population contribute to the increase in CT number. A huge increase in terms of number of pts aged 75+ receiving CT in the recent period. Is it possible that the increase in CT scans just because of age structure of the population?
AUTHOR RESPONSE:
Thank you for your comments. There was an increase of 2.7% in the probability of having CT scan between two study periods among people aged 75+ year (Table 1). Results from the decomposition analysis indicated that while the change in distribution of the oldest group contributed only a minor proportion (-0.004%), the change in relative probability of having CT scan in the oldest age group contributed to 1.9% of the change in CT use. This means that the changing age structure per se was not responsible for the major increasing use of CT scan, other factors such as comorbidities or other clinical conditions which are often highly prevalent in the older age group drive the use of health care services. Our study is in line with the previous study (1) which suggested that ageing of the population is not a major driver of CT scan use. Decomposition analysis allowed us to differentiate between the influences of changes in distribution of specific characteristics of the patients from changes in the probability of use of CT according to those characteristics on use of CT scanning. Our study adds to the literature by showing that changes in the distribution of clinical conditions and comorbidities rather than aging of the population itself is a major driver of the growth in CT use.
We have revised the discussion with the discussion on the impact of ageing on increasing use of CT as follows.
Page 13, lines 310-321: "Our findings again confirmed that the impact of changing in age structure (i.e. increasing proportion of older people) was not a major driver of the use of CT scanning. In addition, by using multivariable decomposition analysis, our study provides a more comprehensive picture of the contribution of various demographic, clinical and other observed factors driving the change in CT use in the hospital setting. This is because our analysis was able to differentiate the influence of changes in the distribution (endowment component) from changes in the relative probability of having CT (effect component) across a large range of observed factors. Our study adds to the literature by showing that it is the change in distribution of comorbidities and clinical conditions which are often highly prevalent in the older population rather than the age of the population itself that contributed the largest component to the growth of CT use. This indicates the need of strengthen public health interventions to promote healthy ageing to reduce the burden on health care systems."

References

1. Wright CM, Bulsara MK, Norman R, Moorin RE. Increase in computed tomography in Australia driven mainly by practice change: A decomposition analysis. Health Policy. 2017;121(7):823-9.
2. Gibson DAJ, Moorin RE, Holman CDAJ. Cohort study of Western Australia computed tomography utilisation patterns and their policy implications. BMC health services research. 2014;14:526-.
3. Powers DA, Yoshioka H, Yun MS. mvdcmp: Multivariate decomposition for nonlinear response models. Stata Journal. 2011;11(4):556-76.