Author's response to reviews

Title: Impact of population ageing on the costs of hospitalisations for cardiovascular disease: A population-based data linkage study

Authors:

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Author's response to reviews: see over
To

Chief Editor

Subject: Submission of a revised manuscript of “Impact of population ageing on the costs of hospitalisations for cardiovascular disease: A population-based data linkage study”.

Dear Chief Editor,

I, Ninh Thi Ha, on behalf of my co-authors wish to submit a revised manuscript of an original manuscript entitled “Impact of population ageing on the costs of hospitalisations for cardiovascular disease: A population-based data linkage study”.

We have indicated revision in different coloured text to facilitate reviewer’s verification. We have also prepared a point-by-point response to all the concerns and suggestions made by the reviewers.

Thank you for your time for revising the manuscript.

Sincerely yours,

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Title:
Impact of population ageing on the costs of hospitalisations for cardiovascular disease: A population-based data linkage study

Reviewer 1:

Abstract - line 23 add full stop at end of sentence Abstract - line 30 add full stop at end of sentence Abstract - line 28 adds at end of episodes Key words - check data linkage vs record linkage terms to ensure consistency

Author response:
Thank you for your suggestion. We have added full stop at the end of the sentences and changed the key word to “data linkage”.

Background - line 64-68, need to explain differences in costs between France, Korea and Australia in more detail.

Author response: (Page 4, line 68-72)
We have revised the lines in the text as following “Although those studies examined the impact of ageing on healthcare expenditure, each study was focused on different types of expenditure. The study in France looked at a combination of ambulatory, pharmaceutical and hospitalisation costs while in Korea costs of health insurance, and in Australia government healthcare expenditure were examined”.

Line 80 - explain component decomposition method in more detail

Author response: (Page 4, Line 86-88)
Thank you for your suggestion. We have added a sentence to further explain for the method: “an approach in which the hospitalisation costs were decomposed into subcomponents and subsequently costs attributable to ageing of the population in each component over a period of time were isolated”. A more detailed explanation of the
component decomposition method was presented in the statistical analysis section (page 7-8).

Methods - line 85 standardised CVD codes, link more to details on lines 88 and 101-102

Author response: (Page 5, line 99)

Thank you for your suggestion. We have revised in the text by adding a sentence to link the lines about CVD codes.

Methods - line 87 add a brief description of the WADLS system, how many hospitals involved, what is the data coverage?

Author response: (Page 5, line 94-97)

The Western Australian Data Linkage System (WADLS) links administrative records from eight validated core datasets: the hospital morbidity data system, the emergency department data collection, the mental health information system, the cancer registrations, midwives’ notifications, birth registrations, death registrations, and electoral registrations dating from 1966 to present 2014\(^1\). The Hospital Morbidity Data System (HMSD) captures records of separations from all public, private acute care and psychiatric hospitals and private freestanding day hospital facilities in Western Australia\(^3\). We have added a brief description of the HMDS and inserted reference for the WADLS in the text.

Methods - line 104, explain inter-hospital transfer

Author response: (Page 6, line 115-119)

Inter-hospital transfers were identified when there were periods of in-patient hospitalisation that overlapped with each other or where separation (discharge) and


\(^2\) Data Linkage - Data collections [http://www.datalinkage-wa.org/data-linkage/data-collections]

admission dates were on sequential days. Capture of transfers between hospitals is required in order to avoid over counting of the number of hospitalisation events. In our study periods of contiguous in-patient hospitalisation were classified as episodes of care. We have revised in the text by adding this explanation to make it clear.

Methods - line 106-107, add more details on the 17 age groups, the intervals do not seem standardised e.g. 18-19, 20-24 how are they selected?

**Author response:** (Page 6, line 121-123)

Thank you for your comment. The first age group comprised only two years (18-19 years) since data extraction was restricted to hospitalisation records for individuals from 18 years and over. We have added more detail in the text to explain.

Methods - line 109 how was the cost of care episode assigned?

**Author response:** (Page 6, line 131-135)

The cost of each episode of care was assigned before adjusting for inter-hospital transfers based on the Australian Refined Diagnosis Related Group (AR-DRG) code recorded in the HMDS record for each record of hospitalisation included within an episode of care (where there were inter-hospital transfers). The cost attributed to each DRG was that reported for that DRG in the National Hospital Cost Data Collection Report relevant to the year of each separation. We have revised in the text to explain that.

Methods - line 111-112 multiple records to form an episode of care, this is a little unclear, what is the timeframe involved?

**Author response:** (Page 6, line 135-139)

As we mentioned in the previous comment, our study counted inter-hospital transfers as episodes of care for individuals having overlapping periods of hospitalization (ie admitted to another hospital prior to separation from the initial institution) or separated (discharged) and admitted on sequential days. This is required in order to avoid over counting of
hospitalisation events due to the common practice of patients being transferred between institutions to receive specialist care that is not available at the primary site. In some cases patients are admitted to another institution for a specific procedure, returning to the initial site after a few days. In other cases the patient does not return and is simply transferred to the second institution. In this case various patterns of admission and separation are possible including some overlap (ie separation from the initial institution some days following admission to the second institution) or sequential admission and separation days (ie the admission date of the second institution is the day following separation from the first). These patterns are due to administrative practices at the institutions involved and do not reflect re-admissions. When calculating number of hospitalisations and length of stay inter-hospital transfers need to be identified carefully so as to avoid over or underestimation (in the case of length of stay); however cost needs to be assigned inclusive for all hospitalization events included within any give episode of care. The cost was assigned in database before adjusting for the inter-hospital transfers and therefore included multiple records in the case of inter-hospital transfer. Thus, the costs of the inter-hospital transfer episodes were a sum of any records that formed the episode of care. We have revised in the text to make this sentence clear.

Statistics - Line 136-7 were medications, investigations and rehabilitation costs included?

Author response: (page 7, line 139-141)

The Australian Refined Diagnosis Related Group is an Australian admitted patient classification system, which provides a clinically meaningful way of relating the number and type of patients treated in a hospital to the resources required by the hospital. The classification categorises acute admitted patient episodes of care into groups with similar conditions and similar usage of hospital resources, using information in the hospital morbidity record such as the diagnoses, procedures and demographic characteristics of
patient. In Australia the system is used by the Australian Government to reimburse hospitals for the cost of treating admitted patients and is an activity based funding mechanism. Thus, the costs in our study hospitalisation costs included medications, investigations undertaken while admitted (radiology and laboratory), physicians, nursing staff, operating theatre, emergency department and “hotel” costs but did not included rehabilitation costs. We have added the explanation in the text.

Results - line 190-3 was sensitivity analysis conducted for all the results? This is not specified.

Author response: (page 9-10, line 207-212)

No sensitivity analysis was conducted for all the results. The study used whole of population data from administrative records that capture under statute all hospitalisations for Western Australia. Costing was undertaken using DRG codes which are allocated to each record at the time of separation by clinical coders within each institution using a national coding system. DRG costing is the mechanism used for reimbursement of hospitals in Australia based on activity. As such the data is of high quality and subject to ongoing routine audit by both State and Commonwealth governments. While it is common practice that sensitivity analysis is conducted on health economic analyses to evaluate the effect of various assumptions and the averaging of values have on the magnitude of the final outcome, in this case there were no assumptions made since the data were not a sample and the number of hospitalisations and costs were those recorded directly in the data set. Thus there were no values that could be varied for use in a sensitivity analysis.

We have added sentences to specify in the text.

Discussion - 223-224 - more explanation on the variation between men and women would be helpful in relation to health policy / service planning.

Author response: (Page 12, line 279-284)
Thank you for your suggestion. We have revised in the text as following “Although the impact of ageing on healthcare expenditure have been measured in many studies, little is known about gender disparity. Our results show a higher impact of ageing on hospitalisation costs for CVD in women than in men. This is explained by the finding that lifetime healthcare expenditure in women was higher than in men. It is also a consequence of a higher life expectancy and higher prevalence of chronic disease among women compared with men.”

Discussion - line 254, further decomposition, what is this in relation to, eg rehab, cost of medications, perhaps add more detail here.

Author response: (Page 13, line 314)

Thank you for your comment. In our study the total costs of hospitalisation for CVD was decomposed into three main components, which were number of population, number of episodes per capita and cost per episode. In the Hospital Morbidity Data System, the database using in our study, costs for hospitalisation were assigned as cost per episode, no further detail of costs such as cost per procedure or services and number of procedures or services used for each patients. Thus, we were not able to decompose to cost per procedure and number of procedures. We have explained that in the text from line 311-314.

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Reviewer 2:

“Component decomposition method” is not a well-known and commonly used statistical or epidemiological method and therefore it needs to be clearly explained in the manuscript (despite the fact that a version of this method was used in the cited manuscripts).

Author response: (Page 7, line 160-166)

Thank you for your comments. We have revised in the text to further explain the method used in our study. In the previous studies, the authors considered the change in healthcare expenditure was attributable to not only the impact of ageing, but also the growth of the population over time, change in proportion of people using healthcare services, and change in the average cost per episode. Similar to other studies, our study also decomposed the change in hospitalisation cost for CVD into changes in subcomponents including population growth, ageing of the population, the increase in total number of episodes of hospitalisations and the increase in average cost per episode.

“Average cost weight”: line 112. It is unclear what “weight” means in this context.

Author response: (Page 6, line 125-135)

The cost weights represent the costliness of an AR-DRG relative to all other AR-DRGs, such that the average cost weight for all separations is 1.00. The cost weight for the specific AR-DRG was provided in the National Hospital Cost Data Collection Hospital Reference Manual for Western Australia. Cost weights are added to the DRG reports so that the relative cost of each DRG can be evaluated over time. Cost weight was NOT used to assign cost in our study. It was the actual cost values reported in the National Hospital Cost Data collection – which is used to assign DRG cost for re-imbursement purposes. We have revised the text to avoid confusion.

Lines 125-127: Is the average cost per episode the same for each diagnosis? I would not think so, in which case the description should be instead something along the lines of “total cost by sex, age group and diagnosis”.

**Author response:** (Page 6, line 125-135 and page 7, line 152-156)

The Australian Refined Diagnosis Related Group (AR-DRG) is an Australian admitted patient classification system, which provides a way of relating the number and type of patients treated in a hospital to the resources required by the hospital. Acute admitted patient episodes of care are categorised into groups with similar conditions and similar usage of hospital resources, using information in the hospital morbidity record such as the diagnoses, procedures and demographic characteristics of patient.

National Hospital Cost Data Collection (NHCDC) is a collection of hospital cost and activity data covering the financial year prior to the collection period. The cost of each DRG is assigned to the cost data report by the National Cost Data collection team by actually costing a sample of patients admitted in each DRG from hospitals around Australia. The cost of each episode of care used in our study is the actual cost attributed to each specific AR-DRG reported in NHCDC for each year. Thus, the average cost per episode is not the same for each diagnosis. We have provided explanation about AR-DRG in the text from line 125-135 and revised the text about “total cost by sex, age group and diagnosis” from line 152-156.

Line 131 “using the age specific cost profile method”: it is not clear with this “method” is. It needs to be explained clearly.

Comments regarding Appendix 1, More importantly, it is not obvious how each one of those changes can be interpreted and whether the change in total cost attributable to the change of age structure or distribution assumes that both the total population and the number of hospitalizations
have the 2003/2004 values while the cost per episode has the 1993/1994 values. This assumption, while fundamental for the calculations, is not described in the main text. It is not clear if this assumption is consistent with the interpretation of the attribution of the effect of aging to hospitalization costs. I believe that this needs to be clearly discussed in the main part of the paper.

**Author response:** (Page 9; line 191-202)

An age-specific cost profile represents the per capita healthcare cost of a specific age group. By holding age-specific cost profiles constant, this approach has an assumption that the impact of other variables with potential influence on healthcare cost does not change. Although the assumption is unrealistic, it is useful for the purpose of isolating the impact of demographic changes (ageing population). The method has been used in many studies. In our study, to capture the proportion of each component contributing to the difference in total cost of hospitalisation in the period, each component in initial year (1993/94) was moved to actual value in 2003/04 in sequence. As each component in the assumption was changed, the difference in total cost of hospitalisation between initial year (1993/94) and the assumed final year (2003/04) was attributable to whichever component was affected by the change in assumption.

We have revised in the main text for further explaining how to use age-specific cost profile method in our study.

Statistical analysis: While this section is describing a number of quantities and variables that play role in the analysis, it uses a narrative style that makes it hard for the reader to follow. A proper statistical notation of the variables and quantities described in the Statistical Analysis section

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needs to be used for the description of those quantities and how they are defined and calculated.

**Author response:** (Page 7, line 145-156)

Thank you for your comment. We have added the notation in the text to make it easier to follow: “Number of episodes per capita (NEC) for gender x and age-specific group j was calculated separately for chronic conditions, ACS, stroke and overall CVD: \( NEC_{x,j} = \frac{E_{x,j}}{P_{x,j}} \),

where \( E_{x,j} \) is the number episodes for gender x and age-specific group j; \( P_{x,j} \) is the WA population in gender x and age group j for that year.

Number of episodes per capita (NEC) for gender x and age-specific group j was calculated separately for chronic conditions, ACS, stroke and overall CVD: \( NEC_{x,j} = \frac{E_{x,j}}{P_{x,j}} \), where \( E_{x,j} \) is the number episodes for gender x and age-specific group j; \( P_{x,j} \) is the WA population in gender x and age group j for that year”.

The formula for the total CVD hospitalization costs uses the variables of group populations, number of episodes per capita and cost per episode, for each group j. However the analysis method uses different quantities such as the Total population and the total number of hospitalizations. A more appropriate version of the cost formula needs to contain those two variables in the expression, so that it is clear how changes of each one of those affect the result.

This comment also concerns the equations and formulas used in the Appendix 1.

**Author response:** (Page 8, line 177-188)

Thank you for your comment. We have revised in the text as following “the change in the WA population over the study period can be decomposed into a change in the total population and a change in the age distribution of population. Similarly, the change in the number of hospital episodes per capita can be decomposed into a change in the total number of episodes and a change in the age distribution of episodes. Thus, a difference in the total hospitalisation costs between 1993/94 and 2003/04 (DHC) was attributable to the change in total population (CPOP), the change in the age distribution of population
(CDEM1), the change in the total number of episodes (CTNE), the change in the age
distribution of episodes (CDEM2) and a change in cost per episode (CCPE)
A change in total hospitalisation costs for a disease $d$ for the time period $t$ (1993/93 and
2003/04) was
$$DHC_d = CPOP_d + CDEM1_d + CDEM2_d + CTNE_d + CCPE_d$$
The total of changes attributable to the change in the age structure of the population
(CDEM1,d) and to the distribution of hospitalisation between age groups (CDEM2,d) reflect
the impact of ageing on total costs, thus impact of ageing= CDEM1,d + CDEM2,d.

Other comments regarding the decompose component analysis described in Appendix 1:
The method implies that the actual change in total cost can be decomposed into a number of
“changes” where some quantities change and some remain unchanged. Some explanation is
needed as to why the sum of those individual changes is equal to the total cost actual change

**Author response:** (Page 9, line 198-205)
Thank you for your comment. As we have mentioned in the previous comment, a
difference in the total hospitalisation costs between 1993/94 and 2003/04 (DHC) was
attributable to the change in total population (CPOP), the change in the age distribution of
population (CDEM1), the change in the total number of episodes (CTNE), the change in
the age distribution of episodes (CDEM2) and a change in cost per episode (CCPE).
A change in total hospitalisation costs for a disease $d$ for the time period $t$ (1993/93 and
2003/04) was
$$DHC_d = CPOP_d + CDEM1_d + CDEM2_d + CTNE_d + CCPE_d$$
The detail steps using to calculate proportion of each component were presented in the
revised appendix 1. To capture the proportion of each component contributing to the
difference in total cost of hospitalisation in the period, each component in initial year
(1993/94) was moved to actual value in 2003/04 in sequence. As each component in the
assumption was changed, the difference in total cost of hospitalisation between initial year (1993/94) and the assumed final year (2003/04) was attributable to whichever component was affected by the change in assumption. Each assumption using the actual value in 2003/04, the sum of the change in individual components is equal to the change in total cost between the two points of time. We have provided the explanation in the text.

Additionally, the subscript notations used for the equations in the Appendix are confusing. Clearer notation is needed

**Author response:** (Appendix 1)

Thank you for your suggestion. We have revised all notation used for the equation in the Appendix. We have presented the equation following the steps conducted. First is the actual change in total cost over the period of time and its equation. Second is the total cost of hospitalisation for each assumption taken in places and equations and the proportion of change in total costs attributable to each component.