PEER REVIEW HISTORY

ARTICLE DETAILS

TITLE (PROVISIONAL)	Geographical and population disparities in timely access to prehospital and advanced level emergency care in New Zealand: a cross-sectional study
AUTHORS	Lilley, Rebbecca; de Graaf, Brandon; Kool, Bridget; Davie, Gabrielle; Reid, Papaarangi; Dicker, Bridget; Civil, Ian; Ameratunga, Shanthi; Branas, Charles

VERSION 1 – REVIEW

REVIEWER	Prof. Kue Young School of Public Health University of Alberta Edmonton, Canada
REVIEW RETURNED	27-Aug-2018

GENERAL COMMENTS	This is a useful and interesting geospatial study to assess disparities in access to EMS. It uses travel time as the measure of access. It is a theoretical study which has definite shortcomings; further studies based on “real-world” data are needed to establish the evidence base to recommend policy and program changes. Any future study needs to focus on outcomes. Some comments and points for clarification: Within a city, neighbourhood population density may not be a critical factor. Level 1 facilities are located where they are generally not based on contemporary urban planning principles but likely for historical reasons. I would also suggest that instead of stratifying the results based on population density, that the type of settlement – urban, rural and remote, however defined, maybe interesting. For some rural/remote communities it is not clear which type of travel [land vs air] was chosen – were some criteria used but not mentioned – eg. any distance above x km was assumed to be by air, or where both air and road were available options, the shorter time by whatever means was chosen? The authors clearly recognize the distinction between travel time and response time – I believe “immediate response” was assumed and some allowance was made in estimating time over and above that consumed by actual patient transfer from the referring facility [or site of incident] to recipient facility. Facility-to-facility transfer of critically ill patients require two-way clinical communications before a transfer is accepted and executed. I also suspect response time varies between facility-to-facility transfers and picking someone “off-the-street” and transported to the nearest appropriate level of facility.

	Distance or travel time is not the only factor in “timeliness” or accessibility. How EMS services are organized regionally and locally can be important determinants of positive clinical outcomes.

REVIEWER	Paul Ouma KEMRI-Wellcome Trust Research Programme, Nairobi Kenya
REVIEW RETURNED	04-Sep-2018

GENERAL COMMENTS	This is article, presents an assessment of geographic access to trauma care in New Zealand, a high income country with a relatively low population density. Of importance is the findings that 16% of the country’s population lacks access to advanced hospital care using 1 hour as the threshold. I have a couple of major and minor comments regarding the article mainly on the methods. Major The authors indicate that they used the Open Source Routing Machine to calculate travel times. It would be useful to give more background information on how the model works, the data inputs and specifically how it obtains travel speeds. Include more information on how the model works. You also indicate that 16% of the population lacks access, does this assume only road transport, helicopter transport or is it a combination of the two? Linked to the question above, the model using helicopter transport assumes that every location/population centroid has an helipad and this might not be the case. Some locations may be far from helipads and patients may need to be transported using road networks. This I find, will likely affect the accessibility results. The authors present results of population within 30, 45, 60, 90 and 120 minutes. I agree with the choice of 60 minutes, but the others are not grounded on any evidences and even their use in the present paper is only limited to what is presented in table 2. I would recommend focusing on the 1 hour only. Minor comments Abstract Line 8: there is repetition in use of both geographic proximity and access. Remove one of them Line 16: Change observations study to observational study Article summary Line 17: remove the word chosen Introduction Line 5: There is repetition in use of the words rapid and timely. Drop one of them Paragraph 1 has no reference despite containing crucial information that sets the scene for the study Results Give statistics of population with access from both the air and road network transport Page 9 line 38, replace to our most with to the most

	Page 9 line 39, the word other starts with a capital letter O

REVIEWER	Susan Puumala HDR Inc., United States of America
REVIEW RETURNED	30-Nov-2018

GENERAL COMMENTS	General comments: This article is very well written and on an interesting topic about potential disparity in access to appropriate advanced level emergency care in New Zealand. The authors have done a great job of compiling data across a number of sources to obtain all the necessary components. The biggest issue with this paper is that there doesn't appear to be any statistical analysis of this data at all and only descriptive results are presented. This is needed to determine if there is a statistically significant difference in access by meshblock characteristics which the authors seem to be claiming without justification. The paper by Carr et al. sited in the manuscript could provide a good guide to statistical analysis of this type of data. As is, this paper doesn't really provide a lot of information, but could be much more valuable if statistical analysis is used. I would also like to see some discussion of the implications of and bias in the use of the meshblock centroid in rural and remote areas. Minor comments: In table 2 under Ethnicity, the totals for Asian seem to be off and only totals 62%. This should be checked.

VERSION 1 – AUTHOR RESPONSE

Reviewer 1. Prof Kue Young
Please leave your comments for the authors below
"same as for editor"
RESPONSE: No direct comments have been provided by this reviewer to respond to.

Reviewer 2. Paul Ouma
Please leave your comments for the authors below
This is article, presents an assessment of geographic access to trauma care in New Zealand, a high income country with a relatively low population density. Of importance is the findings that 16% of the country's population lacks access to advanced hospital care using 1 hour as the threshold. I have a couple of major and minor comments regarding the article mainly on the methods.

Major comments
Comment R2.1: The authors indicate that they used the Open Source Routing Machine to calculate travel times. It would be useful to give more background information on how the model works, the data inputs and specifically how it obtains travel speeds. Include more information on how the model works.
RESPONSE R2.1: We have included a reference that provides all the relevant information for readers who are interested in how the software's modelling approach works for these type of calculations.

The following sentence has been added to the Methods, Geospatial access calculations, paragraph 2, sentence 4: "A detailed description on how spatial data are modelled in OSRM is available elsewhere.18"
Reference 18. Luxen D, Vetter C. Real-time routing with OpenStreetMap data. GIS'11 Proceedings of the 19th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems; 2011; Chicago, Illinois.

Comment R2.2: You also indicate that 16% of the population lacks access, does this assume only road transport, helicopter transport or is it a combination of the two?
RESPONSE R2.2: The reference to 16% of the population lacking access represents the combined road and air EMS coverage. This has now been clarified where we refer to this figure as outlined below:
Abstract, results, sentence 1: "An estimated 16% of the New Zealand population does not have timely EMS access to advanced-level hospital care via road or air."
Results, paragraph 1, sentence 2: "While less than 16% of our land area allows emergency access via road or air within 60 minutes…."
Discussion, paragraph 1, sentence 3: "Applying the concept of the 'golden hour', we estimate 16% of the New Zealand population does not have timely theoretical access to advanced-level hospital care via road or air EMS."

Comment R2.3: Linked to the question above, the model using helicopter transport assumes that every location/population centroid has a helipad and this might not be the case. Some locations may be far from helipads and patients may need to be transported using road networks. This I find, will likely affect the accessibility results.
RESPONSE R2.3: The reviewer raises a valid point, as this exercise is theoretical (and clearly identified as such) it does make assumptions that the meshblock centroid is accessible via either road or helicopter. We acknowledge this may operationally be difficult, such as for reasons of the lack of availability of a suitable site to land a helicopter.
This is a limitation of this analysis and has been clarified further in the discussion section, paragraph 6, sentences 4 & 5:
"This analysis also assumes simultaneous dispatch by road and air EMS services, however the operational reality is that air response can take longer when emergency first responders are required to assess severity of an acute event prior to helicopter dispatch. It also assumes the availability of suitable helicopter landing sites at the meshblock centroid which may not be available. The benefits of the extended air ambulance coverage identified in our analysis would therefore only be achieved if air ambulance services were dispatched without delay and if suitable helicopter landing sites were available."

Comment R2.4: The authors present results of population within 30, 45, 60, 90 and 120 minutes. I agree with the choice of 60 minutes, but the others are not grounded on any evidences and even their use in the present paper is only limited to what is presented in table 2. I would recommend focusing on the 1 hour only.
RESPONSE R2.4: The use of the categories within 30, 30-45, 45-60, 60-90 and greater than 90 minutes are included to illustrate the variation in coverage by finer-grained access times categories before presenting the aggregated dichotomous variable (within 60 minutes and greater than 60 minutes). We think the findings that 66% of the population has access within 45 minutes and that only 4% are estimated to have more than 90 minutes are of importance. In our revision, we inform readers of the reason for using this categorisation and what they represent in the methods, geospatial access calculations, paragraph 1:
"The continuous access times were categorised using relatively fine-grained (<30, 30-45, 45-60, 60-90, ≥90) categories for descriptive purposes and to ensure the use of the 'golden hour' was sensible for the NZ population. Timely access was defined as the proportion of the population or land area

from which an injured person was theoretically able to reach an advanced-level hospital within a given time of 60 minutes via air and road EMS."

Minor comments
Comment R2.5: Abstract, Line 8: there is repetition in use of both geographic proximity and access. Remove one of them.
RESPONSE R2.5: Both terms have been replaced by the term "geographical access". Sentence now reads "This study aims to systematically examine geographical access to prehospital care provided…."
Comment R2.6: Abstract, Line 16: Change observations study to observational study
RESPONSE R2.6: Thank you for pointing out this typographical error. The manuscript has since been thoroughly checked for other typographical/grammatical errors.

Comment R2.7: Article summary, Line 17: remove the word chosen.
RESPONSE R2.7: The word "chosen" has been removed.

Comment R2.8: Introduction, Line 5: There is repetition in use of the words rapid and timely. Drop one of them.
RESPONSE R2.8: The word "rapid" has been removed.

Comment R2.9: Introduction, paragraph 1 has no reference despite containing crucial information that sets the scene for the study.
RESPONSE R2.9: The following references have been added to support our opening introduction, paragraph 1, sentences 1& 2: "Globally, millions of people with life-threatening injuries or health events require timely access to advanced healthcare services, including prehospital emergency services, to prevent needless mortality and morbidity.1 The public health burden of time-critical medical emergencies can be further exacerbated in countries with challenging terrain, long travel distances, and dispersed populations, despite relative economic standing and available resources.2"
Reference 1. Sasser S, Varghese M, Kellermann A, et al. Prehospital trauma care systems. Geneva: World Health Organization, 2005.
Reference 2. Waller A, Baker S, Szocka A. Childhood injury deaths: national analysis and geographic variations. Am J Public Health 1989;79:310-15.

Comment R2.10: Results, Give statistics of population with access from both the air and road network transport.
RESPONSE R2.10: We were unsure what was specifically meant here. We have now included the separate statistics for air and road network access. (Results, paragraph 1, sentence 2: "While less than 16% of our land area allows emergency access via road or air (3.5% accessible by road only and 15% by air only) within 60 minutes,….") We have also now included denominators for Table 2 giving population level frequencies and tests of differences in proportions when direct comparisons are made in the Results section, paragraph 2.
Comment R2.11: Results, Page 9 line 38, replace to our most with to the most
RESPONSE R2.11: This change has been made as suggested.

Comment R2.12: Results, Page 9 line 39, the word other starts with a capital letter O
RESPONSE R2.12: Typographical error has been corrected.

Reviewer 3. Susan Puumala
Please leave your comments for the authors below
General comments:

This article is very well written and on an interesting topic about potential disparity in access to appropriate advanced level emergency care in New Zealand. The authors have done a great job of compiling data across a number of sources to obtain all the necessary components.

Comment R3.1: The biggest issue with this paper is that there doesn't appear to be any statistical analysis of this data at all and only descriptive results are presented. This is needed to determine if there is a statistically significant difference in access by meshblock characteristics which the authors seem to be claiming without justification. The paper by Carr et al. sited in the manuscript could provide a good guide to statistical analysis of this type of data. As is, this paper doesn't really provide a lot of information, but could be much more valuable if statistical analysis is used.
RESPONSE R3.1: In response to this Reviewer's comment we have added 95% Confidence intervals to the percentages presented in Table 3. We have examined the analysis undertaken by Carr et al., with regards to statistical analysis. Although we could produce a table akin to Carr's Table 1 (Demographic characteristics of block groups in the US, stratified by trauma centre access (unadjusted)), the focus of our paper was to calculate the percentage of the population (rather than the percentage of meshblocks) with timely access. In addition the New Zealand Census data available at the meshblock level does not allow for multivariable modelling. As stated in the Carr paper, the average US block group contains roughly 1500 people; in comparison a New Zealand meshblock contains roughly 90 people. While we have been able to obtain meshblock populations stratified by one variable, meshblock-level populations are not available stratified by more than one variable.

Comment R3.2: I would also like to see some discussion of the implications of and bias in the use of the meshblock centroid in rural and remote areas.
RESPONSE R3.2: A discussion regarding potential bias through the use of meshblock centroids has been included in the discussion section, paragraph 6, sentences 9-11.
"The use of centroids may have led to geographical selection bias when some of the meshblock is on the time threshold, yet the centroid sits outside this threshold and is not selected. Manual review of the 1044 large, remote meshblocks where the centroid was 10 km, or greater, from the nearest road revealed none of these meshblocks were reachable by air or road EMS within the time-limits examined."

Minor comments:
Comment R3.3: In table 2 under Ethnicity, the totals for Asian seem to be off and only totals 62%. This should be checked.
RESPONSE R3.3: Thank you to this reviewer for picking up our error in the totals for "Asian" in Table 2. The value for 30-45 minute access has now changed from "20" to "57".

VERSION 2 – REVIEW

REVIEWER	Susan Puumala HDR, Inc., United States of America
REVIEW RETURNED	16-Apr-2019

GENERAL COMMENTS	The authors have done a great job of answering my questions. I only have one remaining issue that I would like them to address. Both in the results and in the discussion the authors discuss "significant" differences. The term significant/significantly should not be used to describe differences when there was no formal statistical test. Please remove the term significant or significantly on page 9, line 34; page 10, line 23; page 10, line 35; page 11, line 9; page 11, line 57. Another term like important could be used instead, but I feel that significantly might be misinterpreted in this context.

VERSION 2 – AUTHOR RESPONSE

Reviewer 1. Prof Kue Young

Comment R1.1. This is a useful and interesting geospatial study to assess disparities in access to EMS. It uses travel time as the measure of access. It is a theoretical study which has definite shortcomings; further studies based on "real-world" data are needed to establish the evidence base to recommend policy and program changes. Any future study needs to focus on outcomes.

RESPONSE: We agree that future studies examining disparities in access to EMS need to focus on outcomes. The current paper sets up the estimated coverage of current EMS in New Zealand and will be cited in future analyses examining trauma outcomes in New Zealand, including the association between access to EMS and the location of trauma deaths.

Comment R1.2: Some comments and points for clarification: Within a city, neighbourhood population density may not be a critical factor. Level 1 facilities are located where they are generally not based on contemporary urban planning principles but likely for historical reasons. I would also suggest that instead of stratifying the results based on population density, that the type of settlement – urban, rural and remote, however defined, maybe interesting.

RESPONSE: We have previously examined the "type of settlement" as suggested by Reviewer 1. The classification system used by Statistics New Zealand that is available at the level of the meshblock classifies "type of settlement" on the basis of population size & average commuting times to work. Our analysis showed that population density is a better predictor of access to EMS in New Zealand. For example there are "rural" areas adjacent to "major urban" areas. We found that population density measure was better able to discriminate levels of access over the time periods examined in this study.

Comment R1.3: For some rural/remote communities it is not clear which type of travel [land vs air] was chosen – were some criteria used but not mentioned – eg. any distance above x km was assumed to be by air, or where both air and road were available options, the shorter time by whatever means was chosen?

RESPONSE: We have clarified this in the methods, statistical analyses section, paragraph 2: "Where both air and road were viable options, the shorter time by whatever means was chosen."

Comment R1.4: The authors clearly recognize the distinction between travel time and response time – I believe "immediate response" was assumed and some allowance was made in estimating time over and above that consumed by actual patient transfer from the referring facility [or site of incident] to recipient facility. Facility-to-facility transfer of critically ill patients require two-way clinical communications before a transfer is accepted and executed. I also suspect response time varies between facility-to-facility transfers and picking someone "off-the-street" and transported to the nearest appropriate level of facility.

RESPONSE: Assumptions used to calculate the total travel time are listed in the Methods, Geospatial access calculations section. As outlined, an immediate response was assumed for road network travel times (paragraph 2, sentence 1), and a response time of 8 minutes was assumed for air EMS travel times (paragraph 3, sentence 3). Note, in this study we only considered calculations based on the direct transportation of the patient from the meshblock to the closest L1 or L2 hospital. We have clarified this in the methods, paragraph 1, sentence 4: "The time required for the nearest air or road EMS to reach the geometric centroid of a meshblock, stabilise a patient, and then direct travel to the nearest advanced-level receiving hospital was calculated for every meshblock."

Comment R1.5: Distance or travel time is not the only factor in “timeliness” or accessibility. How EMS services are organized regionally and locally can be important determinants of positive clinical outcomes.

RESPONSE: We agree with the reviewer’s comment. Within our limitations section (discussion, paragraph 6) we discuss other possible strategies to the delivery of prehospital care. We have clarified the role of local and regional EMS services further in the limitations “A further limitation is that the EMS scenario modelled in our analysis fits “scoop & run” prehospital care, and does not consider other possible regional or local prehospital and EMS options, such as a differentiated strategy, or rapid delivery of specialist medical expertise to the patient”.

Reviewer 3. Susan Puumala

Comment R3.1. The authors have done a great job of answering my questions. I only have one remaining issue that I would like them to address. Both in the results and in the discussion the authors discuss "significant" differences. The term significant/significantly should not be used to describe differences when there was no formal statistical test. Please remove the term significant or significantly on page 9, line 34; page 10, line 23; page 10, line 35; page 11, line 9; page 11, line 57. Another term like important could be used instead, but I feel that significantly might be misinterpreted in this context.

RESPONSE: We have replaced the terms “significant”/”significantly” with the term “important” where suggested by the reviewer.