Author's response to reviews

Title: The role of multilevel factors in geographic differences in bicycle crash risk: a prospective cohort study

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Author's response to reviews: see over
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Professors Philippe Grandjean and David Ozonoff
Editors-in-Chief
Environmental Health

Dear Professors Grandjean and Ozonoff

Re: The role of multilevel factors in geographic differences in bicycle crash risk: a prospective cohort study

We appreciate the detailed feedback and comments provided by the editors and reviewers to improve this manuscript and have responded to each of the suggestions as noted below. Changes made in the revised manuscript are highlighted in blue.

Editorial comments:

As for the formatting, on the title page change the institutional address so that it is one beginning with a superscript number that should be placed after all the authors' names. See published articles for examples.

Changes have been made as requested.

Italicized text should be changed to normal except where indicated in the References.

Italicized text has been removed in pages 6 & 7.

The heading for the abbreviations should be List of abbreviations and formatted as abbreviation:term separating the pairs with semi-colons in sentence format.

The list of abbreviations has been amended in page 15.

Please remove the Authors' information.

Authors' information has been removed (page 15).

For the tables, all horizontal lines should be visible.
Horizontal lines have been made visible in Tables 1 and 4. Thank you.

Comments from Reviewer 1:

**Major Compulsory Revisions**

The title of the manuscript is misleading. 1. To which extend is this an ‘prospective cohort study’? 2. The only ‘geographical’ variable I see in this manuscript is the difference between Auckland and the rest of NZ and the use of mesh blocks (although the mesh blocks only seem to be used to make a difference between Auckland and the rest of NZ).

In the Taupo Bicycle Study, the majority of participants were recruited in 2006 and followed up through linkage to four national databases up to 30 June 2011. It is a prospective cohort study as baseline data were collected well in advance of crash outcomes. A follow-up survey was also conducted in 2009 to assess changes in exposure over time.

Our previous analysis (published in Preventive Medicine 2013, volume 57, pages152-161) shows that the risk of on-road crashes is higher in Auckland (New Zealand’s largest urban region) than in Wellington (New Zealand’s capital region) and the rest of the country but the risk of off-road crashes is similar across the regions. As shown in Figure 1, many factors at individual, neighbourhood and broader environmental levels may contribute to the higher risk of on-road crashes in Auckland. This paper therefore assessed the relative contribution of these factors using a mediation analysis. As such we believe that the title of the manuscript is not misleading.

Meshblocks are the smallest geographical units defined by Statistics New Zealand and they were used in this study to categorise the study participants by region, urban-rural status and neighbourhood deprivation.

This manuscript is a combination of 2 (or even 3) very different topic: 1. Accidents statistics; 2a. factors that would influence cycling; 2b. perception of environmental factors.

Could the authors give a rational for including both topic into one study?

Part 2a and 2b will have an influence on bicycle usage, but I do not see the link with accidents. Will a ‘barrier to cycling’ e.g. too hilly (Table 4) cause an increased risk for bicycle accidents?

We apologise for any confusion but we feel this manuscript is not a combination of different topics. Rather it focuses on the question of which factors contribute to the excess risk of on-road crashes in Auckland.

The manuscript first presents the incidence and risk of on-road vs. off-road crashes in the Auckland region vs. the rest of New Zealand (Table 2), suggesting that Auckland had a higher risk of on-road crashes but has a similar risk of off-road crashes compared to the rest of the country. The manuscript
then presents the results of the mediation analysis (Table 3), indicating that demographics, residential factors, cycling characteristics and risk behaviours (that is, information collected from the study participants at baseline) accounted for 53% of the excess risk in Auckland. We speculated that the remaining risk differential (47%) could be attributed to environmental factors not measured in the study. Our speculation was supported by differences in perceptions toward environmental factors between the Auckland participants and others (this information is collected in the follow-up survey conducted in 2009) (Table 4). The Auckland participants were significantly more concerned about traffic volume, speed and drivers’ behaviour, but perceptions of other factors such as weather and topography were similar to those in the rest of New Zealand. We therefore concluded that Auckland’s car dominated transport environment may have contributed to the remaining risk differential. This does not mean that factors presented in Table 4 such as “too hilly” influence the risk of bicycle crashes.

Study 1: bicycle accidents

- This study has a very detailed and rich database (crash data, insurance, police, ...) that was already be used in other manuscripts from the same authors. The only novelty for this manuscript is the analyses between Auckland and ‘the rest of NZ’. The manuscript does not give any indication of the (geographical) differences between both that could be interesting to conduct a study on. Is Auckland a large built-up area and the rest of NZ part of the country side? Does NZ only has one large city?

- What is the incentive to look for a difference between Auckland and the rest of NZ?

As mentioned in the manuscript, Auckland is the largest urban region in New Zealand (this does not mean that the rest of New Zealand is a countryside or New Zealand has only one large city). The region also has a higher level of car use and a lower level of active travel, compared to the country average (Additional file 2).

As mentioned above, our previous analysis shows a higher risk of on-road crashes in Auckland, compared to Wellington and other regions. This provided the impetus to employ a mediation analysis to identify factors that may have contributed to this risk differential. Using this method we were able also to quantify the relative contribution of different behavioural and environmental variables. This manuscript therefore is not about geographic differences in crash risk (the subject of the previous analysis published in Preventive Medicine) but about why there are geographic differences in crash risks, using Auckland as an example.

- The novelty of this manuscript could have been an analyses using the meshblocks. Unfortunately, the results section does not mention anything about the mesh blocks, except that they are use to differentiate between Auckland and the rest of NZ.

As mentioned in the manuscript, meshblocks are the smallest geographical units defined by Statistics New Zealand (containing an average of 100 people and 40 dwellings). If we were to conduct analyses at the meshblock level, study power would be very limited and the results would be difficult to interpret. Therefore we aggregated meshblocks in this study and categorised the study participants by region, urban-rural status and neighbourhood deprivation.
- The results section on the accidents only deal with on- and off-road. Poor for a manuscript and not original.

We presented the incidence and risk of on-road vs. off-road crashes in the Auckland region vs. the rest of New Zealand to highlight the fact that the risk of on-road crashes is higher in Auckland but the risk of off-road crashes is not. Table 2 also presents differences in crash risk between Auckland and other regions in more detail than our previous paper in Preventive Medicine.

Study 2: there is no reference to which questionnaire were used. Where these existing questionnaires? Were these questionnaires validated? On which previous research are they based?

We assume that study 2 means our analyses presented in Table 4. This information was collected in the follow-up survey. We mentioned this in the second paragraph of the “design, setting and participants” section as well as the last paragraph of the “analyses” section. This follow-up questionnaire was developed based on the study’s baseline questionnaire and pilot-tested (we did not use baseline information because perceptions toward barriers to cycle commuting were not asked in the baseline questionnaire).

- The Methods section describes in great detail which were the databases (crash data, insurance,...) that were used and describes the statistical procedures. What is missing is a (detailed) description of the parameters that your used for your models.

We mentioned the variables measured in the second paragraph of the “design, setting and participants” section and also described how participants’ addresses were categorised by region, urban-rural status and neighbourhood deprivation in the first paragraph of the “analyses” section. More detailed information about study recruitment can be seen in our previous paper (Injury Prevention 2008, volume 14, pages 11-18).

The results section:
- Table 2 gives absolute numbers of crashes
- Table 3 the risk of on-road accidents without any ‘geographical’ characteristic
- Table 4 environmental factors perceived as important in influencing cycling for transportation
Where is the ‘link’ between bicycle accidents and the rest of the study?

Please see our responses mentioned above.

Minor Essential Revisions

- Abstract, Results and further on in the manuscript: “Of the 2554 participants whose ….”. In the Methods section (page 6) the authors indicate that “a total of 1537 participants completed the questionnaire”. Page 8: “all the data were completed for 2435 participants”. And on page 9 the authors write that “… 1511 participants were used…”.

Does the study include 2554, 1537 or 1511 participants?

As mentioned in the Methods, the baseline questionnaire was completed by 2628 participants, of whom 2590 were resident in New Zealand (overseas participants were excluded as their crash...
outcome data were not available through record linkage). Of 2590 participants, 36 were further excluded as their addresses could not be mapped. As such, analyses presented in Tables 1, 2 and 3 were based on 2554 participants, of whom 2435 had complete baseline data. The missing values for the remaining participants were computed using multiple imputation.

The follow-up questionnaire was completed by 1537 participants. As before, 26 participants were excluded as they stayed overseas or their addresses could not be mapped. Analyses presented in Table 4 were based on 1511 participants.

- What is meant with ‘baseline differences? The authors should indicate this in the Methods section.

This means differences in baseline characteristics between the Auckland participants and the rest of the cohort. We mentioned this in the second paragraph of the “analyses” section and presented the results in Table 1.

- Conclusion of the manuscript, last sentence. Would you promote cycling in an unsafe environment like Auckland (if I know that 322 Auckland participants experienced 538 bicycle crashes, is 2 per person in 4.6 years)? Or would you rather first advocate for building a cycling friendly environment and ‘educate’ car drivers for respecting the vulnerable road users?

We are not persuaded that public health advocates must choose between promotion of cycling and environmental change. In practice, both are required. Strategies for a healthier and more sustainable transport mix include not only behavioural change programmes but also engineering measures such as creating a bicycle-friendly environment and multi-faceted policies such as traffic calming, driver education, and restriction of car use. We have not described these matters in greater detail here, because they are beyond the scope of the present study.

Discretionary Revisions
- Page 4: “…level of active travel.[16]” should be “…level of active travel [16].”

This has been amended. Thank you.

- Page 8: what is meant with: “The participants were censored on 30 June 2011 or date of death.”?

Censoring is essential in survival analysis. As we performed survival analysis for repeated events and there was minimal loss to follow-up (as the crash outcome data were collected through record linkage), we censored the participants on the closing date of follow-up, that is, 30 June 2011. Those who died prior to 30 June 2011 were censored on their date of death.

Comments from Reviewer 2:

A nice analysis of a complex dataset, but I found it a bit hard to interpret. I came to the article with the expectation that this major city would have higher rates of cycling than its surroundings and therefore (assuming "safety in numbers") a lower rate of injury. But as you describe in the Discussion – and somewhat less clearly in the Introduction -- Auckland, like many less dense American cities, does not fit that pattern of mode choice, being somewhat less dense and more car-oriented. In fact, however, given the actually *lower* rates of bicycle transportation in the city, the higher rates of injury there are not inconsistent with "safety in numbers", although puzzling at first glance (the numbers may actually be too low everywhere in NZ to promote increased safety).
We agree. Auckland has a higher level of car use, a lower level of active transport and a higher level of on-road bicycle crashes. We termed this effect as “risk in scarcity” (in contrast to “safety in numbers”) in our previous paper (Australian and New Zealand Journal of Public Health 2011, volume 35, pages 357-363). We added this term in the first paragraph of the Background. We agree also that the prevalence of cyclists on the road in New Zealand may presently be too low to trigger the safety in numbers effect.

MAJOR COMPULSORY REVISIONS
None.

Thank you.

MINOR ESSENTIAL REVISIONS
1. Relating to the above point, that Auckland has higher injury rates: I found the attribution of some of the risk of injury to "residing in urban areas" (quoted from the Abstract, and with similar phrasing elsewhere) to be a confusing and groundless generalization; in fact, the the "urban area[s]" refers only to Auckland. "Urban residence" (a term also used in the Abstract) is much nearer the mark, but "Auckland residence" would be still more exact. It would be unfortunate for a reader to conclude that the study found "urban areas" generally to have higher rates of injury.

We apologise for the confusion. "Urban areas" does not refer to Auckland only. As mentioned in the Methods, it means main urban areas defined by Statistics New Zealand as centres with populations of 3000 or more. Obviously, Auckland (the largest urban region in the country) has more main urban areas than the rest of the country. This is reflected in Table 1 – 95.5% of the Auckland participants vs. 64.9% of the rest of the cohort resided in main urban areas. This difference has contributed to a higher risk of on-road crashes in Auckland (not the risk of injury in general).

2. I do not agree that the Amoros (2011) study supports the conclusion that "on-road bicycle crashes occur more often in urban areas", if you mean that the risk of injury is higher in urban areas, since Amoros does not have exposure data and does not calculate rates. You may mean that more crashes are on-road than off-road crashes, in which case, please clarify.

We apologise for the confusion again. We do not mean that the risk of injury is higher in urban areas but want to say instead that while the majority of crashes occur in urban areas more severe crashes tend to be located in rural areas. The Amoros (2011) study supports the latter. For clarity, we have amended the sentence and also provided references separately (page 13).

DISCRETIONARY REVISIONS
1. The significance of "off-road cycling" is lost on me -- does that refer to mountain biking trails for recreational riding, or off-road cycle paths for commuting, or both? Or might it be the latter in Auckland, and the former outside the city? Well-designed off-road commute paths or cycle tracks might be expected to lower injury rates, whereas recreational off-road trail riding could go either way depending on difficulty and the skill of the cyclist. If off-road riding is primarily one or another type of riding, please describe that.

We asked the participants “what percentage of your time spent cycling is off-road?” but did not require them to distinguish the type of off-road cycling (e.g., recreation/mountain biking, commuting on off-road cycle pathways). Our impression is that most of the off-road cycling reported relates to
mountain biking. The Auckland participants reported 5.8% and the rest of the cohort reported 9.8% on average (Table 1). This difference has contributed to a higher risk of on-road crashes in Auckland. Also note that the risk of off-road crashes was similar between Auckland and the rest of the country (Table 2).

We agree that different types of off-road cycling may result in different risks of off-road crashes. However, as noted above, we did not collect specific data to investigate this topic and have avoided speculating beyond the scope of this paper which aims to investigate why the risk of on-road crashes is higher in Auckland.

This question relates to my general unease that the data described probably conflates a number of subpopulations of cyclists: for example, recreational mountain bikers, recreational road bikers, and transportation riders. The problem of "off-road" riding (trails vs commutes) is a good example of what may be very different behaviors in this cohort. Future work distinguishing between these groups may help us understand the underlying patterns of risk better.

The majority of cyclists in this study are road bikers (The Auckland participants spent only 5.8% of total cycling time off-road and the rest of the cohort spent only 9.8% on average, and the median of %time spent cycling is 0% for both groups). They are mostly recreational bikers as we recruited them from a cycling event but about one-third of them also cycle for commuting (Table 1).

We agree that different types of off-road cycling may result in different risks of off-road crashes and it is worth investigating further. But this is beyond the scope of this paper.

2. I would have liked to see the beta estimates for the various components of each model; please consider supplying this as supplementary data. From Table 3 I cannot tell (for example) whether "Years of cycling" or "Mainly use road bike" contribute to or detract from injury rates.

Beta estimates and standard errors have been provided in Table 3.

3. The linkage of crashes appears to be very good (the ACC seems like a remarkable dataset!). However, differential reporting by different groups of cyclists could bias the data; in the USA, I would be concerned that some groups are less trusting of the police and less likely to report accidents, for example. When the authors say, "this [police report] database contains information on all police-reported bicycle collisions involving a motor vehicle", is there any data on what percentage of crashes is actually reported?

We agree and acknowledged this limitation in the second paragraph of the “strengths and limitations” section. A previous study shows that only 54% of hospital-reported collisions appear in police reports (see Injury Prevention 2003, volume 9, pages 376-379). In our study, 64% of hospital reported collisions were linkable to police reports whereas 43% of police reported collisions were linkable to hospital records (see BMC Public Health 2013, volume 13, page 420 for more detail). This is the reason why we used the crash data from multiple sources.

Later on, I see that "minor" crashes which are self-reported but do not appear in these databases constitute two-thirds of self-reported crashes. You do not mention self-reporting before that and it would have been clearer to point out earlier in the paper that you do have, but do not use, self-report data. I think that police/insurance data must also be "affected by personal, social and health service factors" to some extent, but I see the point.
In the follow-up survey, we asked the participants about the number of bicycle crashes experienced in the past twelve months. The follow-up response rate was 60%. As the self-reported crash data do not cover the whole follow-up period, self-reports were used for validation purposes only, that is, to assess the quality of the crash outcome data collected through record linkage (see BMC Public Health 2013, volume 13, page 420 for more detail).

4. You do not mention fatalities, but this reader wonders whether and how many of the reported injuries were fatal.

There was only one death due to a collision with a motor vehicle among the Auckland participants and none in the rest of the cohort. This has been mentioned in the second paragraph of the Results.

5. I assume the red outline on Additional File 1 delineate the metro area of Auckland? Additional File 2 could use a title and/or brief caption. I found this table helpful in understand the Auckland patterns.

The red outline marked the boundary of the Auckland region. The title of the table in Additional File 2 is “Characteristics of Auckland vs. New Zealand”. We mentioned this in the manuscript file but have also provided this information in the additional files. Thank you.

We thank the editors and reviewers for the helpful suggestions and the opportunity to respond.

Yours sincerely

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