Author’s response to reviews

Title: Short-term association between ambient temperature and homicide in South Africa: a casecrossover study

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Author’s response to reviews:

REVIEWER #1

I think the paper could say more about the literature on violence per se. The part that interests me most is why the association between violence and homicide is lower in SA than in some studies. The distinction here that needs to be made is between violence related to aggression and violence related to 'goods', the latter is not thought of as being temperature related, but is very common in SA. The phrase 'aggressive crime, including homicide' is not perfect. Many homicides in the cause of a robbery, for example, may not be related to the temperature nexus, but a shootout with cops, or a nervous rather than aggressive shooter. WHO reports on homicides provide such theory. I suspect there might be some breakdown of what % of murders in the country are related to those 2 broad categories. Gangster deaths in the W.Cape are similarly interesting, I imagine many are related to turf wars, and thus not temperature related possibly. Some more interrogation of that would be useful so that if future studies on the topic obtain much higher estimates they will be provided with sufficient information to be able to understand those differences.

We have expanded our discussion of the literature both in the Background and (primarily) in the Discussion. However, it is difficult to directly compare South Africa with other locations because there are so few studies that use the same outcome (homicide as opposed to “violent crime”) and that also focus on daily temperature rather than annual or seasonal temperature/climate. In fact, the association we find is actually substantially larger than what is reported in study by Gamble and Hess (2012) in Dallas, which is the study that is probably closest to ours in terms of study design. That said, we agree that there could be differences based on, for example, aggressive vs goods-related vs intimate-partner violence.
Unfortunately our dataset does not include any information on the circumstances of each homicide. We conducted several analyses to try and (indirectly) explore these issues, but they do not elucidate any obvious differences. For instance, we did not observe any clear differences by age (thanks for the suggestion! – see below) or sex. Similarly, the new provincial-level analyses (thanks again! – also see below) place the Western Cape – the province that the SAPS reports as having by far the highest rate of gang violence– intermediate among the provinces in terms of its temperature effect. Gang-heavy district municipalities (e.g. City of Cape Town, Nelson Mandela Bay) also exhibit effect sizes close to the overall country-level effect.

None of this is to say that we have ruled out these potentially important differences between South Africa and other countries, or between locations within South Africa, or between types of homicide, but rather that we have not detected them here.

The practice of presenting data at change per 1 degree makes sense and is a useful continuous measure of temp effects. However, and I think, more importantly from a programmatic viewpoint, is the difference between rates of homicides when we compare a day when the temp is 22.5 (your lowest 'basket' to when it is above 35, you find a 25% rise, absolutely remarkable. If you were to go to the police minister on a Wednesday when the temp is 22 degrees and there are 100 murders on average on days with a temp of 22 and you say to her that tomorrow the temp will be 35 and you can expect 125 murders, that is key info? Please present both the continuous and categorical data for these estimates, as would be done with all 'diseases'.

We agree that different ways of presenting data appeal to different users, for example epidemiologists vs policymakers. We have presented both types of data. The ORs in Table 2 provide information on the effect per degree. The data in Figure 1 – although presented primarily for the purposes of exploring (non)linearity – show the effect in several categories of temperature compared to a reference case of below 20 °C. In addition, we have now also estimated the additional number of deaths for a 35 day vs a 22 °C day, which can be found in the first paragraph of the Discussion.
The lag 0-1 is higher in all measures than the other lags. I am surprised that the authors did not mention this in more detail. It makes complete biological sense to me. The impact of heat occurs thru multiple hormonal and behavioural pathways. Some might act on day 1 through adrenalin, for example, but the stress hormones, which is a more classical heat impact hormone I would imagine take some time to build up, and aggression or irritability is not a 0 and 1 binary, I imagine the accumulation of 'heat hormones' and some build-up of aggression or irritability over a day or 2 of hot weather is more required before one takes out one's neighbour? Perhaps homicide in particular requires some high moving average temperature, rather than lesser forms of assault? The higher associations between mean temp and homicides than with daily max also maybe suggests that it is prolonged how weather on a day (and hot evening), rather than an afternoon spike that is most important? Lag 0-1 mean temp fits all the above and is the highest measure? You claiming that is by chance alone? You will struggle to make that claim as the CIs of that measure and the CIs of the daily max measures do not cross each other?

Thanks for this comment. We are not claiming that the effect from maximum temperature at lag0 was somehow more important than for other temperature metrics or lags. We highlight it because we chose it a priori, knowing that we would be conducting multiple tests. However, we see now that only highlighting those results could be misleading. As a result, we have “promoted” the mean and minimum temperature results to the main text (Table 2) so they are more easily visible. We also note specifically in a sentence on L179-181 and L215-216 that the strongest effects were seen for mean temperature at lag0-1.

Is it possible to present the data by age of victim?

Thanks for the suggestion – this new analysis, presented in Table 3, adds an important new dimension. The effect estimates were consistent across age groups (0-17, 18-44, 45+) and similar to our main model estimate.

The ethics declaration about no humans being involved comes across as odd, perhaps qualify that

Thanks – we have amended the declaration.
There is a recent review by Chersich and others ‘Violence in hot weather: Will climate change exacerbate rates of violence in South Africa?. I am surprised that the authors do not refer to that paper, even if they hold different views, or wish to critique that paper or its methods, it would seem important to include some mention of it since there is so little written on the topic in SA.

Thank you for mentioning this review – since it was published so close to our original submission date we had not identified it from our literature searches. It is of course highly relevant (and interesting!) and we now cite and discuss it in both the Background and Discussion.

If there was more than 1 weather station in a district, how was 1 of them selected? How was a definition of representative made? If there was more than 1, then some mean of the 2 might be useful? Or the Tmax from either of the stations? Perhaps that is something that could be mentioned in the limitations section, and alternative discussed.

For this study, we used the weather stations from two networks: the National Oceanographic and Atmospheric Association (NOAA) and the Agricultural Research Council (ARC). The NOAA dataset included 63 daily series covering a subset of 30 districts, while the ARC dataset included 50 series, one for each district except the City of Johannesburg and Nelson Mandela Bay. We only had 2 weather stations for 28 of the districts and often the time-series were short, interrupted and/or non-overlapping. Therefore, we decided to select the “best” weather station for each district, based on the time period, start and end date of the measurements, and the gaps and homogeneity of the series. More specifically, we selected the weather station based on a methodology developed by a team including co-author Fiorella Acquaotta and recognized internationally as CoTemp (Comparing series of Temperature - available at https://github.com/UniToDSTGruppoClima/CoTemp). CoTemp works on parallel series with an overlapping period of at least 1 year. It starts with a statistical analysis, classifies the events (in cold, mean and heat events), and then shows their differences. CoTemp is a cross-platform software, easily adaptable to different needs, that takes as input a single text file with daily information of two temperature series and outputs tables (in CSV format) and plots (as PDF images) that help in the interpretation of the data. CoTemp is reported in one very recently published article and another that is in press (see below for citations).

In response to this helpful comment and similar comments by the other reviewers we now provide additional detail on the temperature series in the Methods, including how we selected the stations and the amount of missing data (Table 1). We also added the relevant citations.
One of my main comments relates to the geographical units used in the study, and the mixing of 2 different things in my view. 1. You selected units based on the data, which is well justified by the authors; but 2. The data are presented by those sub-units (and overall), that approach is no well justified, i.e. why are the data-defined units necessarily be the best sub-unit to present the findings? I think provincial level is better. The country has ‘autonomous’ provinces, each of which differ in almost all ways, including climate. I am really interested to see if the size of the association in the W.Cape differs from KwaZulu Natal, for example. This is also important information as in provinces where there is no association, or a small one, then there is no need to heighten police services during hot weather. I thus suggest that Table A! be changed to be by province and then district, so you would say: Gauteng province and give the point estimate for that province, and then list the districts in that province and their point estimates, then North West Province point estimate and the districts in that province etc.

District-level is the smallest possible unit given our data and therefore the only unit of analysis that we can conduct without aggregating up to a larger regional unit. Nevertheless, it is an excellent suggestion to also provide provincial level results, as this is another policy relevant unit and one that allows for easier comparison than amongst 52 different districts. Therefore, we have added the provincial-level analysis, which can be found in Table S2. Associations are significant at the 5% level in all provinces (except Limpopo for definite homicides, which is borderline). Thanks for this suggestion.
The authors note that there was no substantial deviation detected from a linear association, and note that the article is important in the context of climate change; but they do not attempt to calculate the additional number of murders that might occur if the temperature rose by 1 degree. The 1 degree rise is not only at the Tmax level, but from 23 to 24, where I can't think of an argument as to why one cannot use the 1.5% or 1.2% rise to calculate the additional homicides. I suggest 2 options here. Firstly, they write a sentence say that, assuming the association is linear and remains linear with a rise in temp, one can calculate that there will be an additional xx homicide cases in SA if the temp rises by xx rise in temp (use the 2100 expected rise?). Or provide an explanation in the limitations section of why this was not possible to calculate. I feel it is important for such studies to actively integrate temperature increments into their work, not just leave it implicit.

We agree with the reviewer that it is always helpful to provide explicit and easily interpretable measures of effect. By reporting an odds ratio, we make it possible to estimate the additional number of homicides that would be expected on a hotter day vs a cooler. However, because odds ratios are multiplicative, a 1 °C change in temperature will lead to a slightly different estimate of excess deaths depending on where it occurs along the temperature distribution. Nevertheless, as a result of this comment and the other one above we now provide a concrete example which we report in the first paragraph of the Discussion where we estimate the increase in homicides that would be expected on a 35°C day vs a 22°C day.

The question of projecting into the future is of course more complicated. Our estimates are based on a change in daily temperature and therefore to run the calculation we would need to use daily temperature projections. In addition, the temperature-homicide relationship could change far in the future as there will be many differences in South Africa such as population size, socioeconomic characteristics etc. For these reasons we prefer not to make estimates under climate change in this specific paper, though it would be an interesting future project.

The interaction by gender is weaker than I had anticipated. I think it is worth making reference to the work of Jewkes and Abrams on femicide in the country. I wonder if you can even say that they are different? The CIs overlap a lot and the point estimates are very similar for 4 of the 6 temperature measures.

We agree that the difference between male and female deaths is not statistically different, as we report on L182-184. However, we have now modified this sentence to be more clear. We also now cite several papers by Jewkes and Abrahams, both in the Methods and the Discussion. (As a side note, we also expected to see a more pronounced difference by sex).
Very good data, very good analytical approach, very good writing, but also a very good opportunity to move the field forwards and do something special here.

Thanks for the positive remarks and all the highly constructive comments!

REVIEWER #2

L90 This is very fascinating study and novel results presented from the developing setting. However, there is a little space for improvement in the background specific to current literature review. There are studies presented but not describe well in detailed and the results of these studies or what they found and what you propose here differently than those studies? Therefore some revision in this section is needed.

Thanks for this suggestion. We have provided more detail on the relevant literature, primarily in the Discussion but also in the Background. However, it is difficult to directly compare our study of South Africa with other locations because there are so few studies that use the same outcome (homicide as opposed to “violent crime”) and that also focus on daily temperature rather than annual or seasonal temperature/climate. Nonetheless, we do now report more effect sizes from other key studies to allow for comparison with ours.

L106 What social outcomes you referred to? What social and demographic indicators you are looking at?

Thanks for this comment. We now realize that this sentence was confusing. The adverse health and social outcome we were referring to was homicide, and we have clarified accordingly.

L112 This section needs little more information about the data and ICD 10 coding. Reported COD and how it has been coded ICD10 it would be helpful for reader to apply and replicate this methods. (if information is available).
We have now made explicit that we used the ICD-10 (see L88-89). In addition we list the ICD codes for the “definite” homicide groups on L93 and the “probable” homicide groups on L96 as well as in all the Tables. As a result, the study should be fully replicable in this regard.

L126 Is there any validation methods used in order to see the correlation coefficient between NOAA data and Local met office data? Please present as supplementary materials.

Thanks for this comment. The other two reviewers also asked about how we selected our stations. I am pasting the reply again here. Also note that the ARC data is not from the local met office but from the Agricultural Research Council.

For this study, we used the weather stations from two networks: the National Oceanographic and Atmospheric Association (NOAA) and the Agricultural Research Council (ARC). The NOAA dataset included 63 daily series covering a subset of 30 districts, while the ARC dataset included 50 series, one for each district except the City of Johannesburg and Nelson Mandela Bay. We only had 2 weather stations for 28 of the districts and often the time-series were short, interrupted and/or non-overlapping. Therefore, we decided to select the “best” weather station for each district, based on the time period, start and end date of the measurements, and the gaps and homogeneity of the series. More specifically, we selected the weather station based on a methodology developed by a team including co-author Fiorella Acquaotta and recognized internationally as CoTemp (Comparing series of Temperature - available at https://github.com/UniToDSTGruppoClima/CoTemp). CoTemp works on parallel series with an overlapping period of at least 1 year. It starts with a statistical analysis, classifies the events (in cold, mean and heat events), and then shows their differences. CoTemp is a cross-platform software, easily adaptable to different needs, that takes as input a single text file with daily information of two temperature series and outputs tables (in CSV format) and plots (as PDF images) that help in the interpretation of the data. CoTemp is reported in one very recently published article and another that is in press (see below for citations).

In response to this helpful comment and similar comments by the other reviewers we now provide additional detail on the temperature series in the Methods, including how we selected the stations and the amount of missing data (Table 1). We also added the relevant citations.


L156 How many such dates/records were missing. Is there any methods applied to interpolate this missing values?

We have now reported missing temperature data in Table 1. We did interpolate (“reconstruct”) some temperature data, as reported on L112-114.

L158 Why not temperature as continuous variable and what was reasoning for indicators variables?

In all the analyses reported in Tables 2 and 3 and the Supplementary Tables, temperature is included in the model(s) as a continuous variable. It is only in Figure 1 that it is included as a categorical variable because such an approach enables an exploration of potential non-linearities. We now state explicitly on L133-135 that it is included as a continuous variable.

L159 Why was less than 20 C the reference group?

Good question. We wanted to be sure that the group was large enough to have sufficient precision, but also ended at a logical cutpoint so as to allow easy comparison with other studies. We now explain this on L138-139.

L184 What could be probable reason for the elevated effect in male victims?

Good question. Although there is some suggestion of an elevated effect in male victims, we are not confident that it is a real effect, as the confidence intervals overlap with those of female victims. Therefore, we prefer not to speculate on this in the paper. However, we have modified the relevant sentence to make it more clear that the differences were non-significant.

L188 Why were results in the highest temperature group uncertain?

The highest temperature group (>35 C) was more uncertain because there were relatively few case days in the dataset that were that hot – it is therefore mainly a result of sample size. We have now explained this on L197-200.

L193 In method section the reference group was 20 degree?

Thanks for catching this typo – we have corrected it to say 20 °C.
L197 In the first section reader needs to understand what are the main findings from current study and in second point how these finding relates to other research studies. what are the main interpretation of the results and then strengths and limitation. therefore this section needs some revision.

We have reorganized the Discussion, with he first paragraph now highlighting the main findings. Thanks for the suggestion. We also discuss strengths and limitations later in the Discussion.

L197 Another very important aspect of the temperature/health outcome association is effect modification by social and demographic indicators which authors did not discussed. Please discuss and present the results if the data is available if not then describe.

We agree with this important comment. We have conducted a new analysis to estimate the effect size by age, which is reported in Table 3 alongside an analysis by sex. Unfortunately we did not have information on socioeconomic status and therefore have added a clause to the sentence on future research (L269) to note the importance of additional sub-group analyses including by socioeconomic status.

REVIEWER #3

This study investigates the association between daily ambient temperature and homicide incidences in South Africa using mortality data. Having undertaken some similar research in the past, and in contexts outside the US, I was very much interested in reading this work. I like the overall premise of the article and I believe the study is publishable and does add to the extant literature.

Thanks for the kind and encouraging comments!

Background: The background is extremely short - I'm not sure whether this is typical in this journal, but I think this section is lacking. The review of the literature (globally and locally) is scant which detracts from the contribution of the work. Literature is reviewed to some extent in the Discussion later on but needs to be delved into here in more detail. Moreover the two main theoretical frameworks commonly used to explain the crime-temperature linkage (TA and RA theory) are not adequately outlined here.
Thanks for these suggestions. We have improved upon our literature review in the Background section, including to specifically cite RA theory and we have also expanded the section in the Discussion where we compare our results with other studies.

Materials and methods: Is there a date provided for each mortality? The author/s mention that a cause is provided for each case - can this be expanded upon?

Yes, the date of death is provided for each death, which is how we assign temperature exposure and also how we select our control periods. We have now made this explicit in the Methods section on L87-90. The data also includes the cause of death as reported by ICD codes. The causes we include in this study are reported in the Methods section, lines 92-97.

How does this data 'align' with SAPS data regarding victims of murder/homicide in the country over the 17 years? If the author/s are concerned with the under-reporting of violent deaths this could provide a point of reference.

This is a great suggestion. We identified SAPS data from the 2008/2009 fiscal year to the present, thus allowing us to compare with the last five years of our data. During this period (2008/2009 to 2012/2013), the numbers in our total homicide category are ~90% of what is reported by the SAPS, which we find encouraging. We now report this explicitly in the Discussion.

Regarding the temperature data, how was the 'representative station for each district' (pg5, line132-133) determined?
We have answered similar questions from the other Reviewers above, and so pasted our response again here and also note that we deleted the word “representative” because it was misleading:

For this study, we used the weather stations from two networks: the National Oceanographic and Atmospheric Association (NOAA) and the Agricultural Research Council (ARC). The NOAA dataset included 63 daily series covering a subset of 30 districts, while the ARC dataset included 50 series, one for each district except the City of Johannesburg and Nelson Mandela Bay. We only had 2 weather stations for 28 of the districts and often the time-series were short, interrupted and/or non-overlapping. Therefore, we decided to select the “best” weather station for each district, based on the time period, start and end date of the measurements, and the gaps and homogeneity of the series. More specifically, we selected the weather station based on a methodology developed by a team including co-author Fiorella Acquaotta and recognized internationally as CoTemp (Comparing series of Temperature - available at https://github.com/UniToDSTGruppoClima/CoTemp). CoTemp works on parallel series with an overlapping period of at least 1 year. It starts with a statistical analysis, classifies the events (in cold, mean and heat events), and then shows their differences. CoTemp is a cross-platform software, easily adaptable to different needs, that takes as input a single text file with daily information of two temperature series and outputs tables (in CSV format) and plots (as PDF images) that help in the interpretation of the data. CoTemp is reported in one very recently published article and another that is in press (see below for citations).

In response to this helpful comment and similar comments by the other reviewers we now provide additional detail on the temperature series in the Methods, including how we selected the stations and the amount of missing data (Table 1). We also added the relevant citations.


Clarify the parenthesis in the following sentence '(daily maximum, 7%; daily minimum, 12%)'. The up-take of temperature data of the 52 districts from 29 to all 52 districts needs to be tabulated or given more attention here. What exactly was missing? When? and how was this accounted for in the analysis?

These are good questions. We have addressed this comment in three ways. First, we have clarified the sentence on L113-114. Second, we now include a graphic showing the number of districts with temperature data over time (Figure S2). And third, we report the percentage of case/control days with missing data (see Table 1).
How was the interaction by district tested? More information required there. Relatedly, the author/s note that 'Study periods with missing temperature data were excluded from the analysis' (pg 6. Line153-154). What % of this of the total?

We tested for interaction by district through the inclusion of product terms between temperature and district in preliminary models. With the product term included in our model, we were able to assess the statistical significance of any interaction occurring by district.

Missing temperature data is now reported in Table 1. (Among cases, 11.0-12.4% of study periods were missing temperature data, and 10.9-12.3% among controls, dependent upon which temperature metric is applied.) We also discuss missing temperature data in the limitations section of the Discussion.

There is also no explicit aim nor hypothesis listed in the script which makes any inferences made somewhat unclear.

Thanks for pointing this out. We have amended language in the last paragraph of the Background section (beginning L76) to be more explicit in our goal.

Discussion: Importance of the study from a policy perspective is largely ignored. Also the implications for South Africa in terms of health.

Thanks for the suggestion. We have highlighted the health impacts and policy implications in two new ways. First, we now give an estimate of the number of additional deaths for a 35 °C vs. a 22 °C day, which can be found in the first paragraph of the Discussion, and thus characterizes the impact for health as well as policy. Second, we added a paragraph to the end of the Discussion describing policy implications.
Some indication of the variability of the size of the districts used would be beneficial. I would expect a large range in size.

That is correct – there is a large range in size. We have now included a map of South Africa, including district boundaries and the location of the temperature stations in the Supplementary Material.

Conclusion: The author/s mention the limitations of their datasets in detail in the Discussion section and then indicate in the first line of this section how 'extensive and detailed' their mortality data is. Which one is it? This section seems like an afterthought and should be integrated into the Discussion section or expanded to provide the unique contribution of the study. As it currently stands, it is weak.

You are right, the conclusion was weak. We have removed it and integrated it into the Discussion instead. Thanks for the advice.