

PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	The Health Effects of Climate Change: An Overview of Systematic Reviews
AUTHORS	Rocque, Rhea; Beaudoin, Caroline; Ndjaboue, Ruth; Cameron, Laura; Poirier-Bergeron, Louann; Poulin-Rheault, Rose-Alice; Fallon, Catherine; Tricco, Andrea; Witteman, Holly

VERSION 1 – REVIEW

REVIEWER	Chua, Paul Nagasaki University
REVIEW RETURNED	04-Nov-2020

GENERAL COMMENTS	<p>Overall: On its current form, the manuscript is hard to read and felt like a report rather than a review article. There is a need for an in-depth analysis of the systematic reviews rather than plainly describing each of them and their characteristics. If the focus is on health outcomes, consider elaborating the Table 2 further in the results part rather than compressing them to just 3 paragraphs. There may be some notable findings in them that can potentially elevate the message of the manuscript.</p> <p>Methods:</p> <ol style="list-style-type: none">1. Explicitly enumerate the eligibility criteria. Note that climate change is not global warming. Define here the categories of exposures rather than in the results. List exclusions if any.2. Simplify the description of the screening process and data extraction. The current paragraphs are confusing and contain unnecessary information.3. Coding and data mapping paragraphs are confusing. Is there any simpler way to discuss how each systematic review got their categories? Consider focusing on the sections of the articles where the decision is based.4. Refer to topics rather than item numbers in modified AMSTAR-2. Only explain and justify the modifications. <p>Results</p> <ol style="list-style-type: none">1. Explain a little about exclusions made in the selection process2. In the quality assessment, what is a poor score and what happens to articles with low score?3. Under the "climate impacts and health outcomes" section, it may be better to decide which is your priority between them rather than report combinations. Figure 4 is good example to present and may be improved with a Sankey diagram. Consider improving or removing Table 1.4. Avoid putting discussion in the results like in page 10 line 44 to 55
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	<p>5. The "summary of findings" section do not justify the wealth of information in Table 2. Consider expounding and picking up notable information/findings. Adding a figure may also be helpful.</p> <p>Discussion part can be improved depending on how the results section improves.</p>
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REVIEWER	Wright, Caradee University of Johannesburg, Environmental Health Department
REVIEW RETURNED	03-Dec-2020

GENERAL COMMENTS	<p>I congratulate the authors on synthesising the literature on climate change and health impacts in a thorough review. The idea to conduct a review of systematic reviews was a good one. This really is a 'one-stop-shop' manuscript that will no doubt be highly cited in the future. I could not find anything incorrect in the way that the review was conducted, however, the manuscript needs to be edited for English grammar and improvement in several places. For example, in the principal results section, the word overview is repeated twice in the first sentence, and in the conclusions section 'the temperature rise' could be rephrased.</p>
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REVIEWER	Levy, Barry Tufts University
REVIEW RETURNED	10-Dec-2020

GENERAL COMMENTS	<p>The paper is extremely well done and I am recommending that it be published with some minor revisions.</p> <p>In the Introduction, on line 56, you may want to also include sea-level rise and wildfires as examples of environmental consequences of climate change.</p> <p>Also in the Introduction on line 56, you give brief mention to the Watts 2019 43-page paper in the Lancet which provides extremely detailed information on the health consequences of climate change. While your paper aims to comprehensively characterize systematic reviews on this subject, the Watts paper provides a more systematic analysis of research on the impact of climate change on health. I suggest that you acknowledge that report and the ongoing work of the Lancet Countdown, which is continuing to provide annual updates of 41 indicators of the health consequences of climate change.</p> <p>The paper should more thoroughly describe limitations concerning conclusions that could erroneously be drawn from this paper. For example, on page 15, the paper summarizes 11 reviews that address pregnancy and birth outcomes. A reader of this paper could erroneously conclude that there are 11 published reviews that demonstrate significant associations between pregnancy and birth outcomes. Aside from the fact that the 11 reviews cited here do not thoroughly address confounding factors that may have accounted for adverse pregnancy-related and birth outcomes, most of the 11 reviews cited report on only suggestive findings or limited, inconsistent, or conflicting evidence. The paper should explicitly state that many of the reviews cited in this paper -- not limited to those on adverse pregnancy-related and birth outcomes -- do not find or establish associations between parameters of climate change and health outcomes.</p>
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	<p>In addition, I suggest that you also cite, in your acknowledgement of other papers in the literature the following article: Patz JA, Frumkin H, Holloway T, et al. Climate change: Challenges and opportunities for global health. JAMA 2014; 312: 1565-1580. This comprehensive paper discusses evidence over the previous 20 years concerning the adverse health outcomes associated with climate change.</p> <p>There is extensive literature on the association between climate change (especially high temperature and/or extremes of temperature) and conflict, including armed conflict, with associated adverse health impacts. This paper should at least cite two major systematic reviews and meta-analyses within that literature. (Hsiang SM, Burke M. 2014. Climate, conflict, and social stability: What does the evidence say? Climate Change 123:39–55; and Hsiang SM, Burke M, Miguel E. 2013. Quantifying the influence of climate on human conflict. Science 341:1235367).</p> <p>My other comments relate to the categorization of health outcomes, as follows:</p> <ol style="list-style-type: none"> 1. I do not understand why you have a separate category of "cardiopulmonary" outcomes in addition to "respiratory" and "cardiovascular" outcomes. It seems to me that it is redundant to state "cardiopulmonary" outcomes. 2. In terms of health outcomes, I was surprised that you do not have a separate category for nonfatal heat-related disorders. I suggest that you address this somewhere in the manuscript. 3. I suggest that you reword "dietary" outcomes to "nutritional disorders." 4. I noted that you place "allergies" together with skin outcomes. Many cases of climate-related allergies involve the respiratory system, notably allergic rhinitis. It would seem to me more appropriate to place respiratory allergies in the respiratory outcome category. For example, Article #41 (Lake 2017) addresses ragweed pollen allergy; this should be placed under respiratory rather than skin. 5. Since almost all of the included reviews concerning occupational health deal with occupational injuries, I suggest refining that category to "occupational injuries" and placing the other occupational outcomes, such as heat-related disorders, in the appropriate other categories. 6. On page 12, lines 31 and 32: The term "food poisoning" is inexact and not frequently used. Also, "salmonella and E. coli" are agents and not diseases, so you may want to say "salmonella and E. coli gastroenteritis" instead.
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VERSION 1 – AUTHOR RESPONSE

Reviewer Reports:

Reviewer: 1

Dr. Paul Chua, Nagasaki University

Comments to the Author:

Overall:

1. On its current form, the manuscript is hard to read and felt like a report rather than a review article. There is a need for an in-depth analysis of the systematic reviews rather than plainly describing each of them and their characteristics. If the focus is on health outcomes, consider elaborating the Table 2 further in the results part rather than compressing them to just 3 paragraphs. There may be some notable findings in them that can potentially elevate the message of the manuscript.

Author response: Thank you for this suggestion. We have elaborated on the findings presented in Table 2 (now Table 1; see Results section “Summary of Findings”), as the focus of the study is indeed on health outcomes. More precisely, we provide a more in-depth analysis and underline notable findings of the summary of health impacts of climate change, according to climate effects. These changes also address comment #10 by Reviewer 1. (p. 8-9)

Methods:

2. a) Explicitly enumerate the eligibility criteria. b) Note that climate change is not global warming. c) Define here the categories of exposures rather than in the results. d) List exclusions if any.

Author response: a) There were two eligibility criteria: 1) if studies were systematic reviews of original research and 2) if they reported at least one health impact (health as defined by the WHO) as it related (directly or indirectly) to climate change. This information was stated in the “Search strategy and selection criteria” section in the “Methods”, but we have reformulated this information to make it more explicit and we have added examples of articles that were included/excluded, based on these two inclusion criteria. (p. 4, lines 118-121)

b) Thank you for alerting us to the fact that we hadn’t explained our rationale for using both terms (climate change and global warming). Because both of these terms are frequently used in the literature, we used both terms during the search and included studies which reported either on climate change or global warming. We have reformulated the section where we present the inclusion criterion to make it clearer that either term could be used, although they do not equate. Specifically, the new text reads: “Although climate change and global warming are not equivalent terms, in an effort to avoid missing relevant literature, we included studies using either term.” (p. 4 lines 139-143)

c) Concerning the categories of exposure and the categories of health impacts, we only organized these during analyses, after we had selected studies. Indeed, various systems of categorizations exist for both the health outcomes and climate impact and we wanted to organize our categories to better reflect our data. Therefore, this information is more representative of our process if we present it in the Results section. To address the reviewer’s concern about lack of details about categories of exposure in the Methods, we have added examples of categories of exposure that were included in this study. We based these categories of exposure on the existing scientific evidence concerning climate change and its related environmental consequences. (p. 4, lines 134-139)

d) We have added information about exclusions for both selection criteria. For instance, for the health impact criterion, we specify that we excluded studies that did not report on a direct health impact of climate change. Specifically, the new text reads: “We excluded studies if they did not report at least one health effect of climate change. For instance, we excluded studies which reported on existing measures of health impacts of climate change (and not the health impact itself) and studies which reported on certain health impacts without a mention of climate change, global warming or environmental consequences made more likely by climate change.” (p. 4 lines 143-147)

3. Simplify the description of the screening process and data extraction. The current paragraphs are confusing and contain unnecessary information.

Author response: We have simplified and shortened the sections “Screening process” and “Data extraction”, partly by combining them in one shorter section and by removing additional information. For instance, we have removed the additional information concerning training of the analysts, which may be cumbersome to the reader. (p. 5 lines 155-169)

4. Coding and data mapping paragraphs are confusing. Is there any simpler way to discuss how each systematic review got their categories? Consider focusing on the sections of the articles where the decision is based.

Author response: We have shortened and simplified the section on “Coding and data mapping” to describe our procedure for coding and data mapping in a simpler way. (p. 5 lines 172-193)

5. Refer to topics rather than item numbers in modified AMSTAR-2. Only explain and justify the modifications.

Author response: We have removed the list of item numbers when we discuss the use of AMSTAR-2. We have also provided an example of topic modifications within two items as well as the justification for doing so. Wanting to keep this section succinct, instead of expanding on all the modifications in the Methods section, we also added a sentence to direct the reader to consult Appendix 2 for a complete list of modifications. Specifically, the new text reads: “For instance, we changed assessing and accounting for risk of bias in studies’ included randomized controlled trials to assessing and accounting for limitations in studies’ included articles. Complete modifications are presented in Appendix 2.” (p. 6 lines 199-201)

Results

6. Explain a little about exclusions made in the selection process

Author response: In addition to the text added in the Methods section (to address comment #2 of this reviewer), we have also added text in the Results section to explain the exclusions that we made during the selection process. The new text reads: “More precisely, following screening of titles and abstracts, 146 studies remained for full text inspection. During full text inspection, we excluded 52 studies, as they did not report a direct health effect of climate change (n = 17), did not relate to climate change (n = 15), were not systematic reviews (n = 10), or we could not retrieve the full text (n = 10).” (p. 6, lines 207-210)

7. In the quality assessment, what is a poor score and what happens to articles with low score?

Author response: The attribution of individual quality scores per article went beyond the purpose of the quality assessment in the context of our overview. More precisely, the purpose of the quality assessment was to evaluate the quality of the included studies as a whole to get a sense of overall quality of evidence, to have data on how much confidence we can have in the results and to see where the biggest methodological flaws are in this field. Therefore, we attributed a score to each article for each topic of the AMSTAR and aggregated the data according to topic, but not according to each study. For these reasons, we did not exclude articles based on quality. However, we do provide the full data to readers in Appendix 4, so if a reader is interested in the quality of a particular study, this information is readily available. We have added text in the Results section under the “Quality Assessment” subsection to specify this information. Specifically, the new text reads: “The purpose of the quality assessment was to evaluate the quality of the included studies as a whole to get a sense of the overall quality of evidence in this field. Therefore, individual quality scores were not compiled for each article, but scores were aggregated according to items. Complete scores for each article and each item are available in Appendix 4.” (p. 7 lines 244-248)

8. Under the "climate impacts and health outcomes" section, it may be better to decide which is your priority between them rather than report combinations. Figure 4 is good example to present and may be improved with a Sankey diagram. Consider improving or removing Table 1.

Author response: Thank you for this comment. Because we are presenting an overview of what research is being done in this area, we believe that reporting the combination of climate impact and health outcomes is important, to better guide future research and syntheses in this field. Therefore, we have kept this information in the Results section. We liked the reviewer's suggestion of a Sankey diagram and therefore created one, but with 10 health outcomes and 5 climate impacts, it was extremely busy and difficult to read, so we ultimately decided to maintain the column charts in Figure 4. Finally, as suggested by the reviewer, we have removed Table 1 and associated text, to better prioritize the key findings. (p. 7-8)

9. Avoid putting discussion in the results like in page 10 line 44 to 55

Author response: We have reviewed our Results section to ensure that we do not discuss findings in this section. For instance, the example that is provided by the reviewer (p. 10, lines 44 to 55) has been shortened and moved to the Discussion section. (p. 16 lines 385-386 and lines 390-393)

10. The "summary of findings" section do not justify the wealth of information in Table 2. Consider expounding and picking up notable information/findings. Adding a figure may also be helpful.

Author response: Thank you, we carefully considered how to address this concern. We agree with the reviewer that the information presented in Table 2 may be unwieldy, and yet, it reflects the literature in this area. Since presenting the state of the literature was our goal, we prefer to maintain Table 2 (which becomes Table 1, now that we have deleted the original Table 1). The reviewer raises a good point about the need for more discussion of notable findings. To address this point, we have now elaborated on the Findings presented in Table 2 (see Results section "Summary of Findings"), to better highlight some notable findings. More precisely, we provide a more in-depth analysis and notable findings of the summary of health impacts of climate change, according to climate effects. These changes also address the comment #1 by Reviewer 1. (p. 8-10)

Discussion:

11. Discussion part can be improved depending on how the results section improves.

Author response: As suggested, we have endeavored to improve and expand the discussion based on the additions we made in the results section. For instance, we now make links with notable findings (now underlined in the Results section) and previous literature, such as the most recent Lancet report. (p. 16-18)

Reviewer: 2

Dr. Caradee Wright, University of Johannesburg, South African Medical Research Council

Comments to the Author:

1. I congratulate the authors on synthesising the literature on climate change and health impacts in a thorough review. The idea to conduct a review of systematic reviews was a good one. This really is a 'one-stop-shop' manuscript that will no doubt be highly cited in the future. I could not find anything incorrect in the way that the review was conducted

Author response: Thank you very much.

2. However, the manuscript needs to be edited for English grammar and improvement in several places. For example, in the principal results section, the word overview is repeated twice in the first sentence, and in the conclusions section 'the temperature rise' could be rephrased.

Author response: We have revised the manuscript to improve the quality of the language and grammar. The two specific examples raised by this reviewer have also been improved (i.e., changed one term 'overview' for a synonym and improved the conclusion section regarding the use of 'temperature rise').

Reviewer: 3

Dr. Barry Levy, Tufts University

Comments to the Author:

The paper is extremely well done and I am recommending that it be published with some minor revisions.

1. In the Introduction, on line 56, you may want to also include sea-level rise and wildfires as examples of environmental consequences of climate change.

Author response: We have added these examples in the Introduction (p. 2, lines 73-74).

2. Also in the Introduction on line 56, you give brief mention to the Watts 2019 43-page paper in the Lancet which provides extremely detailed information on the health consequences of climate change. While your paper aims to comprehensively characterize systematic reviews on this subject, the Watts paper provides a more systematic analysis of research on the impact of climate change on health. I suggest that you acknowledge that report and the ongoing work of the Lancet Countdown, which is continuing to provide annual updates of 41 indicators of the health consequences of climate change.

Author response: Thank you for this suggestion. We agree that the on-going work of the Lancet Countdown report should better be acknowledged. We have therefore updated the reference to the most recent Lancet Report (2021) and we have added a few sentences to describe the work behind this report as well as the key findings of the most recent report. We also refer to this paper in the Discussion to help interpret our findings. (p. 3 lines 79-85 and p.16 lines 412-414 and p. 17 lines 429-430 and lines 446-449, and lines 460-465)

3. The paper should more thoroughly describe limitations concerning conclusions that could erroneously be drawn from this paper. For example, on page 15, the paper summarizes 11 reviews that address pregnancy and birth outcomes. A reader of this paper could erroneously conclude that there are 11 published reviews that demonstrate significant associations between pregnancy and birth outcomes. Aside from the fact that the 11 reviews cited here do not thoroughly address confounding factors that may have accounted for adverse pregnancy-related and birth outcomes, most of the 11 reviews cited report on only suggestive findings or limited, inconsistent, or conflicting evidence. The paper should explicitly state that many of the reviews cited in this paper -- not limited to those on adverse pregnancy-related and birth outcomes -- do not find or establish associations between parameters of climate change and health outcomes.

Author response: We have expanded on this both in the results section and in the discussion. More precisely, we have added a paragraph in the results section to make it clearer that not all associations studied reached conclusive and consistent findings. We have also changed the wording in Table 2 (now Table 1) to better emphasize that some of these associations are supported by limited or conflicting findings. For example, we changed the use of "are" associated for "may be" associated and

the use of reviews “suggest an association” to reviews “suggest a potential association”. We also added a section in the Discussion to highlight the fact that some of the studies presented inconclusive or null findings, and that findings should be interpreted accordingly. (e.g., p.8 lines 300-302; p. 13 Table 1; p. 17 lines 451-458)

4. In addition, I suggest that you also cite, in your acknowledgement of other papers in the literature the following article: Patz JA, Frumkin H, Holloway T, et al. Climate change: Challenges and opportunities for global health. JAMA 2014; 312: 1565-1580 PubMed . This comprehensive paper discusses evidence over the previous 20 years concerning the adverse health outcomes associated with climate change.

Author response: We have added this reference in the introduction, when we present previous research on the health impacts of climate change. (p. 3, line 78)

5. There is extensive literature on the association between climate change (especially high temperature and/or extremes of temperature) and conflict, including armed conflict, with associated adverse health impacts. This paper should at least cite two major systematic reviews and meta-analyses within that literature. (Hsiang SM, Burke M. 2014. Climate, conflict, and social stability: What does the evidence say? Climate Change 123:39–55; and Hsiang SM, Burke M, Miguel E. 2013. Quantifying the influence of climate on human conflict. Science 341:1235367).

Author response: Thank you for these references. We agree that it is important to recognize the adverse health impacts ensuing from the socio-political consequences of climate change. We have therefore added a reference to these studies in the introduction and we have also added these health outcomes as examples of adverse health outcomes in the introduction. (p. 3, line 78)

My other comments relate to the categorization of health outcomes, as follows:

6. I do not understand why you have a separate category of "cardiopulmonary" outcomes in addition to "respiratory" and "cardiovascular" outcomes. It seems to me that it is redundant to state "cardiopulmonary" outcomes.

Author response: We have eliminated the term “cardiopulmonary” within this category to avoid redundancy. This change has been made throughout the manuscript whenever this category name appeared. (e.g., p.8 line 275)

7. In terms of health outcomes, I was surprised that you do not have a separate category for nonfatal heat-related disorders. I suggest that you address this somewhere in the manuscript.

Author response: Indeed, most nonfatal heat-related disorders were studied in the context of occupational health and injuries. Therefore, these studies were grouped and are discussed in the “Occupation health and injuries” category. The few studies that explored these nonfatal heat-related disorders unrelated to occupational health were then categorized and discussed in the “Other health outcomes” category. We have added a sentence in the results section to bring attention to these findings. (p. 9, lines 315-817)

8. I suggest that you reword "dietary" outcomes to "nutritional disorders."

Author response: We have reworded this category from “dietary” to “nutritional” outcomes. We chose the term ‘outcome’ over ‘disorder’ to remain consistent with the presentation of the other categories in which we use ‘outcomes’ instead of disorders (e.g., mental health outcomes, other health outcomes,

etc.). This change has been made throughout the manuscript whenever this category name appeared. (e.g., p.8 line 276)

9. I noted that you place "allergies" together with skin outcomes. Many cases of climate-related allergies involve the respiratory system, notably allergic rhinitis. It would seem to me more appropriate to place respiratory allergies in the respiratory outcome category. For example, Article #41 (Lake 2017) addresses ragweed pollen allergy; this should be placed under respiratory rather than skin.

Author response: Thank you for this suggestion. We have recategorized the Lake (2017) article which addresses pollen allergy in the respiratory category. The other papers categorized in skin and allergies referred to skin outcomes specifically and therefore remain in that category. The name of the category was also changed for clarity to "Skin allergies and diseases". The recategorization of the Lake paper also changed some frequencies in the description of studies, and the concordant changes have been made to frequencies and descriptive results. (see p. 12, Table 1)

10. Since almost all of the included reviews concerning occupational health deal with occupational injuries, I suggest refining that category to "occupational injuries" and placing the other occupational outcomes, such as heat-related disorders, in the appropriate other categories.

Author response: There may have been some confusion in how the results were presented for this category. We have reworded the description of findings within this category to make it clearer that most studies looked at various occupational health outcomes (not just injuries). Therefore, to remain inclusive and representative of the included studies, we have kept the category name to "Occupational health and injuries". (p. 14-15 Table 1)

11. On page 12, lines 31 and 32: The term "food poisoning" is inexact and not frequently used. Also, "salmonella and E. coli" are agents and not diseases, so you may want to say "salmonella and E. coli gastroenteritis" instead.

Author response: We have eliminated the term "food poisoning", as suggested and we have made the change to add "gastroenteritis" to "salmonella and E. coli". (p. 10, Table 1)

VERSION 2 – REVIEW

REVIEWER	Chua, Paul Nagasaki University
REVIEW RETURNED	20-Mar-2021

GENERAL COMMENTS	<p>The manuscript has been revised sufficiently and needs some minor revisions:</p> <p>Page 8 Lines 244-247: Second sentence should be moved to methods.</p> <p>Page 8 Lines 263-264: It may be better to list all meteorological factors being associated with health outcomes. Also, heat waves may not fall under this category but under extreme weather events.</p> <p>Page 10 Lines 345-348: Confusing sentence, consider improving especially the phrase "...climate change generally..." at line 346</p>
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	<p>Page 17 Lines 382-383: It may not be appropriate to say meteorological impacts are climate impacts</p> <p>Page 17 Line 385: May not be true to say "...all health outcomes..."</p> <p>Page 17 Lines 387-390: This sentence are not related to the first two sentences. Rise in temperatures in the form of temperature anomalies are different from short-term meteorological factors. Also, temperature anomalies have direct and indirect effects on droughts, fires, and air pollution.</p> <p>Page 17 Lines 390-393: Consider the limitations in measuring climate change impacts and the indirectness of pathways to health outcomes</p> <p>Page 17 Lines 399-400: Consider rephrasing "..better mitigate..." because this relates to reduction of GHGs. May be appropriate to say that it relates to more support for mitigation policies.</p> <p>Page 17 Lines 402-414: Seems like the phrase "...bias of Western definitions of health..." is not justified here because all examples mentioned in the paragraph were "Western definitions of health" anyways.</p> <p>Page 18 Lines 436-447: I do not understand the point of the paragraph.</p> <p>Page 18 Lines 451-458: It may be better to say something about the conflicting findings and need for further research</p> <p>Page 32 Lines 875-879: Move the names of the countries in the caption to the results or supplemental.</p>
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REVIEWER	Levy, Barry Tufts University
REVIEW RETURNED	24-Mar-2021

GENERAL COMMENTS	The abstract is accurate and balanced. It is incomplete to the extent it mentions only two study limitations and on lines 572-573 of the manuscript the authors list four main limitations.
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VERSION 2 – AUTHOR RESPONSE

Reviewer Responses:

The Health Effects of Climate Change: An Overview of Systematic Reviews

Reviewers' Comments and Responses:

Reviewer: 1

Dr. Paul Chua, Nagasaki University

Comments to the Author:

The manuscript has been revised sufficiently and needs some minor revisions:

1. Page 8 Lines 244-247: Second sentence should be moved to methods.

Author response: This sentence was moved to methods. (see p.6, lines 196-199)

2. Page 8 Lines 263-264: It may be better to list all meteorological factors being associated with health outcomes. Also, heat waves may not fall under this category but under extreme weather events.

Author response: As suggested, we have added information to list all meteorological factors considered by previous studies (p.7, line 270). We agree that heat waves could be considered under the category of 'extreme weather event', but since some previous studies tended to treat high temperatures and heat waves together, we decided to keep heat waves in the meteorological factor category. We have added a note to specify this detail in the text. (p. 8, lines 273-275)

The new text reads:

"Although heat waves could be considered an extreme weather event, papers investigating heat waves' impact on health were classified in the meteorological impact category, since some of these studies treated them with high temperature."

3. Page 10 Lines 345-348: Confusing sentence, consider improving especially the phrase "...climate change generally..." at line 346

Author response: As suggested, we have improved these sentences to make it clearer that what we mean by 'climate change generally' includes studies that did not precise the specific climate change impact they were studying, but simply listed climate change as the impact they studied. (p.9, lines 354-356)

The new text reads:

"Reviews which stated climate change as their general focus and did not specify the climate impact(s) under study were less frequent (n=5), but they suggest an association between climate change and pollen allergies..."

4. Page 17 Lines 382-383: It may not be appropriate to say meteorological impacts are climate impacts

Author response: As suggested, we have deleted the mention of 'climate impact' in this sentence. The new text reads:

“First, meteorological impacts, mostly related to temperature and humidity, were the most common impacts studied by included publications.” (p. 16, lines 391-393)

5. Page 17 Line 385: May not be true to say "...all health outcomes..."

Author response: As suggested, we have modified this sentence to specify 'all health outcomes that we identified in our categorization'. The new text reads:

“Indeed, meteorological factors’ impact on all health outcomes identified in this review are explored...” (p. 16, line 394)

6. Page 17 Lines 387-390: This sentence are not related to the first two sentences. Rise in temperatures in the form of temperature anomalies are different from short-term meteorological factors. Also, temperature anomalies have direct and indirect effects on droughts, fires, and air pollution.

Author response: Thank you for this comment. We have modified these sentences according to suggestions. We specify that temperature rise is indeed a long-term meteorological impact and that this long-term impact can have direct and indirect effects on other climate-related factors, such as droughts, fires and air pollution. The new text reads (p.16, lines 396-400):

“Although this may not be surprising given that a key implication of climate change is the long-term meteorological impact of temperature rise, this finding suggests we also need to undertake research focused on other climate impacts on health, including the direct and indirect effects of temperature rise, such as the impact of droughts and wildfire smoke.”

7. Page 17 Lines 390-393: Consider the limitations in measuring climate change impacts and the indirectness of pathways to health outcomes

Author response: Thank you for this suggestion. We have added a sentence in the Discussion to note the limitations and challenges relating to measuring the pathways (direct and indirect) in which climate change impacts health. This challenge was also raised by multiple included studies. The new text reads (p. 18, lines 464-467):

“These conflicting and limited findings highlight the need for further research. These associations are complex and there exist important methodological challenges inherent to exploring the causal relationship between climate change and health outcomes. This relationship may at times be indirect and likely determined by multiple interacting factors.”

8. Page 17 Lines 399-400: Consider rephrasing "...better mitigate..." because this relates to reduction of GHGs. May be appropriate to say that it relates to more support for mitigation policies.

Author response: Thank you for this suggestion. We have modified the text accordingly. The new text reads:

“This will provide better support for mitigation policies and allow us to adapt to the full range of threats of climate change.” (p. 17, lines 409-410)

9. Page 17 Lines 402-414: Seems like the phrase "...bias of Western definitions of health..." is not justified here because all examples mentioned in the paragraph were "Western definitions of health" anyways.

Author response: Thank you for this comment. We have eliminated the section of the sentence specifying the Western bias. (p. 17, lines 413)

10. Page 18 Lines 436-447: I do not understand the point of the paragraph.

Author response: This paragraph is meant to summarize the key finding that most reviews do suggest an association between climate impacts and health outcomes. We have aimed to clarify the purpose of the paragraph and hope that it is now clear.

The revised text reads (p.17-18, lines 445-457): “Fourth, overall, most reviews suggest an association between climate change and the deterioration of health in various ways, illustrating the interdependence of our health and well-being with the well-being of our environment. This interdependence may be direct (e.g., heat’s impact on dehydration and exhaustion) or indirect (e.g., via behavior change due to heat.) The most frequently-explored and consistently-supported associations include an association between temperature and humidity with infectious diseases, mortality, and adverse respiratory, cardiovascular and neurological outcomes. Other less frequently studied but consistent associations include associations between climate impacts and increased use of healthcare services, some adverse mental health outcomes, adverse nutritional outcomes, and adverse occupational health outcomes. These associations support key findings of the most recent Lancet report, in which authors report, amongst others, increasing heat exposure being associated with increasing morbidities and mortality, climate change leading to food insecurity and undernutrition, and to an increase in infectious disease transmission.²”

11. Page 18 Lines 451-458: It may be better to say something about the conflicting findings and need for further research

Author response: Thank you for this suggestion. We have modified the text to specify that these conflicting and limited findings point to the need for further research. The text now reads:

“These conflicting and limited findings underline the need for further research.” (p.18, lines 464-465)

12. Page 32 Lines 875-879: Move the names of the countries in the caption to the results or supplemental.

Author response: As suggested, we have moved the names of the countries in the caption to the results section. (p.6, lines 224-229)

Reviewer: 3

Dr. Barry Levy, Tufts University

Comments to the Author:

The abstract is accurate and balanced. It is incomplete to the extent it mentions only two study limitations and on lines 572-573 of the manuscript the authors list four main limitations.

Author response: Thank you for this comment. Unfortunately, due to space limitations, we could not detail each limitation. However, we have now summarized all four in the following line: "Study limitations include possible missed relevant reviews, no meta-meta-analyses, and no assessment of overlap." Note that possible missed relevant reviews could occur due to two listed limitations (i.e., possible flaws in the search strategy and the date of the search.) (p. 2, lines 47-48)

Reviewer: 1

Competing interests of Reviewer: None declared.

Reviewer: 3

Competing interests of Reviewer: No competing interests