

Resubmission of: Does concern regarding climate change impact subsequent mental health? A longitudinal analysis using data from the Avon Longitudinal Study of Parents and Children (ALSPAC) (PCI Registered Reports #793)

Response to Reviewer 1 (Anna Castiglione)

In this study the authors plan to investigate A. whether climate concern triggers mental health issues or reduces well-being, and B. whether individual climate action and efficacy beliefs moderate this effect. They plan to analyze longitudinal data from the ALSPAC survey, where participants' well-being and mental health (among other variables) were measured two times: once at baseline (between ages 21 and 25) and once at age 31-32. Additionally, climate concern was measured between these two times, at age 30. The authors plan to analyze the data to answer their two research questions analyzing a large sample (N~1,000, imputable to ~5,000) via linear regressions. In the causal estimation of the effect of climate concern on mental health/well-being, the authors are thoughtfully planning to rule out multiple confounding variables in their analyses, such as baseline mental health / well-being, offspring sex, ethnicity, relationship status, various measures of socioeconomic position, personality traits, and parental measures of depression, anxiety and socioeconomic position.

I find the author's research questions very sensible and urgent, given the ever-increasing psychological issues related to the climate crisis, especially among the youth. I particularly like the constructive approach of looking at climate action and efficacy beliefs as moderators of the more severe psychological reactions. I think the results of this study can greatly inform educational interventions aimed at helping young adults cope with their climate distress, via empowerment and constructive engagement in action.

The causal-effect estimations (rather than hypotheses) are well-stated and capable of answering the research questions. The protocol is well detailed, enabling reproducibility. Indicative power analyses were performed, although it is unclear which effect size metric was used (see below). Interpretations given different outcomes could be better elaborated in the final table. The authors provide an extensive introduction of the topic, with a satisfying overview of the prior literature and motivation for their study (i.e. the lack of longitudinal studies connecting climate concern to mental health via causal estimation). There are all reasons to believe the proposed research falls within established ethical norms, as data collection was part of a bigger survey project Based at the University of Bristol (ALSPAC).

We thank the reviewer for the positive and constructive review! We have responded to all comments in turn, with the reviewer's original comments in black font, and our responses in blue. We have also updated the 'interpretation given different outcomes' section in Table 3 to provide additional detail.

I list some comments below, that I hope may help the authors improve their design.

- I would be cautious calling your measured construct "climate anxiety," rather than "climate concern." I appreciate your explanation for why you still decided to use the term "climate anxiety;" however, I believe the literature itself is quite confusing on the use of this term, which for this study is particularly problematic, for the following reasons. First, climate

anxiety is often characterized by clinical symptoms that are well beyond “worrying”, such as impairment in concentration and sleep, mood and emotionality, changes in diet, social isolation (e.g. [Doherty 2015](#); [Hogg 2021](#)). These symptoms are not captured (and should not be assumed) by the question “how concerned are you about the climate crisis?” In the real world (outside of a research study) these more severe symptoms may not be alleviated by mere engagement in climate action (rather, they may require clinical treatment). So, if for example you found that the effects of climate concern on mental health are moderated by climate action (because it somehow “alleviates” concern) it would not be accurate to believe that action alleviates *anxiety* the same way (somebody who suffers from severe climate anxiety may need to step away from climate action for a while? Or maybe would need therapy in combination with action). Second, the term “anxiety” generally comes attached to mental health issues (in fact, you are using “generalized anxiety” as one of your mental health outcomes). So, by using this term you are already associating your *concern* construct to mental health, when (from what I understand) the goal of this study is to find causal links between these two variables. Third, “climate concern” is likely a much more common emotional state across the population, than the more severe climate anxiety. So, using “climate concern” would make your results more widely generalizable. I am thinking especially about your second research question, on whether climate action moderates the degeneration of concern into mental health issues; if this was the case, your results would suggest that all those concerned about climate (rather than the smaller number of people affected by eco-anxiety), would benefit from engaging in climate action; this is quite a bigger impact result that should not be understated!

Thank you for raising these important points. We completely agree that ‘climate concern’ should not be treated synonymously with ‘climate anxiety’. In our original submission we did try to address this in the ‘Exposures’ section when discussing our ‘climate concern’ variable; however, given the importance of being clear about this and the aims of our study, we have now updated the introduction with a paragraph discussing why we focus specifically on ‘climate concern’ rather than ‘climate anxiety’:

“Note that throughout the rest of this paper we predominantly focus on concern regarding climate change (‘climate concern’) rather than ‘climate anxiety’ specifically. As we discuss in more detail below, while climate concern and climate anxiety are correlated they are not synonymous, with climate concern reflecting the less-severe manifestations of climate anxiety (Lutz et al., 2023). However, we focus on climate concern here for several reasons. First, climate concern is much more common than climate anxiety in the population, with approximately 60% of 16-25 year-olds worldwide ‘extremely’ or ‘very’ worried about climate change (Hickman et al., 2021); for similar results, see (Clayton, 2020; Major-Smith, Halstead, Major-Smith, et al., 2024). Understanding the causal relationships between climate concern and mental health/well-being could therefore have important public health implications beyond focusing on more extreme manifestations of climate anxiety. Second, it is possible that the concept of climate anxiety – often characterised by clinical symptoms of depression and anxiety disorder (e.g., panic attacks, helplessness, sadness, sleeplessness; Climate Psychology Alliance, 2020; Coffey et al., 2021) – conceptually overlaps with our mental health outcomes, and hence measure the same (or very similar) constructs. While not all scales of climate anxiety focus on these clinically-relevant symptoms (e.g., Clayton & Karazsia, 2020), we side-step this potential complication in our study by focussing on climate concern, rather than climate anxiety. Finally, from a practical perspective, we are also constrained by our secondary dataset, which only contains information on climate concern, not climate anxiety.”

We have also updated throughout the manuscript to be clear that we are measuring and assessing climate concern, rather than assuming we are measuring climate anxiety.

- Page 6 line 213: I wouldn't call this "secondary analysis" – this is part of your main research questions (question 2); therefore, it is primary analysis, correct? I point this out because I know in RR it is quite important to distinguish primary and secondary analyses for Stage 2 follow-up on the Stage 1 analysis plan.

To avoid any potential confusion regarding this, we have updated this from 'primary' and 'secondary' analyses to 'research question 1' and 'research question 2' analyses throughout.

- Hypothesis 2:
 - o You may want to specify that you are looking at *individual* pro-climate action (as shown in supplementary table 1). This is important e.g. for those who might want to build interventions based on your results, using action engagement as coping mechanism to climate concern. Plus, we already know that collective action helps ([Schwartz 2022](#), which you also referenced), so in a way you are adding an extra piece here, which is worth mentioning. (I'm very curious to see if individual action also helps; I have a feeling people are less encouraged/relieved by it compared to collective action because it feels so small impact, but we will see from your results!). Yes, good point – We have updated 'climate actions' to 'individual climate actions' throughout. We have also updated the introduction to make it clear that Schwartz et al. found that collective – but not individual – climate action appeared to moderate their results: "such adaptive behavioural responses – and in particular collective, as opposed to individual, climate actions – have been suggested to mitigate the negative aspects of climate anxiety (e.g., Schwartz et al., 2023)."

As an aside, while we would probably also anticipate collective action to have more of an impact on mental health/well-being than individual action, we feel there are a few limitations with the individual climate actions used by Schwartz. For instance, items such as 'I recycle' may not necessarily be for climate reasons, while 'I feel guilty if I waste energy' asks about feelings rather than actual behaviours. Our measures of individual climate action are of course far from perfect (as discussed below), but they do at least measure behaviours performed specifically for climate change reasons. This could produce different results from Schwartz et al. – Hopefully we'll find out shortly! We will discuss this in more detail in the Discussion section of our final paper.

- o The way the climate action survey question is framed worries me that it only captured occasional action (maybe done once), rather than recurring actions. This may confound your results: i.e. you may find no moderation effect of action for the people who did those actions only once and lightmindedly, while there may be a strong moderation effect for those who did the climate actions repeatedly and with strong change-making intentions (the type of action engagement that relieves people and prevents degeneration of concern into mental health). But mixing these participants up may water-down your moderation effect – maybe worth mentioning if you do not find one?
Yes, this is a legitimate concern. A few sentences on this have been added to the 'measurement error' section of the manuscript:

“We also note that our ‘individual climate actions’ effect modifier could be measured with error as the question asked whether participants had performed any of these actions, regardless of frequency (Table S1). This could lead to a dilution of any potential effect modification if, for instance, engaging repeatedly in these climate actions moderated the relationship between climate concern and mental health/well-being more compared to only performing these actions once; yet in these analyses both situations are impossible to separate and would be grouped together.”

- Power analysis. It is unclear what effect size metric you are using in your power analysis. There is only the number but not the effect size symbol...is it Cohen’s d ? Cohen’s f ? η^2 ? Partial η^2 ? This information determines how large/small an effect size of 0.25 is, and therefore how big of an effect size your study is powered to detect.
Apologies for this omission – We used standardized mean differences in these power analyses, which are comparable to Cohen’s d . This has now been added to the manuscript: “As these effect sizes are on the standardised mean difference scale, they are comparable to Cohen’s d effect sizes.”

- Another threat to causality that was not mentioned is that climate concern was not measured at age 25. If mental health was good at 25 (and climate concern, which was not measured, was low at 25), then climate concern high at 30, and mental health bad at 32, then you found your causal relationship (increase climate concern = worsen mental health). But if climate concern was already high at 25, and all the other variables kept the same, it might not be climate anxiety that changed mental health! In other words, for better causal inference you would need to see a change from low to high climate concern and a corresponding change from good to bad mental health. Now, the ALSPAC survey study was run, so there is not much to do about this (unless there was another time point at which climate concern was measured near the baseline period? But I imagine you already thought about this; if so maybe you could just mention this in your limitations?).
Yes, unfortunately age 30 was the first time-point in ALSPAC where climate change data were collected, so there is no prior data available. This has been added to the ‘Confounding’ section: “As ALSPAC has currently only asked the climate questions once, we are not able to adjust for prior climate concern, which could perhaps be a relevant confounder if it impacts both climate concern at age 30 and subsequent mental health (independent of prior mental health; VanderWeele, 2021).”

- One further question is about generalizability. The ALSPAC survey focuses only on Avon population, and it should be mentioned in the limitations that the results should not be assumed to necessarily apply to other cultures or locations.
This was going to be mentioned in the final paper, but we agree there is no harm in making these limitations to generalisability clear at this stage. This information has been added at the end of the ‘threats to causality’ section:

“As this sample is based on ALSPAC offspring born in the early 1990s in the Bristol/Avon area of south-west England, the extent to which results may be generalisable to the wider UK population – or beyond – is unclear. For instance, ALSPAC offspring are more ethnically homogenous compared to the wider UK population (~4% of ALSPAC offspring have an ethnicity other than White vs ~14% in the wider UK population) and are less likely to come from low income households (Boyd et al., 2013; Fraser et al., 2013). The extent to which

results would generalise to ages beyond those studied here (early 30s) is also unknown. Finally, we note that the city of Bristol is a very 'green' city, being the first in the UK to declare a Climate and Ecological Emergency (Bristol City Council, 2023) and one of the first to elect a Green Party member of parliament. It is possible that this could alter the relationship between climate concern and mental health, compared to other less 'green' areas; for instance, those concerned about climate change might have a larger social support network of like-minded individuals, potentially mitigating any impacts on mental health or well-being."

More stylistic notes:

- Page 3, line 79: APA citation style could be used to reference the news articles.
This has been updated.
- Page 3, line 85: "as summarized by Clayton and Coffey (Clayton, 2020; Coffey et al., 2021)"
This has been updated.
- Page 3, line 90: watch out for double parentheses, in the rest of manuscript as well
This has been checked and updated throughout.
- Page 5: I found the description of the sample quite redundant (like the information about the mothers and about the offspring stage of the participants), but maybe this is costume in developmental psychology (which is not my field of expertise). Either way, I would start the paragraph with "The current research focuses on the ALSPAC offspring generation;" as it is now, it seems that the sample was recruited just for this study.
We believe that this section provides useful background information on the ALSPAC cohort and study numbers (and is mandatory for all studies using ALSPAC data: <https://www.bristol.ac.uk/media-library/sites/alspac/documents/alspac-publications-checklist.pdf>). Either way, we have updated the section as suggested, starting with the sentence "The current research focuses on the ALSPAC offspring generation".
- It would help to state in the text the age window when the baseline variables were measured, at least for the well-being and mental health variables measured between age 21-25 (it took me a while to see that these were listed in Table 2, and having this info in the text would facilitate the immediate grasping of your cool longitudinal design!). Maybe you could add it in Fig. 1!
This has now been added to the 'Confounders' section in the Methods: "All confounders were measured prior to the exposure and outcome, with most measured in early adulthood (between 21 and 28 years of age), other than personality assessed at age 13 and parental variables assessed during the pregnancy of the study offspring or shortly afterwards (Table 2)."

As the baseline confounders and mental health/well-being variables come from a range of ages, we have decided not to include this information in Figure 1 to avoid complicating this figure further.

Resubmission of: Does concern regarding climate change impact subsequent mental health? A longitudinal analysis using data from the Avon Longitudinal Study of Parents and Children (ALSPAC) (PCI Registered Reports #793)

Response to Reviewer 2 (Esther Papies)

This is a very thoughtful proposal to use existing longitudinal data to address the question of whether climate change concern affects mental health measured at a later time. This will contribute very usefully to the ongoing debate whether concerns or anxiety about climate change occur in individuals who are already suffering from ill mental health, or whether they cause or exacerbate mental health problems, or both.

As the data have already been collected and it is not possible to change any aspect of the study except the planned analyses, this is a somewhat unusual registered report. If given the possibility, for example, I would have advised the authors to measure climate change concern also at T2, and to include other, validated measures of climate anxiety to assess validity. Given that this is not possible, I only have one suggestion about the analyses, and a few about the write-up – overall, I very much think this study should go ahead and be executed as planned, even though the available data cannot answer all the questions we may have on this topic. I also don't have state-of-the-art expertise on all the analyses proposed, esp regarding treatment of missing data and the interpretation of the resultant findings.

We thank the reviewer for the positive review and constructive feedback. We completely agree that it would have been preferable to have more control over what was measured and when, but unfortunately this is rarely possible when using secondary data. Nonetheless, we have made these limitations clear in our manuscript (including a lack of validated climate anxiety scales), and hope that our paper can make a useful contribution to the literature, despite some open questions remaining. We have responded to all comments in turn, with the reviewer's original comments in black font, and our responses in blue.

Throughout the manuscript (including figures and figure captions), I would suggest to change the phrasing of "... cause mental health". From my perspective, if you use the term "cause", then you would need to refer to a specific outcome (e.g., good mental health, mental health struggles). If you want to keep the directionality or valence open and simply refer to the domain (i.e., mental health), you might need to use a different term such as "affect" (e.g., "... affect mental health").

We respectfully disagree with this suggestion. From our perspective (with backgrounds in epidemiology and causal inference), 'cause' is agnostic regarding direction. We would prefer to keep the term 'cause' to be clear that the aim of this paper is causal inference (rather than terms such as 'affect', which could perhaps be interpreted differently). Of course, we may expect the causal relationship to be in a specific direction (e.g., climate concern causing worse mental health or well-being) – and note this throughout the paper – but would disagree that there is an issue with saying 'climate concern causes mental health' (for instance).

We have tried to clarify this in the introduction: "This makes it difficult to know whether climate anxiety does in fact cause subsequent mental health, and – if so – how best to support those with climate anxiety (note that, following standard practice in causal inference literature (Hernán & Robins, 2020), throughout this paper our use of 'cause' is agnostic regarding the direction of effect)."

For the final article, I would also advise including more subheadings to provide a clearer structure and overview for the reader, especially in the “Exposures” and “Analyses” sections. Related, the term “exposures” is unfamiliar to me in this context, could this section also be named “Measures”?

We have tried to provide more structure and subheadings in the Methods section to improve clarity. For instance, we have changed the ‘Exposures’ subheading to ‘Climate Concern Exposure’, created a new section for ‘Individual Climate Actions and Efficacy Effect Modifiers’ and changed ‘Outcomes’ to ‘Mental Health and Well-being Outcomes’. We are unclear how to further subdivide the ‘Analysis’ section, as this already includes sections for ‘Research question 1 – Main effect of climate concern’, ‘Research question 2 – Effect modification’, ‘Missing data’ and ‘Power analyses’, but would consider any specific recommendations.

Regarding our use of the term ‘Exposures’, this is again a term common in epidemiology and causal inference, as it specifically denotes the variable we are trying to estimate the causal effect of (akin to ‘independent variable’). In this context, ‘measure’ would appear too broad, as could include the exposure, outcome and confounders. Nonetheless, as noted above, to improve clarity and make it clear what the exposure is we have changed this to ‘Climate Concern Exposure’.

Finally, I would suggest including the variable of “having children” as an additional potential confounder (I assume this is available in the data). This life change may trigger new or increased worries about the future, but can also affect relationships and mental health especially in the perinatal period, so it would seem useful to control for this, especially in the age group available for the study.

Yes, this is a great suggestion, thanks! This has now been included in our updated manuscript (‘Confounders’ section and Table 2).