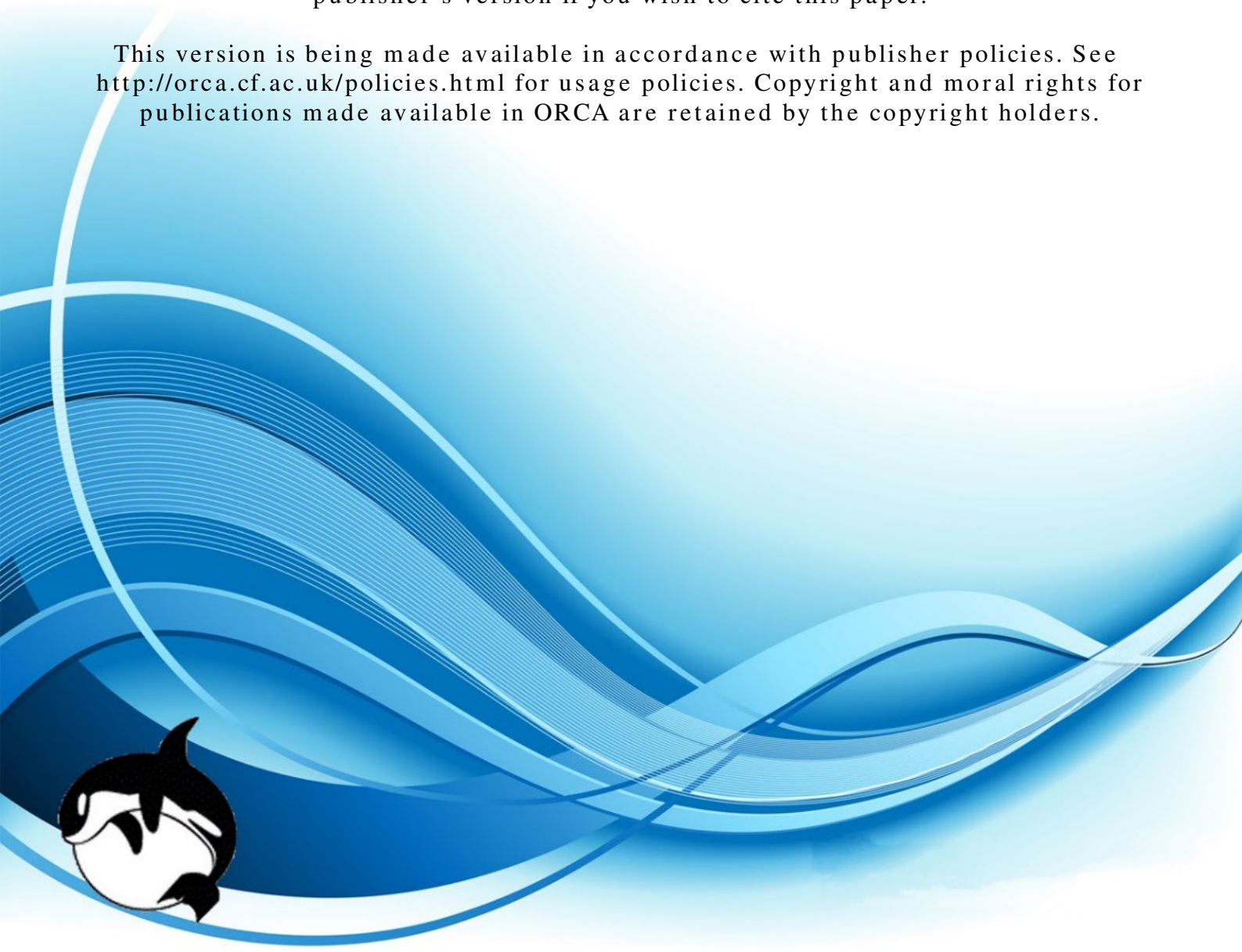

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The relationship between climate change and mental health information-seeking: a preliminary investigation

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Abstract

Purpose: Extreme weather events are known to be detrimental to well-being, and there is growing interest in anxiety connected to unfolding climate change. The purpose of this paper is to investigate the global association between information-seeking relating to climate change and mental health. Methodology: Using Big Data from Google searches and website traffic, evidence is presented that worldwide information-seeking for climate change and mental health-related terms are highly correlated. Regression analyses account for seasonal variation, which is known to influence online searches for mental health terms. Findings: There is an association between climate change and mental health-related information-seeking for the period of 2006-2020. This paper proposes causal models to account for the data, with future directions for how these could be tested. Value: This is the first paper to the author's knowledge to demonstrate a strong association between information-seeking for climate change and mental health, and highlights the importance of considering mental health issues in the era of rapid climate change.

1. Introduction

It is known that extreme weather events can erode the mental health of those who experience them; for example, the influence of hurricane Katrina on psychological distress in affected areas was still evident 12 years after the fact (Raker et al., 2019). Much of the research interrogating the link between climate change and mental health focuses on impacts arising from an array of national weather-related events, such as the mental health sequelae of flooding in the south of England (Reacher et al., 2004) and heatwaves in Australia (Hansen et al., 2008). Manning and Clayton's (2018) review of studies linking weather events to mental health outcomes considers not only acute events, but also the likely impact of chronic changes to the climate, noting, for instance, the harmful effect of high temperatures on suicide rates (e.g., Preti et al., 2007). Ebi et al. (2018) argue for the importance of collecting data with respect to indicators of health risks resulting from climate change, highlighting that mental health risks in particular are likely to be overlooked.

As media coverage of climate change increases (Watts et al., 2018), there are likely to be psychological implications. While understanding the gravity of climate change is a prerequisite for public and government action, it may also be a catalyst for mental health problems. One reason for this has to do with the inherent uncertainty in predicting the exact consequences of climate change (Deser et al. 2010) as well as the array of socio-political consequences that may result (Eriksen et al., 2015); this has consequences for anxiety, given the mental health conceptualisation of anxiety as resulting in part from uncertainty (Hirsch et al., 2012), and that difficulty in tolerating uncertainty is a transdiagnostic risk factor for mental health problems including depression and anxiety (Dugas et al., 2004; Carleton, 2012). Another implication is that facing up to human-caused environmental impacts may evoke feelings of guilt, e.g., with respect to the impact on non-human species (Swim & Bloodhart, 2015), as well as ecological grief (Cunsolo & Ellis, 2018). The concept of ecoanxiety is receiving increasing focus in the literature, with some preliminary empirical data to suggest that this might be a common experience; for example, a survey reported by Kelly (2017) found high levels of climate change-related anxiety in a student sample.

Researchers have used Google Trends data to look at search patterns for health, including mental health (see Nuti et al. [2014] for a review). Ayers et al. (2013) found seasonal patterns of Google searches for all included mental health terms, including anxiety, depression, bipolar disorder, and suicide, concluding that a plausible explanation for this time pattern was the influence of seasonal affective disorder. These authors highlight the advantages of analysing data such as Google search terms, which are arguably a more accurate reflection of a person's state of mind than methods that rely on retrospective accounts in which people report when their mental health experiences were at their worst (Blazer et al., 1998). Another way of sampling large amounts of non-self-report data on internet activity is looking at the volume of traffic to different websites. Hart and Leiserowitz (2009) used this method to investigate the association between interest in "global warming" (as measured by traffic to relevant websites) and the release of the blockbuster film about the impact of climate change - "The Day After Tomorrow". Data on the frequency of Google search terms and website traffic over time could be considered particularly suitable for addressing questions relating to population mental health, both given their ease of extraction and as such data are presumably less subject to the social desirability bias which is known to operate on survey data for sensitive topics (Krumpal, 2013).

The present study addresses a heretofore unanswered question: is global concern about climate change associated with global concern about mental health? To investigate this, three main hypotheses are tested: that climate change and mental health-related Google Trends search data are correlated; that there is a unique association beyond the effect of seasonality on mental health searches; that these searches are correlated with traffic to climate change and mental health-related websites, as this would indicate that Google searches for these terms are a reliable reflection of information-seeking activity.

2. Methods

Worldwide Google Trends data for the search terms to be compared for the main analysis were extracted from http://www.google.com/trends on 21.06.2020. Only English language search terms were included, returning worldwide data only for searches conducted in this language. The broad search terms used in previous Google Trends research relating to manmade environmental change have been "Climate Change" and "Global Warming" (e.g., McCallum & Bury, 2013; Lang, 2014). Anderegg and Goldsmith (2014) noted the temporal concordance of terms such as "Global Warming" with other climate-related terms (such as "Greenhouse Gases"). The author was also aware of "Greenhouse Effect" as another popular term, but Google Trends searches revealed that this third term is used far less commonly than the other two. Previous research has also included more specific terms (such as "drought" and "flood"; Kam et al., 2019; Lang, 2014). Given this study's focus on concern with general climate change, the decision was made not to include searches for specific environmental concerns and to include only searches for "Climate Change" and "Global Warming".

The author decided that "Mental Health" would be an appropriate term due to this study's interest in the broad area of climate change and mental health, and this is a term that has been used previously in similar studies (e.g., Ayers et al., 2013). Ayers et al. also used a range of other, more specific terms, including "Bipolar Disorder" and "Anorexia". Of these, "Depression" and "Anxiety" were chosen as search terms for additional analyses in the present study given that they refer to the most common mental health problems that people are likely to experience (National Institute of Health and Care Excellence; NICE, 2011). Google Trends data were extracted to provide relative frequencies of search terms with respect to another search term. Intervals between data points depend on the length of the period from which data are extracted (monthly for data extracted for the period of 2006 – 2020; weekly for data extracted for yearly timespans; daily for data extracted over a 3 month period).

Data for website traffic volume (from Mobile and Desktop devices) were from SimilarWeb (http://www.similarweb.com) for two websites providing mental health-related information/services

and two websites providing information on climate change, in order to investigate whether these would be correlated with Google Trends data. Data were extracted to represent website traffic between 1st March 2020 and 31st May 2020, as this was the most recent 3-month span of data available on the date of extraction (28.06.2020). Data from the same time-period for relative search frequencies for "Climate Change" and "Mental Health", and for "Global Warming" and "Mental Health", were also extracted.

Four websites were chosen in total: two providing information/help relating to mental health and two providing information on climate change. The mental health websites were chosen by looking at SimilarWeb for websites within this category with the highest share of the traffic volume. Table 1 shows the top rankings and the reasons for including/excluding each website. While there was no category of website for "Climate Change", two climate change websites were chosen for the following reasons (see Table 1).

Table 1. Websites, their SimilarWeb ranking on 28.06.2020, and reasons for including/excluding each in analyses. Insights by SimilarWeb

Website	SimilarWeb Ranking	Outcome & Reason
Mental Health		
Psychologytoday.com	1	*Excluded.* This website was found not to be exclusively mental health-related.
Doxy.me	2	*Excluded.* This website was found to provide telemedicine solutions.
Verywellmind.com	3	*Excluded.* This website was found not to be exclusively mental health-related.
Psychcentral.com	4	***Included.*** This website was deemed to have a mental health focus, with a list of mental health conditions and links to articles relating to each on its front page.
Simplepractice.com	5	*Excluded.* This was found to be a website providing information on how to build a private practice.
Psychologies.ru	6	*Excluded.* This website was written in Russian and its content could not be verified.
Betterhelp.com	7	***Included.*** This website provides mental health support as it is a counselling service.
Climate Change		
climate.nasa.gov	N/A	***Included.*** This was the first result in a Google search for "Climate Change" (on 28.06.2020), and it was

		found to have a high volume of traffic according to SimilarWeb.
ipcc.ch (Website of the International Panel for Climate Change)	N/A	***Included.*** This was the second result of a Google search (on 28.06.2020), and it was found to have a high volume of traffic according to SimilarWeb.

The four chosen websites were psychcentral.com, betterhelp.com, climate.nasa.gov, and ipcc.ch.

Analyses were conducted using RStudio (RStudio Team, 2020) and SPSS Version 25 (IBM Corp, 2017).

3. Results

3.1 Correlations between Google Trends results for climate change and mental health-related terms

Data for the search terms "Climate Change", "Global Warming", and "Mental Health" all showed significant deviations from normality in their Q-Q plots. In view of this, non-parametric correlations between weekly search frequencies of the search terms was conducted for these years. All correlations were significant, except for "Global Warming" and "Mental Health" in 2006 (see Table 2).

Table 2. Spearman correlations (ρ) between Google Trends data for "Mental Health" (MW) and 1. "Climate Change" (CW) 2. "Global Warming" (GW), by year (from 1st January 2006 – 21st June 2020).

	Year														
	'06	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**	**'14**	**'15**	**'16**	**'17**	**'18**	**'19**	**'20**
MH and CC	.28*	.46**	.56**	.40**	.74**	.59**	.57**	.72**	.65**	.72**	.76**	.54**	.69**	.74**	.56**
MH and GW	-.04	.63**	.68**	.47**	.71**	.62**	.49**	.72**	.64**	.65**	.73**	.42**	.64**	.76**	.49*

*Note. N (per year) = 52. **p < .01; *p < .05.*

To test the generalisability of the association to other mental health-related searches, Spearman correlations were conducted between monthly Google searches for "Depression" and "Anxiety" separately for "Climate Change", and then for "Global Warming", from 1st January 2006 – 2nd June

2020 (data extracted on 02.07.2020). All correlations were found to be significant and in a positive direction, except for that between searches for "Anxiety" and "Global Warming", which showed a negative correlation (see Table 3.)

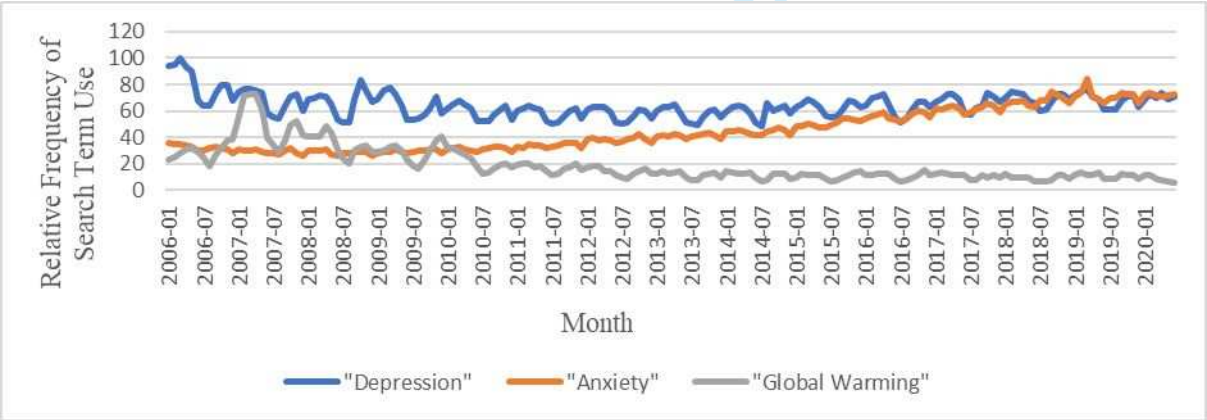
Table 3. Spearman correlations between variables.

		1	2	3	4
1	**Searches for "Depression"**				
2	**Searches for "Anxiety"**	.19*			
3	**Searches for "Climate Change"**	.53**	.21**		
4	**Searches for "Global Warming"**	.20**	-.81**	.20**	

*Note. N = 175. **p < .01; *p < .05.*

To inspect the nature of the negative correlation between "Anxiety" and "Global Warming", Figure 1 was generated, which indicates a downward trend in searches for "Global Warming" and, over the same period, an upward trend in searches for "Anxiety", whereas "Depression" searches appear more stable on average over time.

Figure 1. Monthly searches for "Depression", "Anxiety", and "Global Warming" from 01.01.2006 to 02.06.2020.



3.2 Inspecting the reliability of Google Trends data as reflective of online information-seeking

Daily traffic volumes of all four websites were found to be significantly correlated with each other and with Google search frequency for both "Climate Change", "Global Warming", and "Mental Health" (see Table 4).

Table 4. Spearman correlations between variables.

		1	2	3	4	5	6	7
1	**Searches for "Climate Change"**							
2	**Searches for "Global Warming"**	.92**						
3	**Searches for "Mental Health"**	.85**	.81**					
4	**psychcentral.com traffic**	.53**	.48**	.60**				
5	**betterhelp.com traffic**	.43**	.43**	.47**	.39**			
6	**climate.nasa.gov traffic**	.60**	.55**	.66**	.59**	.38**		
7	**ipcc.ch traffic**	.59**	.59**	.66**	.60**	.65**	.61**	

Note. $N = 92$. $^{**}p < .01$.

3.3 Regression analyses controlling for seasonality

Weekly search frequency data from 1st January 2006 – 21st June 2020 were compiled into one dataset. Data were visually inspected using Q-Q plots and residuals were deemed approximately normal. A preliminary regression was conducted with Google Trends searches for "Climate Change" as a predictor of Google Trends searches for "Mental Health", which was found to be significant, $F(1, 754) = 223.15$, $p < .01$, $R^2 = .23$.

Weekly search data were then categorised by season (Winter: December – February; Spring: March – May; Summer: June – August; Autumn: September – November). The category of "Season" was transformed into three dummy variables to represent Spring, Summer, and Autumn, which were each entered into a regression model in addition to Google Trends relative search volumes for "Climate Change". Inputting these dummy variables allowed a regression model to be computed comparing

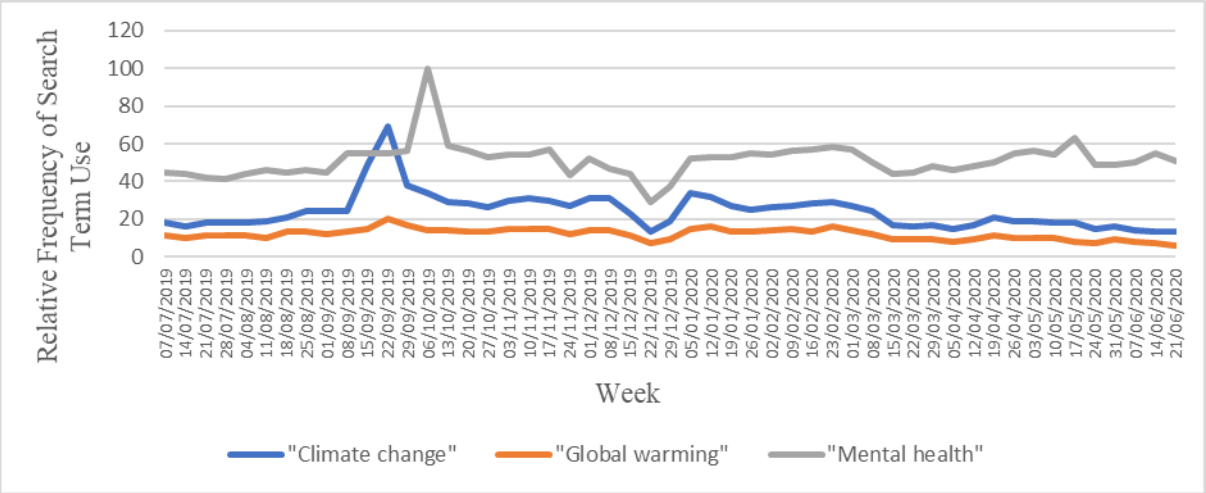
Google Trends searches for "Mental Health" in Winter as a baseline (as the first month in a calendar year) with the other three months. The tested model was therefore Y = "Climate Change" search frequency + Spring + Summer + Autumn. This model was found significantly to predict Google Trends searches for "Mental Health", $F(4, 751) = 59.78$, $p < .01$, $R^2 = .24$. All four predictors explained unique variance in the model, ($p < .01$ for searches for "Climate Change" and "Spring"; $p < .05$ for "Summer" and "Autumn").

Regression analyses were repeated for "Global Warming" and "Mental Health" search terms. As residuals deviated from a normal distribution on visual inspection, bias-corrected accelerated 95% confidence intervals (BCa 95% CI) were obtained (with 2000 bootstrap replications). "Global Warming" was a significant predictor of "Mental Health", $F(1, 754) = 25.22$, $p < .01$, $R^2 = .03$. When the three seasons were included as dummy variables, the model was found significantly to predict Google Trends searches for "Mental Health", $F(4, 751) = 12.11$, $p < .01$, $R^2 = .06$. "Global Warming" searches explained unique variance in the model ($p < .01$; BCa 95% CI: .05 to .18), as did Spring ($p < .01$; BCa 95% CI: 1.81 to 9.13) and Autumn ($p < .01$; BCa 95% CI: 2.27 to 9.37). Summer did not predict unique variance in the model ($p = .89$; BCa 95% CI: -3.7 to 3.30).

3.4 Inspecting visual patterns

To inspect visual patterns in searches for "Climate Change", "Global Warming", and "Mental Health", weekly trends were extracted (by extracting data for year-long periods), as these were found to show the clearest visual peaks. An example of a graph of 07.07.2019 – 21.06.2020 (the most recent year-span data available on the date of extraction; 01.07.2020) is shown in Figure 2.

Figure 2. Weekly searches for "Mental Health" and "Climate Change" from 07.07.2019 to 21.06.2020.

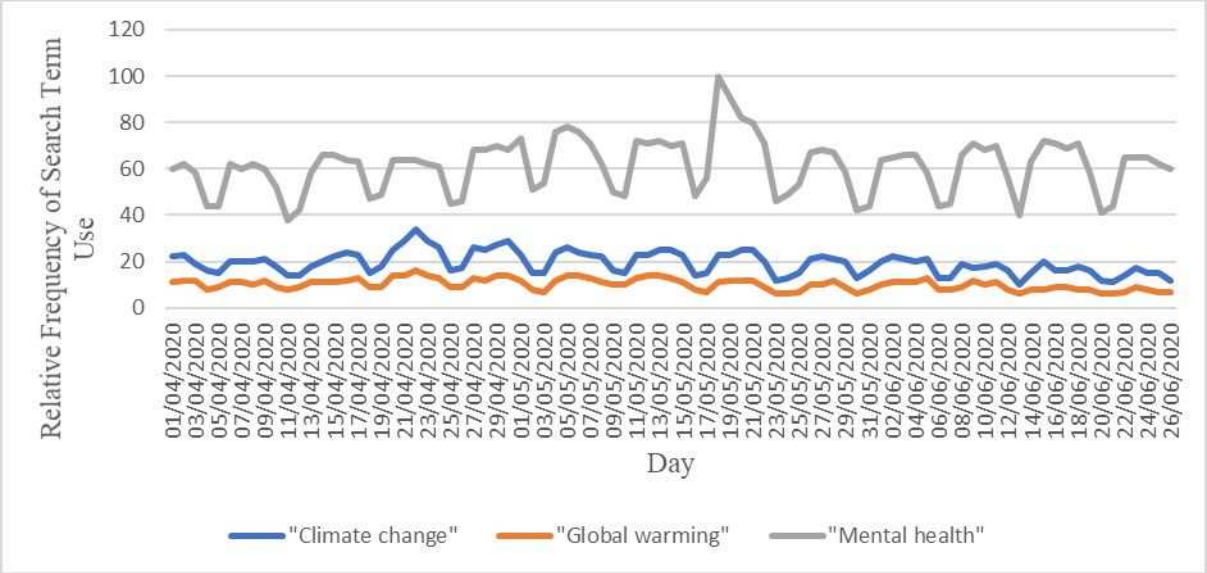


The peak in "Mental Health" searches happens from October 6 – 12, 2019; this is a regular peak in previous years. Google searches for "Mental Health October" revealed that October 10 is World Mental Health Day.

The peak in "Climate Change" searches happens from 22 – 28 September, 2019. Separate searches on Google for "Climate Change" and "Global Warming" within this date range found websites referring to the 2019 UN Climate Action Summit taking place in New York on 23 September. A search for "Climate Change" on the New York Times website within this date range revealed two articles whose titles referred to this summit, one article referring to this week being "Climate Week" in New York, and one article whose title referenced a report by the UN: "The World's Oceans Are in Danger, Major Climate Change Report Warns" (Plumer, 2019).

Extracting data from Google Trends over a 3 month period allows for daily patterns to be seen. The most recent three months of data (April 1 2020 to June 26 2020) available on the date of extraction for "Climate Change", "Global Warming", and "Mental Health" were extracted (see Figure 3).

Figure 3. Daily searches for "Mental Health" and "Climate Change" from 01.04.2020 to 26.06.2020.



The peaks in the graph take place consistently from Monday – Friday, and the troughs are consistently from Saturday – Sunday.

To summarise, significant correlations were found between searches for "Climate Change" and "Mental Health", and between "Global Warming" and "Mental Health" for every year from 2006 – 2020 (with the exception of a non-significant correlation between "Global Warming" and "Mental Health" in 2006). Seasonality predicted "Mental Health" searches but did not account for the association between "Climate Change"/"Global Warming" and "Mental Health" searches. All mental health and climate change website traffic volumes were significantly correlated with each other and with searches for these terms. "Depression" and "Anxiety" searches were found to be significantly correlated with both "Climate Change" and "Global Warming"; these correlations were positive, with the exception of the correlation between "Anxiety" and "Global Warming", which was negative.

4. Discussion

This study is the first to provide evidence that there is an association between online information-seeking for climate change and mental health- related terms and that this cannot be accounted for by seasonality. Searches for "Climate Change" explained more of the variance in searches for "Mental

Health" than did those for "Global Warming", which may be due to the general decline in searches for the latter as indicated in Figure 1 (and as noted by McCallum and Bury, 2013). Another interesting anomaly is that searches for "Anxiety" were negatively correlated with searches for "Global Warming" from 2006 - 2020. Figure 1 suggests that this may be due to the concomitant rise in searches for "Anxiety" and decline in searches for "Global Warming" since 2006.

The analyses reported in this study are limited to online information-seeking, and therefore cannot be generalised to understanding any link between climate change concern and mental health more broadly. This study also does not allow for firm conclusions to be drawn about the reasons for the observed associations in the data. There are, nonetheless, two broad causal models that deserve consideration. The first is that concerns about climate change exacerbate mental health. Researchers have demonstrated that news reports are the principal source of indirect information and knowledge about climate change (e.g., Willox et al., 2015) and Nghiem, Papworth, Lim, and Carrasco (2016) showed that climate change-related news items are correlated with web searches for climate change. Fritze, Blashki, Burke, and Wiseman (2008) posit that factors such as editing of news items and how they are framed will influence responses to the information, and it is plausible that worry and distress resulting from these news items lead to mental health-related internet searches. Powell and Clarke (2006) found a significant correlation between past and current mental health problems and using the internet to search for mental health terms, which raises the possibility that climate change news may increase the mental health-related Google searches of those who already have a history of, or current, mental health difficulties. However, there is little in the present study's data to support this; the peaks in Figure 2 can be attributed to separate world events, according to Google searches and New York Times articles. It is also difficult to explain how, if the Climate Change Summit / Week in New York somehow exacerbated global mental health concerns, why it would take weeks for the corresponding peak to appear in "Mental Health" searches. One way of elucidating these possibilities would be to analyse time sequences of big international climate change news items and internet searches for climate change and mental health-related terms.

Another causal model is that population-level declines in mental health trigger more ecoanxiety, leading to searches for information about climate change. The data (Figure 3 in particular) are potentially consistent with this model: daily searches for these terms appear contemporaneous, and with clear weekday/weekend patterns. One possibility is that a decline in mood at the start of the week and its improvement on the weekend (linked to work patterns) triggers concurrent searches for mood-congruent material; indeed, it is known that mental health problems are associated with cognitive biases toward threatening information (see Goodwin, Yiend, & Hirsch [2017] for a review pertaining to generalized anxiety disorder). A mood induction study would clarify this possibility, in which internet searches for climate change-related sites is compared for those induced to have either an anxious, dysphoric, or neutral mood (see Vanderveren et al., 2020, for a recent example of this procedure). The data do not allow for deciding between these two causal models at present, including the possibility of a bidirectional, reciprocal relationship between climate change concern and mental health concern.

5. Conclusions

The data presented in this paper point to the need for clarification around the nature of the relationship between internet information-seeking for climate change and mental health-related terms and the most likely causal model(s) to account for the observed associations. While ecoanxiety can be conceptualised as a response to climate change, the current study highlights the additional possibility that ecoanxiety fluctuates with the population's mental health. The data also reinforce the assertion of Hayes et al. (2018) that "An updated overview of recent evidence on the mental health implications of climate change is timely given the ongoing, rapid expansion of research in the broad field of health and climate change as well as increasing public concern about climate change trends and risks" (p. 2). Berry et al. (2018), in their argument for a systems approach to understanding the impact of climate change on mental health, provide an example illustration of interacting socio-economic consequences of one extreme climate event - drought - and its various possible ramifications for mental health and

suicide. The current study suggests that information-seeking about climate change and mental health might be another part of the system that needs to be better understood.

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Article Title Page

[The relationship between climate change and mental health information-seeking: a preliminary investigation]

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Structured Abstract:
Purpose: Extreme weather events are known to be detrimental to well-being, and there is growing interest in anxiety connected to unfolding climate change. The purpose of this paper is to investigate the global association between information-seeking relating to climate change and mental health. Methodology: Using Big Data from Google searches and website traffic, evidence is presented that worldwide information-seeking for climate change and mental health-related terms are highly correlated. Regression analyses account for seasonal variation, which is known to influence online searches for mental health terms. Findings: There is an association between climate change and mental health-related information-seeking for the period of 2006-2020. This paper proposes causal models to account for the data, with future directions for how these could be tested. Value: This is the first paper to the author's knowledge to demonstrate a strong association between information-seeking for climate change and mental health, and highlights the importance of considering mental health issues in the era of rapid climate change.

Keywords: Mental health; Climate change; Ecoanxiety; Google Trends; Website traffic

Article Classification: Original Research Paper

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