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Exposure to Climate Events and Mental Health: Risk and Protective Factors from the California Health Interview Survey

Short Title: CLIMATE EVENTS AND MENTAL HEALTH IN CHIS

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Abstract

There is increasing awareness of the effects of climate change on mental health, but more work on understanding risk and protective factors is needed. The 2021 California Health Interview Survey included new questions about exposure to extreme weather events and mental health responses. This study aims to identify how individual factors and neighborhood social cohesion are associated with negative mental health effects of exposure to extreme weather events. In this cross-sectional, representative study, we used data from the 2021 California Health Interview Survey to analyze the association between respondent characteristics and negative mental health effects following exposure to extreme weather events. Univariate and multivariate logistic regression models were used, adjusting for individual-level sociodemographics and measures of neighborhood social cohesion. We found that 53% of the sample was affected by climate events (n = 12,955), and of these, 22.8% (n = 2,955) reported a negative impact on their mental health. Respondents who were younger, White, female, college-educated, or living in a rural area were more likely to report adverse mental health effects of climate events for themselves or household members. Individuals who had experienced property damage were much more likely to report negative mental health effects due to climate events [property damage adjusted OR 3.73, 95% CI 2.82-3.76]. This study identifies subgroups that may have higher vulnerability to the mental health effects of climate change events. Future research is needed to develop targeted prevention and outreach interventions these subgroups to build individual- and community-level resilience.

Keywords: mental health, climate change, extreme weather

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Introduction

Climate change is the defining public health crisis of the 21st century, with both direct and indirect effects on mental health [1]. Directly experiencing extreme weather events (e.g., hurricanes, wildfires, and floods) has been linked to elevated levels of anxiety, depression, and post-traumatic stress disorder [2]. Chronic climate change events, such as sea level rise and drought, have also been associated with an increase in mental health issues, from psychological distress to suicide risk [2,3]. Climate change also has indirect effects on mental health by leading to threats to one's livelihood, such as economic loss, displacement, and migration, which can have profound consequences for mental well-being [4,5].

In addition, there is an increasing understanding of the mental health effects of climate change from a health equity lens. Climate change amplifies existing disparities in access to healthcare along racial, ethnic, gender, and socioeconomic lines, with low-income and racially/ethnically minoritized groups at the greatest risk of health harms from climate change despite typically contributing the least to greenhouse gas emissions [6,7]. Children and adolescents also appear to experience a disproportionate burden of mental health consequences, reporting increased levels of anxiety and depression from the existential threat of climate change compared to adults [8]. In a large 2021 survey of youth across ten different countries, 59% of respondents said that they were either very or extremely worried about climate change and experienced feelings of betrayal due to inadequate government response [9].

However, many questions remain unanswered regarding individual and community factors affecting climate change-related mental health outcomes. Previous survey studies on climate change and mental health have either focused on a single acute climate disaster, such as

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Hurricane Katrina [10,11], or required linking meteorological and behavioral health datasets [12–14) and inferring causal effects. The focus on an isolated climate disaster can address mental health responses to a specific localized weather event, and data linkages can reveal important timescale and geolocated effects. However, these studies often do not capture how respondents are personally affected by climate events, such as experiencing damage to one's home. In addition, the emphasis on an acute climate disaster does not reflect how mental health is affected by chronic climate change, which is characterized by gradual change with multiple events and fluctuations in severity over time [11,15]. Finally, less attention has been paid to the impact of climate change on mental health in the setting of community factors, such as social cohesion and trust in one's community, which may serve as buffers to distress and represent opportunities to support collective psychosocial resilience [16].

To address these gaps, we utilized data from the California Health Interview Survey (CHIS), a state-level survey with over 24,000 respondents [17]. We examined a new set of questions included in the 2021 CHIS, which asked respondents whether they had experienced extreme weather events and whether their mental health or the mental health of household members had been adversely affected by these events. To our knowledge, this is the first state-wide panel survey that directly asks about climate change-related mental health effects, providing normative state-wide data on climate-related distress levels from a large, diverse sample of respondents. In addition, this survey is notable for capturing data from a state that has shouldered a significant burden of climate events, including wildfires and floods, in recent years, particularly 2020 and 2021 [18,19], roughly the past two years that the survey assessed. This analysis aims to address previous gaps in the literature on mental health effects of climate change by incorporating CHIS-

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specific data on risk factors, such as property damage, and on protective factors, such as social cohesion, into modelling the effects of climate change on mental health.

Materials and Methods

Data and Study Population

This was a cross-sectional analysis of data from the 2021 California Health Interview Survey, or CHIS [https://healthpolicy.ucla.edu/chis/Pages/default.aspx]. CHIS, the country's largest state health survey, used multistage geographic stratification and random-digit dialing via landline and cell phone to interview California households in English, Spanish, Mandarin, Cantonese, Korean, Vietnamese, and Tagalog [17]. Data collection began March 18, 2021 and ended December 31, 2021. Participants ages 18 and older were included in this study. The 2021 data contained new questions on exposure to extreme weather events and the impact of these events on mental health. All measures were self-reported except where explicitly noted.

Ethics Statement: This study did not required Institutional Review Board approval at the University of California, San Francisco because it used de-identified data, which does not meet the definition of human subjects research.

Measures

For the main analysis, the primary outcome was the negative effect of climate change on mental health, which was measured in a two-part question (see **Appendix** for details). Respondents were asked, "The next set of questions are about potentially hazardous weather-related events that are

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increasing in California, including extreme heat waves, flooding, wildfires, smoke from wildfires, and the public safety power shutoffs of electricity to prevent a wildfire. In the past two years, have you or members of your household personally experienced any of these events?" Respondents who marked yes were then asked, "Was your mental health (or the mental health of members of your household) harmed by any of these events?".

Covariates

We evaluated the association between the adverse effects of climate change events on mental health and predictor variables of age (ages 18 - 29, 30 - 39, 40 - 49, 50 - 64, older than 65), sex (male, female), marital status (married, never married, other/separated/divorced/living with partner), race/ethnicity (African American Non-Hispanic, American Indian/Alaskan Native NH, Asian NH, White NH, Hispanic, Other), proficiency in English (speak only English, not well/not at all, very well/well), education level (college degree or above, some college, high school education, < high school education), percent of federal poverty level (300% FPL or above, 200 - 299% FPL, 100 - 199% FPL, 0-99% FPL), urbanicity (urban, suburban, mixed, rural), damage to property (no, yes), current housing situation (very unstable, fairly unstable, somewhat unstable, fairly stable, very stable), trust in neighbors (strongly disagree, disagree, agree, strongly agree), feeling safe in neighborhood (all the time, most of the time, some of the time, none of the time), willingness to help neighbors (strongly disagree, disagree, agree, strongly agree), and volunteered in the past 12 months (no, yes). These predictor variables were also used as covariates in the multivariate regression models and were selected based on prior literature suggesting that they may mediate the association between climate change and mental health.

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Statistical Analyses

We used univariate logistic regression models to evaluate the odds of answering "YES" to the question "Was your mental health (or the mental health of members of your household) harmed by any of these [extreme weather] events?" based on individual-level factors. We then used multivariate logistic regression models to assess the impact of climate events on mental health, adjusting for covariates (age, sex, race/ethnicity, marital status, English proficiency, education, poverty level, current housing situation, urbanicity, trust in neighbors, feeling safe in neighborhood, willingness to help neighbors, and volunteered in the past 12 months). All analyses incorporated survey weights supplied by CHIS to account for the sampling design and generate accurate variance estimates [20]. Two-sided $p < 0.05$ was considered statistically significant. All analyses were performed using R 4.2.2.

Results

This study included 24,453 respondents. Of these, 11,498 (47.0%) said they were not affected by climate events and were thus removed from the subsequent analyses. Of the remaining 12,955 respondents (53.0%), 2,955 (22.8%) reported that their mental health was harmed by climate events. These respondents were more likely to be younger, White, female, college-educated, proficient in English, and residing in rural areas (see **Table 1**).

Table 1 - Characteristics of respondents to the question, "Was your mental health (or the mental

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health of members of your household) harmed by any of these [extreme weather] events?"
Source: CHIS 2021

	NO (N=10000)	**YES (N=2955)**
Age		
18-29 Years	865 (69.9%)	372 (30.1%)
30-39 Years	1275 (67.5%)	613 (32.5%)
40-49 Years	1449 (73.0%)	537 (27.0%)
50-64 Years	3323 (78.8%)	895 (21.2%)
65 or older	3088 (85.2%)	538 (14.8%)
Ethnicity		
White, non-Hispanic	5863 (74.7%)	1987 (25.3%)
African American, non-Hispanic	339 (86.7%)	52 (13.3%)
American Indian/Alaskan Native, non-Hispanic	73 (73%)	27 (27%)
Asian, non-Hispanic	1405 (85.7%)	235 (14.3%)
Hispanic, non-Hispanic	1876 (79.6%)	480 (20.4%)
Other	444 (71.8%)	174 (28.2%)
Sex		
Male	4520 (81.4%)	1031 (18.6%)
Female	5478 (74.0%)	1922 (26.0%)
Marital Status		
Never Married	1930 (73.2%)	706 (26.8%)
Married	5102 (80.1%)	1267 (19.9%)
Other/Sep/Div/Living W/Partner	2968 (75.1%)	982 (24.9%)
English Proficiency		
Not Well/Not At All	236 (87.4%)	34 (12.6%)
Very Well/Well	2336 (81.3%)	539 (18.7%)

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	NO (N=10000)	YES (N=2955)
Speak Only English	7428 (75.7%)	2382 (24.3%)
Education		
< High School Education	252 (81.8%)	56 (18.2%)
High School Education	1025 (82.5%)	217 (17.5%)
Some College	2769 (78.5%)	759 (21.5%)
College Degree or Above	5954 (75.6%)	1923 (24.4%)
Poverty Level		
0-99% FPL	734 (72.7%)	275 (27.3%)
100-199% FPL	1073 (73.5%)	387 (26.5%)
200-299% FPL	1087 (76.8%)	328 (23.2%)
300% FPL and Above	7106 (78.3%)	1965 (21.7%)
Urbanicity		
Urban	3288 (78.0%)	930 (22.0)
Suburban	3598 (79.6%)	924 (20.4%)
Mixed	991 (78.9%)	265 (21.1%)
Rural	2123 (71.7%)	836 (28.3%)
Property Damage		
No	9459 (79.5%)	2436 (20.5%)
Yes	541 (51.0%)	519 (49.0%)
Housing Stability		
Very Unstable	120 (60.6%)	78 (39.4%)
Fairly Unstable	205 (64.7%)	112 (35.3%)
Fairly Stable	2196 (73.1%)	807 (26.9)
Somewhat Stable	785 (69.2%)	350 (30.8%)
Very Stable	6694 (80.6%)	1608 (19.4%)

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	NO (N=10000)	YES (N=2955)
Trusts Neighborhood		
Strongly Disagree	206 (65.8%)	107 (34.2%)
Disagree	1152 (70.1%)	491 (29.9%)
Agree	6970 (78.3%)	1926 (21.7%)
Strongly Agree	1670 (79.6%)	429 (20.4%)
People In Neighborhood Willing To Help Each Other		
Strongly Disagree	192 (63.6%)	110 (36.4%)
Disagree	1137 (73.8%)	404 (26.2%)
Agree	6183 (77.4%)	1809 (22.6%)
Strongly Agree	2486 (79.8%)	630 (20.2%)
Volunteered In Past 12 Months		
No	8615 (78.7%)	2327 (21.3%)
Yes	1385 (68.6%)	628 (31.2%)
Feels Safe In Neighborhood		
None of the Time	79 (60.3%)	52 (39.7%)
Some of the Time	651 (68.9%)	294 (31.1%)
Most of the Time	5505 (75.3%)	1805 (24.7%)
All of the Time	3763 (82.4%)	802 (17.6%)

Unadjusted and adjusted odds ratios from logistic regressions modelling the effects of climate events on mental health are presented in **Table 2**.

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Table 2 – Unadjusted and adjusted odds of responding "yes" to the question, "Was your mental health (or the mental health of members of your household) harmed by any of these [extreme weather] events?"
Source: CHIS 2021. **Notes:** [1] OR = Odds Ratio, CI = Confidence Interval

Characteristic	Unadjusted OR	Adjusted OR[1]	95% CI[1]	p-value
Age				
65 or Older	—	—	—	
50-64 Years	1.55***	1.39***	1.23, 1.59	<0.001
40-49 Years	2.13***	1.90***	1.63, 2.22	<0.001
30-39 Years	2.76***	2.26***	1.94, 2.64	<0.001
18-29 Years	2.47***	1.84***	1.53, 2.22	<0.001
Race/Ethnicity				
White, Non-Hispanic	—	—	—	
African American, Non-Hispanic	0.45***	0.38***	0.27, 0.53	<0.001
American Indian/Alaskan Native, Non-Hispanic	1.09	0.96	0.58, 1.55	0.9
Asian, Non-Hispanic	0.49***	0.52***	0.43, 0.61	<0.001
Hispanic, Non-Hispanic	0.75***	0.68***	0.59, 0.78	<0.001
Other	1.16	0.80*	0.65, 0.98	0.036
Sex				
Male	—	—	—	
Female	1.54***	1.27***	1.15, 1.39	<0.001
Marital Status				
Married	—	—	—	
Never Married	1.47***	1.05	0.92, 1.20	0.5
Other/Sep/Div/Living W/Partner	1.33***	1.14*	1.02, 1.27	0.022

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English Proficiency				
Not Well/Not At All	—	—	—	
Very Well/Well	1.60*	1.08	0.72, 1.65	0.7
Speak Only English	2.23***	1.47	0.98, 2.26	0.068
Education				
< High School Education	—	—	—	
High School Education	0.95	0.91	0.63, 1.32	0.6
Some College	1.23	1.17	0.83, 1.67	0.4
College Degree or Above	1.45*	1.65**	1.17, 2.36	0.005
Poverty Level				
0-99% FPL	—	—	—	
100-199% FPL	0.96	1.02	0.83, 1.25	0.8
200-299% FPL	0.81*	0.92	0.75, 1.14	0.5
300% FPL And Above	0.74***	0.89	0.74, 1.06	0.2
Urbanicity				
Urban	—	—	—	
Suburban	0.91	1.02	0.91, 1.14	0.8
Mixed	0.95	0.95	0.80, 1.13	0.6
Rural	1.39***	1.46***	1.28, 1.66	<0.001
Property Damage				
No	—	—	—	
Yes	3.73***	3.26***	2.82, 3.76	<0.001
Housing Stability				
Very Stable	—	—	—	
Fairly Stable	1.53***	1.18**	1.06, 1.32	0.004
Somewhat Stable	1.86***	1.32**	1.12, 1.56	0.001

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Fairly Unstable	2.27***	1.26	0.96, 1.66	0.1
Very Unstable	2.71***	1.39	0.98. 1.97	0.061
People In Neighborhood Willing To Help Each Other				
Strongly Disagree	—	—	—	—
Disagree	0.62***	0.77	0.56, 1.05	0.10
Agree	0.51***	0.88	0.65, 1.20	0.4
Strongly Agree	0.44***	0.80	0.58, 1.11	0.2
Trusts Neighborhood				
Strongly Disagree	—	—	—	
Disagree	0.82	1.10	0.80, 1.52	0.6
Agree	0.53***	0.96	0.69, 1.33	0.8
Strongly Agree	0.49***	1.16	0.82, 1.65	0.4
Feels Safe In Neighborhood				
None of the Time	—	—	—	—
Some of the Time	0.69*	0.85	0.55, 1.34	0.5
Most of the Time	0.50***	0.82	0.53, 1.29	0.4
All of the Time	0.32***	0.65	0.41, 1.03	0.062
Volunteered In Past 12 Months				
No	—	—	—	—
Yes	1.68***	1.55***	1.38, 1.75	<0.001

Respondents aged 18 – 29 years (adjusted OR: 1.84, 95% CI 1.53 – 2.22), 30 – 39 years (aOR; 2.26 95% CI 1.94 - 2.64), 40 – 49 years (aOR: 1.90 95% CI 1.63 – 2.22), and 50 – 64 years

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(aOR: 1.39, 95% CI 1.23 – 1.59) were all more likely to report adverse mental health effects due to climate events than respondents aged 65 years and above in both univariate and multivariate models.

Compared to White respondents, those who identified as African-American (aOR: 0.38, 95% CI 0.27-0.53), Asian (aOR: 0.52, 95% CI 0.43-0.61), or Hispanic (aOR: 0.68, 95% CI 0.59-0.78) were less likely to report negative mental health effects of climate events. Additionally, female respondents had higher odds of their mental health being affected by climate events compared to male respondents (aOR: 1.27, 95% CI 1.15-1.39).

Respondents who obtained a college degree or above were more likely to report negative mental health due to climate change events compared to respondents who completed less than a high school education (aOR: 1.65, 95% CI 1.17-2.36). There was a higher likelihood of reporting negative mental health due to climate events among respondents who were separated, divorced, or living with a partner compared to married respondents (aOR: 1.14, 95% CI 1.02-1.27). Respondents living in rural areas (vs. urban dwellers aOR: 1.46, 95% CI 1.28-1.66) and those who experienced property damage due to climate events (vs. no property damage aOR: 3.26, 95% CI 2.82-3.76) also had higher odds of their mental health being adversely affected by climate events. Having fairly or somewhat stable housing (compared to very stable) was associated with an increased likelihood of harm to mental health due to climate events (fairly stable aOR: 1.18, 95% CI 1.06 – 1.32; somewhat stable aOR: 1.32, 95% CI 1.12, 1.56).

In univariate models, respondents who were willing to help their neighbors were less likely to report negative mental health effects of climate change compared to respondents with low willingness to help their neighbors (strongly agree OR: 0.44, 95% CI 0.34 – 0.57; agree OR:

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0.51, 95% CI 0.40 – 0.65). Respondents who trusted their neighbors also were less likely to report negative mental health effects of climate change compared to respondents who had low trust in neighbors (strongly agree OR: 0.49, 95% CI 0.38-0.64, agree OR: 0.53, 95% CI 0.42 – 0.68). Lastly, respondents who felt safe in their neighborhood (all the time OR: 0.32, 95% CI 0.23 – 0.46; most of the time OR: 0.50, 95% CI 0.35 – 0.71; some of the time OR 0.69, 95% CI 0.47 – 1.00) were less likely to report negative mental health effects of climate change compared to respondents who did not feel safe in their neighborhood any of the time. However, these effects for measures of neighborhood social cohesion did not persist in multivariate models. By contrast, respondents who led or organized volunteering efforts in one's community in the past 12 months had significantly higher odds of their mental health being impacted by climate events in both univariate and multivariate models compared to respondents who did not volunteer in the past 12 months (aOR: 1.55, 95% CI 1.38-1.75)

Discussion

In a large representative sample of California adults, over half reported being affected by an extreme weather event in the past 2 years. Nearly 23% of those exposed to climate events reported mental health consequences. Those who identified as White, female, ages 30-39, or well-educated were more likely to report poor mental health related to climate events. Those who lived in rural areas and experienced property damage were also at elevated risk of adverse mental health outcomes from climate events. These sociodemographic factors were found to be significant even in adjusted models, suggesting that these factors independently and robustly are associated with more negative climate change-related mental health outcomes.

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Our results reveal key contextual factors in understanding the disproportionate impact of adverse climate change-related mental health effects on vulnerable populations. These findings suggest that there may be two different groups that are disproportionately affected by climate change: those who have high levels of education, which may reflect higher levels of awareness and education around climate change, and those living in rural areas, who may have experienced more directly damaging effects of climate change such as property loss or impacts to agricultural livelihoods. This is relevant from a public health lens, as patients who reside in remote settings and/or are physically displaced already have well-documented disparities in healthcare access, satisfaction, utilization, and quality [21,22]. These results contrast with previous reports that climate change uniformly amplifies existing health disparities across racial, ethnic, gender, and socioeconomic lines. The underlying mechanism for mental health disparities in these two broad high risk-groups may be very different [15,23–26].

Furthermore, these findings identify mental health disparities with different sociodemographic patterns than physical health disparities related to climate change. Though elderly populations are considered at higher risk of adverse physical health effects of climate change — due to thermoregulation and mobility challenges in extreme heat, for example — our findings reflect a lower risk of adverse climate change-related mental health effects for older adults [3,27,28]. The age-stratified effects show greatest distress in younger adults and lowest distress in older adults due to exposure to climate events. These results mirror the age gradient from other national surveys on climate anxiety, but is a novel demonstration of mental health impacts after exposure to climate events [31]. These effects may reflect the greater impact on young adults who will be more affected by climate change across their lifespans, but may also reflect lower resilience and resources among younger adults during stressors. These findings

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mirror other patterns of mental health disorder prevalence and impacts from disasters, such as the rates of depression and anxiety during the coronavirus pandemic, which were dramatically higher in younger than older adults [32].

We also find that respondents aged 30 - 39 years are at a higher risk of experiencing adverse climate change-related mental health effects compared to respondents aged 65 years or above. We hypothesize that this age group may be most likely to be raising young children and therefore have additional concerns about planetary health for their children's futures (sometimes referred to as the "green parenthood effect") [29,30]. Though this may suggest greater awareness of climate change among certain subgroups, our results also reflect specific groups whose mental health is disproportionately affected by climate change, and who require additional support and outreach.

Our study also highlights that measures of neighborhood social cohesion, such as trust in and willingness to help neighbors, as well as perceived safety of neighborhood, may be protective factors against adverse mental health outcomes. Previous work has demonstrated that social cohesion appears to buffer the effects of stressful life events on both adolescent and adult mental health [33]. By contrast, volunteering in one's community was found to confer additional risk of adverse mental health outcomes, possibly reflecting a group of respondents who are highly conscientious, with enhanced awareness of the climate crisis and its implications for planetary health. Our findings suggest that social cohesion and community resilience remain important resources in recovery after a climate disaster, and represent key opportunities for public health interventions [33,34].

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Limitations

Our study is based on data from a single state and may not be generalizable to other U.S. states or locations. Additionally, zip code-level data were not publicly accessible, limiting analysis to rural, mixed, urban, and suburban categories. The study did not include adolescents and young children; therefore, we are unable to compare responses to other large youth surveys of climate change and mental health. Lastly, the survey did not collect data on mental health impacts of climate events on those who were not directly impacted by events. However, these limitations should be balanced against the study's relative strengths: utilizing a unique survey question about exposure and responses to extreme weather events, having a large and diverse sample size from the most populous U.S. state, and incorporating detailed data on sociodemographics, individual-level property damage, and social cohesion.

Policy Implications

Our findings reveal opportunities for policy change targeting populations that are at greatest risk of adverse mental health outcomes from climate change events. Our study highlights that those who live in rural areas and have experienced property damage may benefit from targeted prevention and outreach. In light of recent and rapid increases in access to telehealth use, these findings point to opportunities to focus efforts on increasing access to mental health care for rural populations [35]. Those who identify as young, White, college-educated, or female also may need greater mental health support for climate change-related distress, and yet developing tailored resources for climate distress prevention and resilience will be needed to target different subgroups.

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Broad-based public health and policy actions are needed to address the upstream drivers of climate change-related mental health effects. For instance, a focus on building affordable housing and ensuring it is not located in areas highly vulnerable to wildfires or floods is an important preventive approach. The development of drought-resistant crops and protection at the rural-wilderness interface will be a critical step in the commitment to protect rural communities that are at particularly high risk of exposure to the effects of climate change [36].

In addition, our research highlights the need to improve the collection and sharing of data to assess climate change-related mental health outcomes. There are a growing number of standardized measures of climate distress [37, 38]. Such data will inform and shape the rapidly evolving landscape for new climate policies. For example, Wheat et al. highlight potential areas of opportunity to document exposure to forces of nature among clinicians using novel International Classification of Diseases (ICD) diagnostic codes [39]. Doing so can help researchers generate novel data and map mental health symptoms onto climate exposure data to better capture clinical presentation and timescale of symptoms [40]. Ultimately, this work could provide valuable information to clinicians and public health advocates to better address the growing mental health needs associated with climate change.

Conclusion

Exposure to climate events can adversely affect mental health, and we find roughly half of a state population impacted by climate events, with one-fifth of them reporting mental health consequences. However, this effect is not distributed equitably or uniformly based on individual sociodemographics, and importantly can be buffered with stronger social capital. There remains an urgent need to reduce the inequitable harms of climate change on mental health through

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increasing access to care and targeting resources for vulnerable populations. Public health interventions with rigorous evaluations are needed to address the mental health impacts of increasingly frequent and severe climate events.

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References

1. The Lancet. A Commission on climate change. Lancet. 2009 May;373(9676):1659.
2. Gao J, Cheng Q, Duan J, Xu Z, Bai L, Zhang Y, et al. Ambient temperature, sunlight duration, and suicide: A systematic review and meta-analysis. Sci Total Environ. 2019 Jan;646:1021–9.
3. Chan E, Lam H, So S, Goggins W, Ho J, Liu S, et al. Association between Ambient Temperatures and Mental Disorder Hospitalizations in a Subtropical City: A Time-Series Study of Hong Kong Special Administrative Region. Int J Environ Res Public Health. 2018 Apr 14;15(4):754.
4. McMichael C, Barnett J, McMichael AJ. An Ill Wind? Climate Change, Migration, and Health. Environ Health Perspect. 2012 May;120(5):646–54.
5. Zscheischler J, Westra S, van den Hurk BJJM, Seneviratne SI, Ward PJ, Pitman A, et al. Future climate risk from compound events. Nat Clim Change. 2018 Jun;8(6):469–77.
6. Agency for Healthcare Research and Quality (US). 2019 National Healthcare Quality and Disparities Report. 2020. Available from: https://www.ncbi.nlm.nih.gov/books/NBK579354/
7. Shi L, Chu E, Anguelovski I, Aylett A, Debats J, Goh K, et al. Roadmap towards justice in urban climate adaptation research. Nat Clim Change. 2016 Feb;6(2):131–7.
8. Sanson AV, Van Hoorn J, Burke SEL. Responding to the Impacts of the Climate Crisis on Children and Youth. Child Dev Perspect. 2019 Dec;13(4):201–7.

This manuscript is a preprint and has not been peer reviewed. The copyright holder has made the manuscript available under a Creative Commons Attribution 4.0 International (CC BY) license and consented to have it forwarded to EarthArXiv for public posting.

9. Hickman C, Marks E, Pihkala P, Clayton S, Lewandowski RE, Mayall EE, et al. Climate anxiety in children and young people and their beliefs about government responses to climate change: a global survey. Lancet Planet Health. 2021 Dec;5(12):e863–73.

10. Raker EJ, Lowe SR, Arcaya MC, Johnson ST, Rhodes J, Waters MC. Twelve years later: The long-term mental health consequences of Hurricane Katrina. Soc Sci Med. 2019 Dec;242:112610.

11. Roberts YH, Mitchell MJ, Witman M, Taffaro C. Mental health symptoms in youth affected by Hurricane Katrina. Prof Psychol Res Pract. 2010 Feb;41(1):10–8.

12. Hwong AR, Wang M, Khan H, Chagwedera DN, Grzenda A, Doty B, et al. Climate change and mental health research methods, gaps, and priorities: a scoping review. Lancet Planet Health. 2022 Mar;6(3):e281–91.

13. Obradovich N, Migliorini R, Paulus MP, Rahwan I. Empirical evidence of mental health risks posed by climate change. Proc Natl Acad Sci. 2018 Oct 23;115(43):10953–8.

14. Cianconi P, Betrò S, Janiri L. The Impact of Climate Change on Mental Health: A Systematic Descriptive Review. Front Psychiatry. 2020 Mar 6;11:74.

15. Clayton S, Manning CM, Krygsman K, Speiser M. Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. Washington, D.C.: American Psychological Association, and ecoAmerica; 2017.

16. Hayes K, Blashki G, Wiseman J, Burke S, Reifels L. Climate change and mental health: risks, impacts and priority actions. Int J Ment Health Syst. 2018 Dec;12(1):28.

17. California Health Interview Survey. CHIS 2021 Adult Public Use Files. 2022. Available from: https://healthpolicy.ucla.edu/chis/data/Pages/GetCHISData.aspx

This manuscript is a preprint and has not been peer reviewed. The copyright holder has made the manuscript available under a Creative Commons Attribution 4.0 International (CC BY) license and consented to have it forwarded to EarthArXiv for public posting.

18. Goss M, Swain DL, Abatzoglou JT, Sarhadi A, Kolden CA, Williams AP, et al. Climate change is increasing the likelihood of extreme autumn wildfire conditions across California. Environ Res Lett. 2020 Sep 1;15(9):094016.

19. Silveira S, Kornbluh M, Withers MC, Grennan G, Ramanathan V, Mishra J. Chronic Mental Health Sequelae of Climate Change Extremes: A Case Study of the Deadliest Californian Wildfire. Int J Environ Res Public Health. 2021 Feb 4;18(4):1487

20. [Frequently Asked Questions (FAQs)]. [cited 2023 Mar 6]. Available from: https://healthpolicy.ucla.edu/chis/faq/Pages/default.aspx

21. Berry HL, Bowen K, Kjellstrom T. Climate change and mental health: a causal pathways framework. Int J Public Health. 2010 Apr;55(2):123–32.

22. Easterday A, Driscoll D, Ramaswamy S. Rural homelessness: its effect on healthcare access, healthcare outcomes, mobility, and perspectives of novel technologies. J Soc Distress Homeless. 2019 Jan 2;28(1):56–64.

23. Trombley J, Chalupka S, Anderko L. Climate Change and Mental Health. AJN Am J Nurs. 2017 Apr;117(4):44–52.

24. Costello A, Abbas M, Allen A, Ball S, Bell S, Bellamy R, et al. Managing the health effects of climate change. Lancet. 2009 May;373(9676):1693–733.

25. Cusack L, de Crespigny C, Athanasos P. Heatwaves and their impact on people with alcohol, drug and mental health conditions: a discussion paper on clinical practice considerations: Heatwaves impact mental health conditions. J Adv Nurs. 2011 Apr;67(4):915–22.

26. Page LA, Hajat S, Kovats RS, Howard LM. Temperature-related deaths in people with psychosis, dementia and substance misuse. Br J Psychiatry. 2012 Jun;200(6):485–90.

This manuscript is a preprint and has not been peer reviewed. The copyright holder has made the manuscript available under a Creative Commons Attribution 4.0 International (CC BY) license and consented to have it forwarded to EarthArXiv for public posting.

27. Davido A. Risk factors for heat related death during the August 2003 heat wave in Paris, France, in patients evaluated at the emergency department of the Hopital Europeen Georges Pompidou. Emerg Med J. 2006 Jul 1;23(7):515–8.

28. Conti S, Masocco M, Meli P, Minelli G, Palummeri E, Solimini R, et al. General and specific mortality among the elderly during the 2003 heat wave in Genoa (Italy). Environ Res. 2007 Feb;103(2):267–74.

29. Shrum TR, Platt NS, Markowitz E, Syropoulos S. A scoping review of the green parenthood effect on environmental and climate engagement. WIREs Clim Change [Internet]. 2023 Jan 23 [cited 2023 Mar 2]; Available from: https://onlinelibrary.wiley.com/doi/10.1002/wcc.818

30. Gaziulusoy Aİ. The experiences of parents raising children in times of climate change: Towards a caring research agenda. Curr Res Environ Sustain. 2020 Dec;2:100017.

31. Leiserowitz A, Maibach E, Rosenthal S, Kotcher J, Ballew M, Marlon J, Carman J, Verner M, Lee S, Myers T, Goldberg M. Global Warming's Six Americas, December 2022. Yale University and George Mason University. New Haven, CT: Yale Program on Climate Change Communication; 2023.

32. Jewett RL, Howell N, Larsen MM. Social Cohesion and Community Resilience During COVID-19 and Pandemics: A Rapid Scoping Review to Inform the United Nations Research Roadmap for COVID-19 Recovery. Int J Health Serv. 2021 Jul;51(3):325–36.

33. Santomauro DF, Mantilla Herrera AM, Shadid J, Zheng P, Ashbaugh C, Pigott DM, et al. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. Lancet. 2021 Nov;398(10312):1700–12.

This manuscript is a preprint and has not been peer reviewed. The copyright holder has made the manuscript available under a Creative Commons Attribution 4.0 International (CC BY) license and consented to have it forwarded to EarthArXiv for public posting.

34. Kingsbury M, Clayborne Z, Colman I, Kirkbride JB. The protective effect of neighbourhood social cohesion on adolescent mental health following stressful life events. Psychol Med. 2020 Jun;50(8):1292–9.

35. Rodriguez JA, Saadi A, Schwamm LH, Bates DW, Samal L. Disparities In Telehealth Use Among California Patients With Limited English Proficiency: Study examines disparities in telehealth use among California patients with limited English proficiency. Health Aff (Millwood). 2021 Mar 1;40(3):487–95.

36. Salas RN, Friend TH, Bernstein A, Jha AK. Adding A Climate Lens To Health Policy In The United States: Commentary explores how health care policy makers can integrate a climate lens as they develop health system interventions. Health Aff (Millwood). 2020 Dec 1;39(12):2063–70.

37. Hogg TL, Stanley SK, O'Brien LV, Wilson MS, Watsford CR. The Hogg Eco-Anxiety Scale: Development and validation of a multidimensional scale. Global Environmental Change. 2021 Nov;71:102391.

38. Clayton S, Karazsia BT. Development and validation of a measure of climate change anxiety. J Environ Psychol. 2020 Jun;69:101434.

39. Wheat S, Lemery J, Limaye V. We're Awash In Climate Change Data, But Health Damages Remain Undercounted [Internet]. 2022 [cited 2023 Feb 10]. Available from: http://www.healthaffairs.org/do/10.1377/forefront.20220323.649504/full/

40. Hwong AR, Kuhl EA, Compton WM, Benton T, Grzenda A, Doty B, et al. Climate Change and Mental Health: Implications for the Psychiatric Workforce. Psychiatr Serv. 2022 May 1;73(5):592–5.

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