Mental health impacts from repeated climate disasters: an australian longitudinal analysis

Anna Mitchell,[a,*] Humaira Maheen,[a,b] and Kathryn Bowen[a,b]

[a]Melbourne School of Population and Global Health, The University of Melbourne, 207 Bouverie St, Carlton, VIC, Australia

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Summary

Background Extreme weather events are becoming more frequent and intense under changing climatic conditions. Whilst there is substantial evidence that exposure to a single weather related disaster is detrimental for mental health, few studies have explored how exposure to multiple disasters impacts mental health.

Methods We utilised 11 waves of data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey, yielding a sample of 16,629 observations from 2003 individuals. Fixed effects linear regression analysis was used to estimate the impact of experiencing multiple disasters on mental health. We tested for effect modification on this association by sex, rurality, employment and presence of a long-term health condition.

Findings Exposure to multiple disasters was associated with a relative decrease in MHI-5 score compared to baseline by −1.8 points (95% CI −3.4, −0.3), whereas exposure to a single disaster was not associated with a decline in mental health scores. There was evidence of effect modification by employment status. Unemployed individuals had evidence of moderate reduction in MHI-5 scores when exposed to a single disaster (−4.3, 95% CI −7.0, −1.5).

Interpretation Findings suggest that repeat exposure to disasters is associated with worsening mental health outcomes. As extreme weather events increase, these findings highlight the need for greater attention on climate change action, and mental health interventions targeting impacted populations.

Funding Suicide Prevention Australia.

Keywords: Climate disaster; Mental health; Australia; Longitudinal

Introduction

Climate change is one of the greatest threats to global health this century.[1] Increasing anthropogenic greenhouse gas (GHG) emissions is resulting in climate change, and warming average global temperatures.[2] Global warming leads to more frequent and intense extreme weather hazards, such as heat waves, droughts, wildfires and extreme precipitation events leading to flooding.[2–4] These weather or climate hazards have the capacity to cause widespread adverse impacts and damage to nature and people beyond natural climate variability, leading to disasters.[5] Disasters occur when there is a serious disruption to the functioning of a community that exceeds its capacity to cope using its own resources, leading to human, material, economic or environmental losses.[6] When weather events occur consecutively or multiple types of extremes coincide, the impacts can compound in severity, leading to a higher chance of a hazard resulting in a disaster.[3] The probability of these compounding extreme events has likely increased due to climate change.[5]

Climate change threatens to negate the global health gains from the past 50 years and further widen pre-existing inequities.[7,8] There is a growing body of evidence which demonstrates the impact of extreme weather and climate change on mental health.[1,4] Globally, depression and anxiety are leading causes of morbidity, and suicide is the fourth leading cause of death amongst young adults (age 15–29 years).[9] The IPCC's Sixth Assessment Report states with high confidence that "changes due to extreme weather events due to climate change, including floods, droughts and hurricanes, which are projected to increase due to climate change, directly worsen mental health and

*Corresponding author.
E-mail address: an.mitchell@alfred.org.au (A. Mitchell).
[b]Joint senior author.

Research in context

Evidence before this study

Whilst there is a reasonable body of research demonstrating the impact of a single climate related disaster on mental health, less in known about psychological impacts of experiencing repeated disasters. A search of PubMed and Embase was conducted in English from database inception to July 18 2022, using the search terms "multiple disaster" or "repeat* disaster" or "recurrent disaster" or "cumulative disaster" or "bushfire" or "wildfire" or "hurricane" or "cyclone" or "flood" with "mental health". We identified that previous literature comparing a single exposure to repeated disaster exposure mostly consisted of cross-sectional studies, with only a few longitudinal analyses on the topic, and none in Australia. Further, many studies have looked at exposure to a combination of climate related disasters and other kinds of disasters (e.g., COVID-19 or oil spill), and not explored the impact of repeated climate related disasters in isolation.

Added value of this study

This is the first study of its kind to utilise longitudinal panel data to investigate the mental health impacts of experiencing multiple climate related disasters. Using a fixed effects regression we have been able to demonstrate that an individual's mental health declines following multiple disaster exposures. This effect was modified by an individual's employment status, with those unemployed being disproportionally impacted.

Implications of all the available evidence

Our findings emphasise the need for critical action to address the psychological impacts of repeated exposure to climate events. As unemployed individuals had disproportionally worsening mental health outcomes with exposure to disasters, they are a group which requires increased support throughout disasters. This research should urge governments to uphold their commitments to halting global warming, and develop community supported disaster risk mitigation strategies to properly prepare communities for the expected increase in extreme weather events.

wellbeing and increase anxiety".[5] As climate hazards increase in frequency and intensity, more research needs to be conducted to look at the impacts on individuals and communities exposed to repeated weather related hazards.[10] Previous studies have demonstrated at risks groups for worsening mental health post exposure to acute weather events and disasters, including women,[11–13] those from disadvantaged socio-economic status,[11,14] and individuals with mental health or health conditions.[13,15]

Across high-income countries, there have been limited studies researching the links between experiencing multiple extreme weather events and the impact on mental health. There is even less research in low- and middle-income settings.[16] In the US, several studies[17–19] have utilised data from the Gulf Long-term Follow-up study, a prospective cohort study examining the health impacts of the Deepwater Horizon Oil Spill, and hurricanes in the Gulf region of the United States, a group of states bordering the Gulf of Mexico. Individuals with exposure to both the oil spill and a hurricane were at a higher likelihood of generalised anxiety disorder, post-traumatic stress disorder (PTSD) and depression relative to those who experienced one disaster.[17,18] A cross-sectional study in Texas, US supported this finding, with each additional exposure to a hazard event, reducing mental health scores in a dose-dependent manner.[20] With a focus solely on hurricanes, Garfin et al. have again demonstrated the deleterious impacts of experiencing multiple disasters and extended this finding to individuals who are indirectly impacted by disasters, either through knowing someone who was injured or killed, being geographically near the pathway of destruction (in a hurricane) or through media exposure.[21]

In an Australian context, only a few cross-sectional studies have examined the impact of experiencing multiple disasters on an individual's mental health. Findings are inconsistent amongst these studies. In two studies by Reifel's et al., there was an increase in odds of lifetime risk of panic disorder and suicide attempt for those exposed to multiple weather-related disasters.[22,23] Other studies have not found any increased risk of poor mental health outcomes for those exposed to previous disasters. Previous exposure to bushfires was not associated with an increased risk of poor mental health outcomes in Australians living in Canberra[24] and prior flood exposure was not associated with increased risk of depression in Australian rural business owners following cyclone related flooding.[25]

There have not been any longitudinal analyses in Australia to investigate the impacts of repeated disaster exposure on mental health. Due to the naturalistic study design required to study weather related hazards and disasters, it is challenging to follow individuals prior to and following subsequent disasters. To address this challenge, our study utilises the data from a large Australian representative panel data set, the Household, Income and Labour Dynamics in Australia (HILDA) survey. The strength of a longitudinal study design is that it can be used to measure information repeatedly over a long period of time, and potentially capture

multiple exposures experienced by a single individual. Further, it can be used to see the dynamic changes in an individual's mental health in response to an exposure. This information will help delineate whether repeated exposure to disasters has increasingly detrimental impacts on mental health, or if individuals develop resilience or increasing capacity to cope with additional trauma. This will enable clinicians to understand risk factors for mental health deterioration post disaster exposure, and be able to screen for communities and individuals at risk of requiring additional mental health support. It will help understand if current mental health programmes are sufficient for those exposed to repeated disasters, or if new services are needed to be applied to multi-disaster scenarios.

Our study aims to examine whether experiencing repeat weather related disasters is associated with poorer mental health compared to experiencing a single disaster. It further examines the role of socio-demographic characteristics including sex, rurality, employment status and long-term health condition to modify this association.

Methods

Data source

Data was collected from 11 waves of the HILDA Survey, a nationally representative longitudinal study of Australian households and individuals. The response rate to wave 1 was 66%.[26] The survey collects information about a range of social, demographic, economic and health characteristics each wave, by a combination of face-to-face interviews and self-responding surveys. The survey began in 2001 (wave 1, N = 13,969), as a large probability sample of Australian households occupying private dwellings. Although data are collected on each member of the household, interviews are only conducted with those 15 years and above. All members of households interviewed in wave 1 formed the basis of the panel to be pursued in each subsequent wave. The sample gradually changes to include any new household members resulting from changes in the composition of the original households, or as individuals within the sample households turn 15 years of age. In 2011, an additional 2153 households were added to the survey to maintain population representativeness. The response rates for new respondents who join the HILDA survey are above 70% and the wave to wave retention rate for respondents who continue the survey is greater than 90%.[26] Ethics approval for the HILDA study is granted by the Human Research Ethics Committee of the University of Melbourne.

Exposure and outcome variables

The survey question, "[In the last 12 months, has] a weather-related disaster (e.g., flood, bushfire, cyclone) damaged or destroyed your home"? was used as our main exposure variable. This question was asked to individuals in the self-completion questionnaire. We categorised the number of disasters into "1 exposure", "2 exposures" and ">2 exposures".

Mental health was measured in every wave using the mental health inventory-5 (MHI-5), as a part of the Short Form 36 (SF-36) health questionnaire. The SF-36 is a widely used self-completion measure of health status that has been shown to be psychometrically sound in the HILDA population.[27] The MHI-5 includes five questions relating to mental health over the past 4 weeks, asking about symptoms of depression and anxiety and aspects of positive mental health (e.g., feeling calm or peaceful). The respondents are asked to answer the questions, ranking the response from 'none of the time' to 'all of the time', and scores are summed and scaled using a linear transformation to produce a score ranging from 0 to 100, with higher scores representing better mental health. The scale demonstrates good internal consistency, with the Cronbach's alpha for these items being 0.82.[27] The MHI-5 is a good screening tool for mood disorders in the general population, with high sensitivity and specificity, as well as some anxiety disorders including generalised anxiety disorder (GAD) and post-traumatic stress disorder (PTSD).[28,29] It has been validated as a measure for depression using clinical interviews as gold standard.[28] There is no universal interpretation of the MHI-5 score, but a difference of three points on the MH scale has been suggested to be clinically significant[30] (Ware et al.). In this study, we used the definitions of small, moderate and large effects for the MHI-5 score provided by Contopoulos-Ioannidis et al.,[31] who classified differences in mean unstandardised scores as small (less than 4 MHI-5 points), moderate (4–10 points) or large (more than 10 points).

Analytic sample and missing data

In order to test the impact of disaster exposure on an individual's mental health, the sample was restricted to only those who have had at least one year where they had a weather-related disaster damaged or destroyed their home. The sample was inclusive of those 15 years and older, as this was when participants were included in the individual survey. Information about weather-related disaster events was available from wave 9 onwards. We included waves 9–19 in the study, which reflects the years 2009–2019. Wave 20 was not included in the analysis due to Australia's COVID pandemic and significant lockdowns throughout 2020.[32,33] COVID lockdowns have been shown to have impacts on individuals' mental health, which may compound our results. Observations with missing data on exposure, outcome or covariates were excluded from analysis (see Supplemental Table S1 for further information on missing data).

Statistical analysis

All analysis was conducted in Stata SE version 17.0. Initially, we conducted a descriptive analysis to assess the demographic details of the population across

observations, according to exposure group. Chi-square tests were used to assess differences in demographics between groups. Differences in mean MHI-5 scores were assessed using an unpaired *t-test* between exposure groups, stratified by effect modifiers. We then used a fixed-effects linear regression model to estimate the association between disaster exposure and MHI-5 score within individuals, specifying respondents (respondent ID) as the panel variable, and wave as the time variable. We employed the fixed effect regression model with "fe vce (robust)" command, to adjust for homoscedasticity within the panel data framework. A fixed effects model estimates changes in outcomes (mental health) in response to changes in exposure status (disaster exposure) within individuals, as opposed to between individuals. This controls for time-invariant confounders (both measured and not measured), as the individual acts as their own control.[34]

Covariates

Confounding variables included in the analysis were: age (<25 years, 26–35 years, 36–45 years, 46–55 years, 56–65 years, >65 years), sex (male, female), education (postgraduate, bachelor degree, diploma or certificate, year 12, not completed year 12), employment status (employed, unemployed (looking for work), not in the labour force (retired, or not actively looking for work)), rurality (city, rural/regional), home ownership status (homeowner, non-home owner), marital status (married/defacto, divorced/widowed, single) yearly household income (equivalised), long term physical or mental health condition (defined as any long term health condition, impairment or disability that restricts you in everyday activities, and has lasted or is likely to last, for 6 months or more), socio-economic advantage or disadvantage (using the SEIFA 2001 scale) and wave (as a categorical variable). Relevant covariates were measured at each wave, concurrent to measurement of exposure and outcome.

Effect modification

We tested effect modification by sex, rurality, presence of long-term health conditions and employment. In each case, we compared the main effects model to a model with the main effects and interaction term included. We assessed significance of the interaction through a likelihood ratio test comparison of the models with and without the interaction. The effect modification results were presented for significant effect modifiers according to the recommendations by Knol et al.[35]

Sensitivity analysis

As a sensitivity analysis, we included "food insecurity" as a potential confounder, acknowledging that this may also be a mediator (e.g., Disaster exposure may lead to food insecurity which may then affect mental health) (Supplemental Table S2a). We conducted a second sensitivity analysis looking at the impact of restricting the analysis to remove individuals who only had a single disaster exposure in wave 9, and hence had no baseline MHI-5 data for comparison (Supplemental Table S2b). The results indicated similar effect sizes.

Role of the funding source

Funders had no role in study design, data collection, data analysis, interpretation or writing of the report.

Results

Descriptive analysis

Across 11 waves of data, 2003 individuals 15 years and older had their home destroyed or damaged by a weather-related disaster in at least one of the years were surveyed. This contributed to a total of 18,284 observations (Fig. 1). After eliminating observations with incomplete data on disaster exposure, mental health outcomes and covariates, the total sample was 2001 individuals with 16,629 observations. Within the eligible sample, 9% of data were excluded due to missingness on variables included in the analysis (Fig. 1 and Supplemental Fig. S1).

The sociodemographic characteristics of the sample according to the number of disaster exposures is presented in Table 1. From the 16,629 observations included, 82.5% were from individuals who reported exposure to 1 disaster. The mean age of observations was 46.9 years (SD 17.6), with 52.1% female. The group who experienced >1 disaster, had a higher percentage of individuals living in rural/remote areas (57.6% vs 51.0%), and overall the population had a majority of observations from participants living in regional/remote

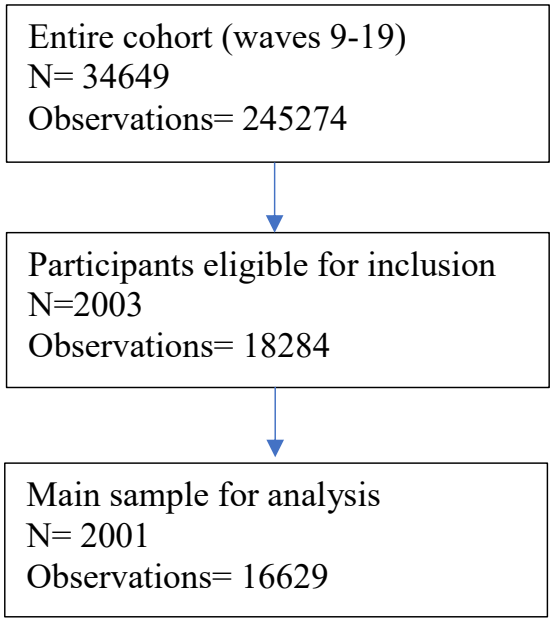

Fig. 1: Sample selection.

Variable	1 disaster	>1 disaster	p value[a]	Overall
Observations	13,720 (82.5%) n = 1683	2909 (17.5%) n = 318		16,629 (100%)
Age (years), mean (SD)	46.4 (17.6)	49.0 (17.1)	p < 0.001	46.9 (17.6)
Sex, (%)				
Male	48.4	45.9		47.9
Female	51.6	54.1	p = 0.014	52.1
Home ownership, (%)				
Home owners	69.9	71.3		70.2
Non-owners	30.1	28.7	p = 0.139	29.8
Rural, (%)				
Major city	49.0	42.4		47.8
Regional/remote	51.0	57.6	p < 0.001	52.2
Yearly disposable income (,000$), mean (SD)	51.5 (32.9)	53.3 (75.2)	p = 0.046	51.8 (43.4)
Education (%)				
Did not complete year 12	27.2	24.4		26.7
Complete year 12	13.3	16.2		13.8
Diploma/cert	36.7	39.4		37.2
Bachelor's degree	11.7	11.0		11.5
Postgrad	11.1	9.0	p < 0.001	10.8
Marriage status (%)				
Married/defacto	68.1	67.8		68.1
Divorced/widowed/separated	13.3	17.4		14.0
Single	18.6	14.9	p < 0.001	18.0
Country of birth (%)				
Australia	81.8	84.2		82.3
English speaking-other country	9.7	6.7		9.1
Non English speaking country	8.5	9.1	p < 0.001	8.6
Employment (%)				
Employed	64.3	59.1		63.4
Unemployed	3.8	4.1		3.8
Not in labour market	31.9	36.8	p < 0.001	32.8
Long term health condition (%)				
Yes	32.8	43.6		34.7
No	67.2	56.5	p < 0.001	65.3
SEIFA				
Lowest quintile	23.9	28.2		24.6
2	20.4	20.5		20.4
3	20.3	18.2		19.9
4	19.4	20.5		19.6
5	16.0	12.7	p < 0.001	15.4

SD = standard deviation. MHI-5 = mental health inventory 5 scores. Data taken from 11 waves, 2009–2019. N = 2001. [a]Calculated by chi square for categorical data and t-test for continuous data.

Table 1: **Characteristics of the analytic sample by quantity of disaster exposures.**

areas (52.2%). The majority of the sample had observations from participants who were married (68.1%), born in Australia (82.3%) and employed (63.4%). In the group exposed to >1 disaster, there was a higher proportion of observations from individuals with long term health conditions (43.6% vs 32.8%). Overall, highest proportion of observations (25.6) were from individuals living in the lowest quintile of socio-economic disadvantage, as defined by the SEIFA scale. Within the group exposed to >1 disaster, this proportion is higher, with 28.2% of observations from participants living in the lower quintile of disadvantage.

Table 2 shows the mean MHI-5 scores according to the number of times exposed to a disaster, stratified by effect modifiers. MHI-5 scores were lower in those who had more than one exposure to a disaster (69.7) compared to those who had only experienced one disaster (72.5). Women had lower MHI-5 scores on average, and this was more significant in those exposed to more than one disaster, where there was an almost

MHI scores (mean, SD)	1 exposure to disaster N = 1683 Observations = 13,720	>1 exposure to disaster N = 318 Observations = 2909	Difference in MHI-5 (CI, p value[a])
All	72.5 (17.9)	69.7 (19.8)	−2.7 (−3.5, −2.0) p < 0.001
Sex			
Male	73.6 (17.3)	72.9 (19.0)	−0.7 (−1.7, 0.4) p = 0.199
Female	71.4 (18.4)	67.0 (20.0)	−4.4 (−5.4, −3.3) p < 0.001
Rural			
Major city	72.4 (17.7)	70.4 (18.1)	−2.0 (−3.1, −0.9) p < 0.001
Regional/remote	72.5 (18.1)	69.2 (20.9)	−3.3 (−4.3, −2.3) p < 0.001
Employment			
Employed	73.8 (16.2)	71.7 (17.7)	−2.1 (−3.0, −1.3) p < 0.001
Unemployed	62.8 (20.4)	67.4 (20.9)	4.6 (0.5, 8.7) p = 0.029
Not in labour force	70.8 (20.3)	66.8 (22.2)	−4.0 (−5.4, −2.6) p < 0.001
Long term health condition			
Yes	66.6 (20.3)	63.9 (21.6)	−2.7 (−4.0, −1.4) p < 0.001
No	75.3 (15.9)	74.2 (16.9)	−1.1 (−1.9, −0.3) p = 0.010

SD: standard deviation. MHI-5 = mental health inventory 5 sore. [a]p values for differences in mean MHI-5 (measured by unpaired t-test).

Table 2: **Mental health inventory-5 (MHI-5) scores based on effect modifiers and number of times exposed to a disaster (2009–2019).**

six-point difference in MHI-5 scores between men (72.9) and women (67.0). Those unemployed had lower mental health scores on average. Individuals with long-term health conditions had significantly lower mental health scores in both the group exposed to one disaster and more than one disaster, with the lowest mental health scores seen by those with a long-term health condition exposed to multiple disasters (63.9).

Fixed effects regression

Table 3 includes the unadjusted and adjusted fixed effects regression. Compared to when an individual had not experienced a weather related disaster, being exposed to a single disaster was not significantly associated with a decline in MHI-5 scores. Exposure to multiple disasters was associated with a small decline in MHI-5 scores by 1.8 (95% CI −3.4, −0.3).

Effect modification

There was no evidence of effect modification by sex (likelihood-ratio test x^2 = 1.48, p = 0.48), rurality (x^2 = 1.52, p = 0.48) or long term health condition (x^2 = 2.75, p = 0.25). There was strong evidence of effect modification of the relationship between disaster exposure and mental health outcomes by employment, as shown in Table 4 (x^2 = 16.87, p < 0.01).

Unlike employed individuals, compared to pre-exposure, those unemployed experienced a moderate decline in MHI-5 scores by 4.3 after exposure to one disaster (95% CI −7.0, −1.5). Whilst not statistically significant, there is a trend for unemployed individuals to experience a larger decline in MHI-5 scores after exposure to multiple disasters (−5.5, 95% CI −11.6, 0.5). There was no significant decline in MHI-5 scores for employed individuals after exposure to a single disaster. For employed individuals, after exposure to multiple disasters, there is a trend towards a small decline in MHI-5 scores by 1.6 (95% CI −3.3, 0.1), acknowledging that this did not reach statistical significance.

Discussion

To our knowledge, this is the first Australian study to use longitudinal panel data to assess the changes in an

Variables	Unadjusted model		Adjusted model[a]	
	Coefficient[b] [95% CI]	p value	Coefficient[b] [95% CI]	p value
Number of disasters				
Baseline MHI	Reference			
1 disaster	−1.2 [−1.7, −0.6]	p < 0.001	−0.6 [−1.3, 0.1]	p = 0.089
>1 disaster	−2.8 [−4.2, −1.3]	p < 0.001	−1.8 [−3.4, −0.3]	p = 0.020

Number of observations = 16,629, Number of people = 2001. Average observations per person = 8.3, min = 1, max = 11. [a]Adjusted for sex, age group, home ownership, rurality, income, education, employment, long term health condition, SES (SEIFA), marital status and wave. Also adjusted for standard error. [b]Coefficients refer to estimated mean difference in MHI-5 score.

Table 3: **Disaster exposure and Mental Health Inventory-5 (MHI-5), before and after adjusting for possible confounders using a fixed effects regression.**

MHI-5 score	Employed	Unemployed	Not in the labour force
	Coefficient[b,c] [95% CI], p value	Coefficient[b,c] [95% CI], p value	Coefficient[b,c] [95% CI], p value
Single disaster exposure			
Baseline MHI	Reference	Reference	Reference
1 disaster	−0.2 [−1.0, 0.6] p = 0.646	−4.3 [−7.0, −1.5] p = 0.002	−1.0 [−2.1, 0.1] p = 0.066
EMM on additive scale[a]	–	−4.1 [−6.8, −1.4] p = 0.003	−0.8 [−2.0, 0.4] p = 0.179
Multiple disaster exposures			
Baseline MHI	Reference	Reference	Reference
>1 disaster	−1.6 [−3.3, 0.1] p = 0.060	−5.5 [−11.6, 0.5] p = 0.072	−1.8 [−4.1, 0.5] p = 0.130
EMM on additive scale[a]	–	−3.9 [−9.9, 2.1] p = 0.203	−0.14 [−6, 2.3] p = 0.911

[a]Interaction on additive scale. [b]Adjusted for sex, age group, home ownership, rurality, income, education, employment, long term health condition, SES (SEIFA), marital status and wave. Also adjusted for SE. [c]Coefficients refer to estimated mean difference in MHI-5 score.

Table 4: **Effect modification of the relationship between disaster exposure and mental health, stratified by employment status.**

individual's mental health after multiple exposures to weather-related disasters. This study's findings suggest that repeated exposures to disasters lead to a decline in mental health outcomes. Findings from this study have implications for individuals living in disaster prone regions of Australia. Our study cohort consisted disproportionally of individuals from low socio-economic communities, rural and regional areas and those with lower education. Within the group exposed to multiple disasters, there was a larger proportion of individuals living in regional and remote areas, participants with long-term health conditions and from the lowest quintile of disadvantage.

The worsening mental health symptoms post multiple disasters in our study population is consistent with both a US longitudinal study which followed participants throughout exposure to multiple hurricanes in Florida,[21] and Chinese longitudinal study on adolescents experiencing multiple earthquakes.[36] Moreover, Garfin et al. found similar patterns of declining mental health with repeat disasters in those indirectly exposed to disasters,[21] which implies that our findings may be applicable to a broader spectrum of individuals, including those who are indirectly impacted. Our study findings add a robustness from the longitudinal data to support previous cross sectional studies conducted by Reifels et al. in an Australian population.[22,23] Reifels et al. found an associated between exposure to two or more weather related disasters and an increased lifetime risk of making a suicide attempt[23] and developing panic disorder compared to a single disaster,[22] which aligns with our findings of worsening MHI-5 scores. There is still limited research on how to best support individuals and communities who are impacted by repeat disasters, so this is an important area for future research.[10] Services need to be easily accessible, with providers trained in trauma-informed practise and available both immediately post disaster and in the long term.[37]

Unemployment had a particularly detrimental effect on mental health post disaster exposure, with moderate declines in MHI-5 scores.[31] Previously, a meta-analysis looking at exposure to a single disaster has demonstrated unemployment as a risk factor for depression in disaster survivors.[38] Unemployed individuals may lack the financial security and resilience to withstand the consequences of disasters, such as property damage.[39] Utilising the same longitudinal HILDA data, Johar et al. have identified that individual's exposed to weather related disasters report worsening financial situation during the same period,[40] and Li et al. showed that compared to matched controls, impacted individuals have an increase in housing and fuel arrears (e.g., not being able to pay electricity, gas or telephone bills on time) following disasters.[41] Unemployed individuals may disproportionally suffer from these financial strains. There are likely additional mediating factors of the relationship between disaster exposure and mental health which have not been assessed in this study, but may shed light onto why employment is such a strong mediator of this relationship. Whilst there was a trend towards unemployed individuals having larger declines in mental health following multiple disasters, this was not statistically significant. This may be due to the smaller numbers in this sub-group analysis. This warrants further research in the future to solidify this finding.

As unemployed individuals are a particularly vulnerable group post disaster, services need to be targeted towards this group, to reduce the inequity in mental health outcomes seen between those employed and unemployed. Individuals who are unemployed as a result of a disaster are able to access short term financial assistance a part of the Disaster Recovery Allowance (DRA) in Australia,[42] and the Disaster Unemployed Assistance (DUA) scheme in the US.[43] However, these schemes do not extend to those unemployed pre-disaster. There are currently no dedicated mental health services for the unemployed in a disaster setting in Australia. In response to the findings of our study, there is a need to include a focus on unemployment in

the National Disaster Mental Health and Wellbeing Framework.

At a government level, these results are important evidence to support the necessity for upholding existing commitments to limit global warming as outlined in the Paris Agreement.[44] Not all weather hazards will result in disasters. The vulnerability of a community (e.g., the infrastructure and wealth) and its ability to prepare and rebuild will determine whether a disaster occurs as a result of a hazard.[6,44] Our population impacted by multiple disasters consisted of those from lower socioeconomic status, with long term health conditions and from rural and regional areas. These are already vulnerable groups, and independent social determinants of health. Climate change has the capacity to widen pre-existing inequalities within society, by pre-dominantly impacting those who are already at risk, who do not necessarily have the social and financial capital to withstand such great shocks.[45]

COVID-19 placed additional strains on disaster survivors. Individuals exposed to previous disasters have been shown to be at increased odds anxiety,[46] and higher levels of stress throughout the COVID-19 pandemic.[32] Individuals exposed to two previous disasters have been shown to be the most at risk group in a US study by Agyapong et al..[33] Given our findings of worsening mental health impacts with additional exposure to climate hazards, it is likely that this cohort is at risk for psychological deterioration if exposed to a further traumatic event, be that climate or other. Another important area for future research is to examine the impact of compounding disasters on mental health, such as experiencing a disaster during a pandemic, or global financial crises.[10]

Strengths and limitations

This study draws on 11 waves of annually collected cohort data from an Australian sample. It is the first study of its kind to utilise longitudinal panel data to investigate the impact of repeat disaster exposure on an individual's mental health. In doing so, we have been able to address vital gaps in knowledge identified in recent review on the public health implications of multiple disaster exposures, particularly the need for research on the psychological effects of repeat disaster exposure.[10] By using a fixed effects regression, this study has been able to look at dynamic, within person changes to mental health after exposure to each additional disaster. A fixed effects approach is able to control for time-invariant individual characteristics, and minimise bias from unmeasured variables that are stable over time.

There are a number of limitations to discuss. A main limitation is that the study establishes an association between recurrent disaster exposure and worsening mental health outcomes, but does not test for causation. A further limitation is the small effect sizes, from a clinical standpoint,[31] demonstrated in the main fixed effects analysis. The question asked of the HILDA participants ("Has a weather-related disaster (flood, bushfire, cyclone) damaged or destroyed your home in the last 12 months?") is restrictive and does not include those who experience repeat disasters in other ways aside from property damage, nor provide information on the severity of experience. The question is self-reported, so relies on interpretation from the individual.

Both the outcome and exposure measures are self-reported and subject to measurement error There is a chance that measurement errors were correlated, leading to dependent misclassification bias. A fixed effect analysis addresses this issue to some extent, as it accounts for any measurement error in an individual which is stable over time. Additionally, the MHI-5 which is normally self-reported, has been validated as a screening tool for depression, and some anxiety disorders.[28,29]

About 9% of observations were dropped due to missing variables, which is a similar proportion seen in other HILDA studies. There is minimal difference seen between the eligible and analysed samples (Supplemental Table S1b). Whilst there is a risk of attrition bias due to loss of follow up, the rate of attrition within HILDA is very low, with wave on wave response rate ranging from 86.9% to 97.0% of participants depending on the year.[26]

This study utilises an Australian population and results may not be generalisable to other populations, more specifically, low to middle income countries. There is need for more research to the impacts of repeat disasters on mental health globally, particularly in low- and middle-income countries, who will disproportionally see the impacts of climate change.[16]

Conclusion

This study uses a robust fixed effects methodology which demonstrates that with increasing exposure to weather-related disasters, MHI-5 scores decline. This study is important to further support the need for immediate action on climate change and to strengthen policy around disaster risk reduction. Individuals and communities who are exposed to repeat disasters are particularly vulnerable, and thus it is imperative to better understand how mental health services can accommodate their particular needs.

Contributors

All authors were involved in study design and conception of study. H.M and K.B jointly supervised the project. A.M obtained approval to access the data and was responsible for data analysis, creation of tables and figures and writing of the manuscript. H.M provided advice on statistics and data analysis. K.B and H.M jointly edited the paper. A.M had responsibility for final submission.

Data sharing statement

The underlying data used to support the findings of this study is available through the National Centre for Longitudinal Data (NCLD)

Dataverse at the Australian Data Archive upon application (https://dataverse.ada.edu.au/dataverse/ncld). Access to the data is subject to approval by the Australian Government Department of Social Services, and is of no cost to the user.

Declaration of interests

We declare no competing interests.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2024.101087.

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