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Collaborative publication

Climate change impacts on mental health in the UK: Current evidence and opportunities for intervention

2025



**CLIMATE
CARES**

Mental health in the climate crisis

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Health Innovation

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Key points

- Climate change-related increases in temperature and extreme weather pose current and future risks to public mental health in the UK.
- Vulnerable populations face heightened mental health risks.
- Direct impacts include anxiety, stress, and trauma from floods and droughts, and increased risks of suicide and symptoms of mental health disorders from heat and air pollution.
- "Eco-emotions" stem from prolonged exposure to climate change-related issues, including grief and guilt over environmental damage and anxiety about future climate-related hazards. Without support, these experiences can worsen mental health and wellbeing.
- Integrating mental health support into climate change strategies offers an opportunity to build public resilience.

Background

Climate change is projected to increase the frequency of extreme weather events in the UK, including heatwaves, flooding, and drought under all climate change scenarios. In 2023, the UK experienced its second-warmest year on record, with precipitation levels at 113% of the 1991-2020 average.¹ There is widespread awareness of the strong evidence that climate change negatively impacts physical health². Physical and mental health are closely linked, with significant comorbidities between the two.³ Increasing evidence indicates that climate change poses a serious threat to public mental health, which is largely missing from policy responses.⁴

The World Health Organization defines mental health as a state of mental well-being that enables individuals to learn and work well, contribute to their community, and be able to cope with the stresses of life.⁵ Mental health conditions can include anxiety, depression, phobias, panic disorders, and post-traumatic stress disorder (PTSD) leading to impairments in daily functioning.⁶

Victims of extreme weather feel mental health impacts directly

Heat and Heatwaves

Under projections of 2°C of warming in 2030, assuming high population growth (UK-SSP5) and no additional adaptation, deaths due to extreme heat in the UK would increase by 169% compared to the near-past baseline (1990–2019).⁷ Grief from the loss of loved ones can be a risk factor for development of depression.⁸ Additionally, there is a correlation between temperature and increased suicide rates. A study in England and Wales found that for every 1°C rise above 18°C, suicide rates increased by 3.8%.⁹ A meta-review of 17 studies showed that 88% found a link between ambient temperature (relative to local norms) and suicide frequency.¹⁰ However, evidence for increased suicide rates specifically as a result of heatwave events has had mixed results.¹¹ A significant correlation between temperature and hospital admissions due to bipolar disorder has

been reported, as well as aggravation of schizophrenic symptoms.¹⁰ Individuals with pre-existing conditions, those taking medications such as certain psychotropics, and those with substance abuse issues are especially vulnerable during heatwaves, including increased likelihood of death.¹²

Maintaining an active lifestyle has widespread mental health benefits, but high temperatures can reduce the frequency, duration, and motivation for physical exercise.¹³ Higher nighttime temperatures have been linked to poor sleep quality, resulting in greater mental health risks.¹⁴ Other impacts of extreme heat include physiological “heat stress”, altering central nervous system functioning and causing emotional and cognitive changes.¹⁴

Floods

Under current adaptation levels, the geographic area exposed to frequent flooding (more than once in 75 years on average) is projected to expand, increasing the number of households at risk by 41% under 2 °C warming and 98% under 4 °C warming by the 2080s.¹⁵ Populations affected by flooding commonly experience mental health issues such as PTSD, depression, and anxiety.¹⁶ In the UK, increased use of alcohol, prescription drugs, and healthcare services has been observed following flood events.¹⁷ A study in England and Wales found that 55% of individuals exposed to a significant flooding event reported anxiety when it rains.¹⁸ Key factors contributing to distress among flood victims include lack of flood warnings, water depth, inadequate insurance, and concerns about potential health risks from floodwaters.^{17–19} Long-term effects that worsen mental health outcomes are attributed to evacuation, continued displacement from the home, and disruption to services. These impacts are unevenly distributed, with women, minorities, and renters experiencing worse long-term mental health outcomes.¹⁷

Droughts

Droughts in the UK are also expected to increase under climate change.²⁰ The summer drought of 2022 had severe environmental and agricultural impacts which triggered downstream social and economic effects.²¹ Those in the agricultural sector are particularly affected, facing crop loss, livestock failure, and reduced production. This results in increased stress due to economic hardship and heavier workloads.²² These pressures can heighten anxiety and contribute to feelings of shame and humiliation, further intensifying depressive symptoms.²³ A global review of 82 studies found there was a strong link between drought and mental health deterioration²², but there is still limited UK-specific research on this connection.

Vulnerable populations are disproportionately impacted

The mental health impacts of extreme weather are unequally distributed due to a combination of social, economic, and environmental exposures. Elderly populations, people already living with mental health conditions, children and youth, those with limited mobility, and individuals living in high-risk areas such as flood plains and coastal regions are particularly vulnerable to poor mental health outcomes.² Additionally, specific occupations, such as people who work outdoors, first responders, and those in caring roles have higher vulnerabilities.²⁴ Disruptions to healthcare, education, and public transportation systems after extreme events can increase stress levels,

especially for those who rely more heavily on these services.²⁵ Children and adolescents are also highly susceptible due to their rapid mental development.²⁶ Additionally, immigrants often experience heightened stress compared to non-immigrants and may face greater mental health risks due to a lack of community support, existing inequalities in housing and employment,²⁷ and potential language barriers that limit access to resources.^{2,4}

The rise of “Eco-anxiety”

Rising awareness of the climate crisis and its environmental and societal impacts has led to a range of emotional responses collectively termed “eco-emotions”.²⁸ Included in these responses is “eco-anxiety”, which has been used to describe emotional responses such as nervousness and fear about ecological threats, along with grief and mourning over environmental damage, and at times feelings of self-blame, guilt and powerlessness.²⁹ Eco-anxiety is also associated with symptoms of depression, PTSD, and insomnia.³⁰

Witnessing the effects of climate change on communities and ecosystems elsewhere can lead to anxiety due to uncertainty of wellbeing for other humans and species.³¹ In the UK, 60% of the public report that awareness of climate change affects their mental health.³² A survey of British individuals aged 16-25 revealed that nearly 50% of respondents reported feeling very or extremely worried about climate change, with 37% reporting that these feelings negatively impacted their daily life and normal functioning.³³ A 2020 study found that young people experienced significantly higher distress related to climate change compared to COVID-19, and this difference was driven by those without pre-existing anxiety.³⁴ Mental health professionals in the UK have reported an increasing prevalence of climate change-related emotional distress among their service users and anticipate this trend will continue.³⁵

Opportunities for intervention

Integrating mental health considerations into mitigation and adaptation policies can help to address the mental health impacts of climate change.³⁶ Despite the passage of the Mental Health Act in 2007³⁷, the Climate Change Act in 2008³⁸, and the Net Zero Strategy in 2021³⁹, there remains limited intersectionality between these policies. There are significant simultaneous benefits to be gained from integrating climate and mental health strategies. For example, expanding access to urban green spaces promotes both mental well-being and climate mitigation and adaptation.⁴⁰ Building climate-resilient healthcare systems and community-driven policies can have mental health co-benefits and reduce inequalities.⁴¹ Additionally, collective action, where individuals feel connected to their communities, can foster mental well-being while driving social change.⁴² Moreover, increased collaboration between climate scientists and mental health researchers will allow for improved methods for measuring the mental health impacts of climate change and benefits of action.⁴³ Finally, educating relevant stakeholders, such as mental health professionals and emergency responders, and providing locally-appropriate public and school-based education

can raise awareness about climate change in ways that support mental well-being and encourage action.⁴¹

For further information on climate change impacts on mental health globally, please see the Grantham Institute's briefing entitled: [The impact of climate change on mental health and emotional wellbeing: current evidence and implications for policy and practice](#).⁴⁴

About this note

This briefing note was written by [Monica McCall](#), a PhD student in the Grantham Institute's Science and Solutions for a Changing Planet Doctoral Training Programme. Monica developed this work as part of her successful application for a fellowship at the UK Parliamentary Office for Science and Technology (POST), during which she was seconded to the House of Lords Environment and Climate Change Committee. The piece is styled as a POSTnote, a format designed to translate contemporary scientific research into clear, actionable insights for policy audiences and decision-makers. The focus, direction, and scope of this work were shaped with guidance from [Dr Emma Lawrance](#) and [Dr Neil Jennings](#) at Imperial College's Climate Cares Centre.

Through the process of researching and writing this note, it became clear that there is already overwhelming evidence linking climate change to mental health impacts here in the UK. Raising awareness of this often-overlooked connection is becoming increasingly more critical as the climate crisis worsens, and the persistent lack of intersection between government policies on climate mitigation, adaptation, and mental health demands urgent attention. We hope readers come away with an awareness of the mounting evidence and can use this to design policies that support the UK's transition to net zero in a way that values planetary and human health in equal measure and benefits from the synergies between the aims and impacts of these policy areas.

How to cite

McCall, Monica. (2025). Climate change impacts on mental health in the UK: Current evidence and opportunities for intervention. Grantham Institute collaborative publication.

DOI: <https://doi.org/10.25560/125069>

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References

1. Kendon, M.; Doherty, A.; Hollis, D.; Carlisle, E.; Packman, S.; McCarthy, M.; Jevrejeva, S.; Matthews, A.; Williams, J.; Garforth, J.; Sparks, T. State of the UK Climate 2023. *Int. J. Climatol.* **2024**, *44* (S1), 1–117. <https://doi.org/10.1002/joc.8553>.
2. Paavola, J. Health Impacts of Climate Change and Health and Social Inequalities in the UK. *Environ. Health* **2017**, *16* (S1), 113. <https://doi.org/10.1186/s12940-017-0328-z>.
3. Bolton, J. M.; Walld, R.; Chateau, D.; Finlayson, G.; Sareen, J. Risk of Suicide and Suicide Attempts Associated with Physical Disorders: A Population-Based, Balancing Score-Matched Analysis. *Psychol. Med.* **2015**, *45* (3), 495–504. <https://doi.org/10.1017/S0033291714001639>.
4. Bourque, F.; Cunsolo Willox, A. Climate Change: The next Challenge for Public Mental Health? *Int. Rev. Psychiatry* **2014**, *26* (4), 415–422. <https://doi.org/10.3109/09540261.2014.925851>.
5. World Health Organization (WHO). *Mental health*. <https://www.who.int/news-room/fact-sheets/detail/mental-health-strengthening-our-response> (accessed 2024-09-12).
6. Baker, C.; Kirk-Wade, E. Mental Health Statistics: Prevalence, Services and Funding in England, 2024. <https://researchbriefings.files.parliament.uk/documents/SN06988/SN06988.pdf#page=4.38>.
7. Jenkins, K.; Kennedy-Asser, A.; Andrews, O.; Lo, Y. T. E. Updated Projections of UK Heat-Related Mortality Using Policy-Relevant Global Warming Levels and Socio-Economic Scenarios. *Environ. Res. Lett.* **2022**, *17* (11), 114036. <https://doi.org/10.1088/1748-9326/ac9cf3>.
8. Fatima, E. Impact of Climate Change on Individual and Community Mental Health. **2022**, *6*.
9. Page, L. A.; Hajat, S.; Kovats, R. S. Relationship between Daily Suicide Counts and Temperature in England and Wales. *Br. J. Psychiatry* **2007**, *191* (2), 106–112. <https://doi.org/10.1192/bjp.bp.106.031948>.
10. Thompson, R.; Hornigold, R.; Page, L.; Waite, T. Associations between High Ambient Temperatures and Heat Waves with Mental Health Outcomes: A Systematic Review. *Public Health* **2018**, *161*, 171–191. <https://doi.org/10.1016/j.puhe.2018.06.008>.
11. Florido Ngu, F.; Kelman, I.; Chambers, J.; Ayeb-Karlsson, S. Correlating Heatwaves and Relative Humidity with Suicide (Fatal Intentional Self-Harm). *Sci. Rep.* **2021**, *11* (1), 22175. <https://doi.org/10.1038/s41598-021-01448-3>.
12. 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**, *67* (4), 915–922. <https://doi.org/10.1111/j.1365-2648.2010.05551.x>.
13. An, R.; Shen, J.; Li, Y.; Bandaru, S. Projecting the Influence of Global Warming on Physical Activity Patterns: A Systematic Review. *Curr. Obes. Rep.* **2020**, *9* (4), 550–561. <https://doi.org/10.1007/s13679-020-00406-w>.
14. Löhmus, M. Possible Biological Mechanisms Linking Mental Health and Heat—A Contemplative Review. *Int. J. Environ. Res. Public Health* **2018**, *15* (7), 1515. <https://doi.org/10.3390/ijerph15071515>.
15. Sayers, P. B.; Horritt, M. S.; Penning-Rowsell, E.; McKenzie, A. Climate Change Risk Assessment 2017 Projections of Future Flood Risk in the UK, 2017. <https://www.theccc.org.uk/wp-content/uploads/2015/10/CCRA-Future-Flooding-Main-Report-Final-06Oct2015.pdf.pdf>.
16. Stanke, C.; Murray, V.; Amlôt, R.; Nurse, J.; Williams, R. The Effects of Flooding on Mental Health: Outcomes and Recommendations from a Review of the Literature. *PLoS Curr.* **2012**. <https://doi.org/10.1371/4f9f1fa9c3cae>.
17. Cruz, J.; White, P. C. L.; Bell, A.; Coventry, P. A. Effect of Extreme Weather Events on Mental Health: A Narrative Synthesis and Meta-Analysis for the UK. *Int. J. Environ. Res. Public Health* **2020**, *17* (22), 8581. <https://doi.org/10.3390/ijerph17228581>.
18. Tunstall, S.; Tapsell, S.; Green, C.; Floyd, P.; George, C. The Health Effects of Flooding: Social Research Results from England and Wales. *J. Water Health* **2006**, *4* (3), 365–380. <https://doi.org/10.2166/wh.2006.031>.

19. Tapsell, S. M.; Tunstall, S. M.; Penning-Rowsell, E. C.; Handmer, J. W. The Health Effects of the 1998 Easter Flooding in Banbury and Kidlington- Report to the Environment Agency, Thames Region, 1999.
20. Watts, G.; Battarbee, R. W.; Bloomfield, J. P.; Crossman, J.; Daccache, A.; Durance, I.; Elliott, J. A.; Garner, G.; Hannaford, J.; Hannah, D. M.; Hess, T.; Jackson, C. R.; Kay, A. L.; Kernan, M.; Knox, J.; Mackay, J.; Monteith, D. T.; Ormerod, S. J.; Rance, J.; Stuart, M. E.; Wade, A. J.; Wade, S. D.; Weatherhead, K.; Whitehead, P. G.; Wilby, R. L. Climate Change and Water in the UK – Past Changes and Future Prospects. *Prog. Phys. Geogr. Earth Environ.* **2015**, *39*(1), 6–28. <https://doi.org/10.1177/0309133314542957>.
21. Barker, L. J.; Hannaford, J.; Magee, E.; Turner, S.; Sefton, C.; Parry, S.; Evans, J.; Szczykulska, M.; Haxton, T. An Appraisal of the Severity of the 2022 Drought and Its Impacts. *Weather* **2024**, *79*(7), 208–219. <https://doi.org/10.1002/wea.4531>.
22. Vins, H.; Bell, J.; Saha, S.; Hess, J. The Mental Health Outcomes of Drought: A Systematic Review and Causal Process Diagram. *Int. J. Environ. Res. Public. Health* **2015**, *12*(10), 13251–13275. <https://doi.org/10.3390/ijerph121013251>.
23. Mathew, L. Coping with Shame of Poverty: Analysis of Farmers in Distress. *Psychol. Dev. Soc.* **2010**, *22*(2), 385–407. <https://doi.org/10.1177/097133361002200207>.
24. Connecting Climate Minds. Global Research and Action Agenda for Climate Change and Mental Health. <https://reader.connectingclimateminds.org/Appendices#6.-applying-the-global-research-agenda:-population-groups,-mental-health-challenges-and-extreme-weather-and-climate-events>.
25. Dodd, S.; Davies, J.; Butterfield, S.; Kragh-Furbo, M.; Morris, A.; Brown, H. Lived Experience of Climate Change and The Impact on Health and Health Inequalities: A Systematic Review of Qualitative Studies from the UK. May 14, 2023. <https://doi.org/10.31223/X5SH47>.
26. Ebi, K. L.; Paulson, J. A. Climate Change and Children. *Pediatr. Clin. North Am.* **2007**, *54*(2), 213–226. <https://doi.org/10.1016/j.pcl.2007.01.004>.
27. Palmer, D.; Ward, K. ‘Lost’: Listening to the Voices and Mental Health Needs of Forced Migrants in London. *Med. Confl. Surviv.* **2007**, *23*(3), 198–212. <https://doi.org/10.1080/13623690701417345>.
28. Comtesse, H.; Ertl, V.; Hengst, S. M. C.; Rosner, R.; Smid, G. E. Ecological Grief as a Response to Environmental Change: A Mental Health Risk or Functional Response? *Int. J. Environ. Res. Public. Health* **2021**, *18*(2), 734. <https://doi.org/10.3390/ijerph18020734>.
29. Kurth, C.; Pihkala, P. Eco-Anxiety: What It Is and Why It Matters. *Front. Psychol.* **2022**, *13*. <https://doi.org/10.3389/fpsyg.2022.981814>.
30. Boluda-Verdú, I.; Senent-Valero, M.; Casas-Escolano, M.; Matijasevich, A.; Pastor-Valero, M. Fear for the Future: Eco-Anxiety and Health Implications, a Systematic Review. *J. Environ. Psychol.* **2022**, *84*, 101904. <https://doi.org/10.1016/j.jenvp.2022.101904>.
31. Cianconi, P.; Betrò, S.; Janiri, L. The Impact of Climate Change on Mental Health: A Systematic Descriptive Review. *Front. Psychiatry* **2020**, *11*, 74. <https://doi.org/10.3389/fpsyg.2020.00074>.
32. Romanello, M.; McGushin, A.; Napoli, C. D.; Drummond, P.; Hughes, N.; Jamart, L.; Kennard, H.; Lampard, P.; Rodriguez, B. S.; Arnell, N.; Ayeb-Karlsson, S.; Belesova, K.; Cai, W.; Campbell-Lendrum, D.; Capstick, S.; Chambers, J.; Chu, L.; Ciampi, L.; Dalin, C.; Dasandi, N.; Dasgupta, S.; Davies, M.; Dominguez-Salas, P.; Dubrow, R.; Ebi, K. L.; Eckelman, M.; Ekins, P.; Escobar, L. E.; Georgeson, L.; Grace, D.; Graham, H.; Gunther, S. H.; Hartinger, S.; He, K.; Heaviside, C.; Hess, J.; Hsu, S.-C.; Jankin, S.; Jimenez, M. P.; Kelman, I.; Kiesewetter, G.; Kinney, P. L.; Kjellstrom, T.; Kniveton, D.; Lee, J. K. W.; Lemke, B.; Liu, Y.; Liu, Z.; Lott, M.; Lowe, R.; Martinez-Urtaza, J.; Maslin, M.; McAllister, L.; McMichael, C.; Mi, Z.; Milner, J.; Minor, K.; Mohajeri, N.; Moradi-Lakeh, M.; Morrissey, K.; Munzert, S.; Murray, K. A.; Neville, T.; Nilsson, M.; Obradovich, N.; Sewe, M. O.; Oreszczyn, T.; Otto, M.; Owfi, F.; Pearman, O.; Pencheon, D.; Rabbaniha, M.; Robinson, E.; Rocklöv, J.; Salas, R. N.; Semenza, J. C.; Sherman, J.; Shi, L.; Springmann, M.; Tabatabaei, M.; Taylor, J.; Trinanes, J.; Shumake-Guillemot, J.; Vu, B.; Wagner, F.; Wilkinson, P.; Winning, M.; Yglesias, M.; Zhang, S.; Gong, P.; Montgomery, H.; Costello, A.; Hamilton, I. The 2021 Report of the Lancet Countdown on Health and Climate Change: Code Red for a Healthy Future. *The Lancet* **2021**, *398*(10311), 1619–1662. [https://doi.org/10.1016/S0140-6736\(21\)01787-6](https://doi.org/10.1016/S0140-6736(21)01787-6).

33. Hickman, C.; Marks, E.; Pihkala, P.; Clayton, S.; Lewandowski, R. E.; Mayall, E. E.; Wray, B.; Mellor, C.; Van Susteren, L. Climate Anxiety in Children and Young People and Their Beliefs about Government Responses to Climate Change: A Global Survey. *Lancet Planet. Health* **2021**, *5* (12), e863–e873. [https://doi.org/10.1016/S2542-5196\(21\)00278-3](https://doi.org/10.1016/S2542-5196(21)00278-3).
34. Lawrance, E. L.; Jennings, N.; Kioupi, V.; Thompson, R.; Diffey, J.; Vercammen, A. Psychological Responses, Mental Health, and Sense of Agency for the Dual Challenges of Climate Change and the COVID-19 Pandemic in Young People in the UK: An Online Survey Study. *Lancet Planet. Health* **2022**, *6* (9), e726–e738. [https://doi.org/10.1016/S2542-5196\(22\)00172-3](https://doi.org/10.1016/S2542-5196(22)00172-3).
35. Croasdale, K.; Grailey, K.; Jennings, N.; Mole, J.; Lawrance, E. L. Planning for the Perfect Storm: Perceptions of UK Mental Health Professionals on the Increasing Impacts of Climate Change on Their Service Users. *J. Clim. Change Health* **2023**, *13*, 100253. <https://doi.org/10.1016/j.joclim.2023.100253>.
36. Corvalan, C.; Gray, B.; Villalobos Prats, E.; Sena, A.; Hanna, F.; Campbell-Lendrum, D. Mental Health and the Global Climate Crisis. *Epidemiol. Psychiatr. Sci.* **2022**, *31*, e86. <https://doi.org/10.1017/S2045796022000361>.
37. United Kingdom Parliament. *Mental Health Act, 2007*. https://www.legislation.gov.uk/ukpga/2007/12/pdfs/ukpga_20070012_en.pdf.
38. United Kingdom Parliament. *Climate Change Act, 2008*. https://www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf.
39. Net Zero Strategy: Build Back Greener, 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf (accessed 2024-09-13).
40. Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice; Kabisch, N., Korn, H., Stadler, J., Bonn, A., Eds.; Theory and Practice of Urban Sustainability Transitions; Springer International Publishing: Cham, 2017. <https://doi.org/10.1007/978-3-319-56091-5>.
41. Alford, J.; Massazza, A.; Jennings, N. R.; Lawrance, E. Developing Global Recommendations for Action on Climate Change and Mental Health across Sectors: A Delphi-Style Study. *J. Clim. Change Health* **2023**, *12*, 100252. <https://doi.org/10.1016/j.joclim.2023.100252>.
42. Godden, N. J.; Farrant, B. M.; Yallup Farrant, J.; Heyink, E.; Carot Collins, E.; Burgemeister, B.; Tabeshfar, M.; Barrow, J.; West, M.; Kieft, J.; Rothwell, M.; Leviston, Z.; Bailey, S.; Blaise, M.; Cooper, T. Climate Change, Activism, and Supporting the Mental Health of Children and Young People: Perspectives from Western Australia. *J. Paediatr. Child Health* **2021**, *57* (11), 1759–1764. <https://doi.org/10.1111/jpc.15649>.
43. What Happens When Climate Change and the Mental-Health Crisis Collide? *Nature* **2024**, *628* (8007), 235–235. <https://doi.org/10.1038/d41586-024-00993-x>.
44. Lawrance, D. E.; Thompson, R.; Fontana, G.; Jennings, D. N. The Impact of Climate Change on Mental Health and Emotional Wellbeing: Current Evidence and Implications for Policy and Practice, 2021. <https://spiral.imperial.ac.uk/entities/publication/5c110007-65ec-4b10-ba93-726d51b5e568>.