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Climate change and neurological diseases: report from the Hot Brain 2: Climate Change and Brain Health meeting, 2024

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As an introduction to this series and an example of the scope of work in this important area, we provide a report of an international multidisciplinary meeting that took place at the University College London (UCL) Queen Square Institute of Neurology on 16 May 2024.

While climate change affects everyone, people with neurological diseases are among those most vulnerable to its health impacts. Recognising these concerns, the world's first conference on climate change and neuroscience, 'Hot Brain', was held at UCL in May 2023.[1] The second in this series, 'Hot Brain 2: Climate Change and Brain Health', organised jointly with *The Lancet Neurology*, addressed further important aspects of climate change impacts on neurological diseases.

The sessions started with personal accounts from individuals who related their lived experience of neurological health issues caused or exacerbated by climate change. OJ, a medical student, described how, even as a very athletic young individual, he suffered from recurrent exercise-induced heat illness while competing in running events on unseasonally warm days. He emphasised the lack of readiness within the current UK healthcare system to handle anticipated increases in heat-related illnesses. JAt, a teacher and highly experienced athlete, with no prior heat-related issues and intensive pre-marathon training, recounted his experience during a late summer marathon. Despite feeling well initially, he collapsed at mile 24 with heat illness that was extremely challenging to manage, requiring induced coma. Of concern, JAt has noted subtle cognitive impairment and reduced cognitive stamina since the event. Both individuals related serious impacts of unseasonal temperatures: they are healthy individuals generally able to cope with increased temperatures and exertion, until on one occasion, so far unpredictably, they suddenly could not. At the moment when that happened, civilian healthcare services were found to be insufficiently experienced and often inadequately prepared. AA (University of Edinburgh, Scotland) reported on the experiences of people with epilepsy under climate change in sub-Saharan Africa. He reported both a correlation between higher temperatures and seizure aggravation, and a heightened risk of developing epilepsy, partly due to shifting regional risks for malaria With the changing climate. He provided examples from Malawi, Lesotho and Kenya, noting the rise in hospital admissions during hotter months due to climate-related factors. AA described the real-world observation of a pernicious cycle, with the climate crisis affecting neurological health, further compromising the ability of individuals with chronic diseases to cope with climate change. Additionally, he discussed how existing regional challenges, like medication access, are worsened by climate change, demonstrating the multilayered impacts of climate change.

The first session of the day, entitled 'The Impact of Climate Change', explored the consequences of climate change on the planet and human health, with a contextualising introduction by LV (UCL, UK) which focused on human rights, equality and climate justice. Climate scientist MM (UCL, UK) described the current parlous state of

affairs: 2023 was the hottest year on record,[2] accompanied by many severe adverse weather events globally. In 2024, the number of extreme weather events around the globe continues to grow, with heatwaves across South and Southeast Asia, severe flooding in Brazil, Kenya, Central Europe and the United Arab Emirates, and wildfires across Canada and southern Europe. Climate change is not a distant existential threat to humanity: communities around the world are struggling with unprecedented challenges today. He stressed the urgent need for proactive measures and both collaborative and individual actions in transitioning towards a low-carbon future. MR (Executive Director of the Lancet Countdown, UCL, UK) delineated health impacts of climate change, with resultant economic and workforce impacts of heat exposure, particularly in sectors like agriculture and outdoor labour. She emphasised the significant impacts of extreme weather events on mental health. Despite these challenges, only 50% of even well-resourced countries (those with a very high Human Development Index) have weather-health warning systems in place currently.[3] Paradoxically, if the global healthcare sector were a nation, it would be the fifth largest greenhouse gas emitter[4]: the sector thus has critical roles in addressing climate change, both as service provider and greenhouse gas emitter. Services will need to build resilience and preparedness to deliver healthcare in a changing world. Focusing these considerations onto neurological conditions, SS (UCL, UK) related the evidence for adverse impacts of climate change, as measured through temperature and humidity variation, including seasonal variation, or the occurrence of adverse weather events, on certain neurological conditions, noting that there is also an urgent need for more systematic, disease-focused research.[5]

The second and third sessions of the meeting explored the multiple interacting ways climate change compromises brain function. SH (London School of Hygiene & Tropical Medicine, UK) highlighted the complex pathways linking climate change to health at population level, with some particularly concerning implications for the developing brain during pregnancy.[6] JB (University of Sheffield, UK) described the impact of temperature changes, neurovascular coupling and breakdown, and epilepsy in a rodent model, illustrating how ambient temperature can directly influence brain excitability.[7] KCD (University of Vienna, Austria) discussed her recent perspective publication which outlines the reciprocal relationship between the changing environment and health behaviours, illuminating the multifaceted impacts of climate change on brain health outcomes, and how neuroscience could be applied directly to promote pro-environmental behaviours.[8] CH (London School of Economics, UK), using the 2022 UK summer heatwave as an example, focused on responses to heat risk, emphasising the urgent need for enhanced preparedness, improved governance and infrastructure changes to adapt to heat-related challenges.[9] CCF (Emory University, USA) discussed temperature effects on brain function, emphasising the critical importance of maintaining optimal body and brain temperatures for improved cognitive outcomes after injury, and highlighted how brain temperature can be quantified from MRI datasets.[10 11] D-JD (University of Surrey, UK) focused on sleep quality and underscored the susceptibility of sleep patterns to the adverse effects of rising temperatures, particularly in older adults and those with dementia, highlighting sleep patterns that are particularly important to preserve, and pointing out how climate change and environmental degradation are joint threats to this vital physiological function.[12 13] LP (Brighton and Sussex Medical School, UK) considered climate change impacts on mental health, noting diverse environmental factors contributing to psychiatric conditions. Together, these presentations brought out pervasive impacts of the changing climate on human neurological health. Further papers in this series develop this critical theme.

The last session of the conference put forward potential strategies to tackle aspects of climate change effects on brain health. KE (University of Washington, USA) explained the importance of interdisciplinary efforts in exploring environmental effects on infectious diseases affecting the brain, noting, for example, that the warming climate is a key driver behind the spread of Lyme disease and dengue fever across the USA.[14] SC (College of Wooster, USA) shared concerns about climate anxiety and its impacts on mental health and behaviours (such as doubts about the value of undertaking education, and making career choices, in the context of the climate crisis) and the link with neurological diseases.[15] She underlined the therapeutic importance of constructive hope that could be supported with protective actions towards the environment to reduce climate anxiety. The last two speakers focused on the central role of research in the understanding of climate change impacts and explored solutions for its challenges. Paula Williams (University of Liverpool, UK) discussed 'greener trials': clinical trials have a large global carbon footprint,[16 17] with over 35 000 new trials listed on ClinicalTrials.gov for 2023 alone. More environmentally sustainable trials can be achieved through faster recruitment, lighter trial materials and web-based data entry. JAl (UK Research and Innovation, UK) presented collaborative work between funders, universities and other stakeholders which has led to a concordat on environmental sustainability in research practice. While the concordat is a voluntary agreement that recognises that all parts of the sector have a role to play in embedding sustainability into the way we carry out research, some UK-based funders have responded by requiring applicants to demonstrate the sustainability credentials of their research proposals, and this practice is likely to extend to many more funding bodies.

We are only just beginning to realise the extent and complexity of the effects of climate change on brain health and neurological disorders. While there is evidence, for example, of temperature-related effects on some conditions, such as dementia and some psychiatric conditions,[5] much more research is needed. Climate change has

complicated direct consequences, and complex indirect effects through connections with other risk factors for brain health, such as pollution, environmental degradation, loss of biodiversity and socioeconomic deprivation. Of particular concern, the detrimental outcomes on neurological diseases may be a foretaste of climate effects on the healthy brain—for all of us.

Everyone thus has a role to play to tackle climate change and adapt to its inevitable consequences. 'The Hot Brain' conference series, now planning a third meeting (20 May 2025), plays an important role, as do other efforts such as this series, in promoting research, raising awareness and taking action against climate change.

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