The hot brain: practical climate change advice for neurologists

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Abstract

"We are called to be architects of the future, not its victims" – Buckminster Fuller

People with chronic neurological conditions may be vulnerable to change and less able to manage its demands: neurological diseases are amongst the most burdensome. Whether climate change has particular effects on specific neurological diseases or not, the known impaired resilience to change affecting people with neurological diseases requires neurologists to have awareness of potential climate impacts and their management. Preparedness should include understanding of general national and local alerts and action systems, and the ability to advise patients about managing extreme weather events, particularly heatwaves, but also floods and cold snaps. At the same time, more research is needed into the particular consequences of climate change on specific neurological diseases. Climate change is a serious health care issue, requiring the neurological community to respond as it would, or did, to other serious challenges, such as COVID-19. As disease experts, we all have a role to play.

Climate change: an existential threat here now

Human impacts on the ecology and geology of the entire planet are now so great that they are measurable, and have led to the declaration of a new geological epoch – the Anthropocene, with climate change a key component. Our climate is changing around us, now. Early July 2023 was marked by the three highest world average surface temperatures since records began, of 17.01°C, 17.18°C and 17.23°C[1]. The atmospheric CO_2 level is at its highest for nearly a million years, and more than 50% higher than pre-industrial times: in May 2023, CO_2 peaked at 424.0 parts per million (ppm).

We are not used to these metrics: they are difficult to grasp. Consider an analogy. Normal blood pH is around 7.4, equating to a blood hydrogen ion concentration of ~$4x10^{-8}$ molar. Doubling the blood hydrogen ion concentration, conceptually as fundamental a change as that happening to our world currently, would lead to a blood pH of around 7.1, with complicated clinical consequences including drowsiness, stupor, coma, and death. Which of us would watch a patient's pH falling in front of our eyes to this level and not act, not admit them to ITU and not get all our colleagues involved to do something? What are we doing about an effect of equivalent magnitude, complexity and threat to life itself?

For a more formal perspective, an excellent digestible summary of the complexity of climate change is provided by the Royal Society [2]. The Earth's climate is warmed by absorbing solar energy, which hits the Earth, and is radiated back into the atmosphere at longer wavelengths. 'Greenhouse gases' in the atmosphere itself absorb this energy and radiate it in all directions, including back down to the Earth: this effect has enabled the development and survival of life on our planet. Greenhouse gases include water vapour, carbon dioxide, methane, and nitrous oxide (and now also anthropogenic anaesthetic gases, which are potent greenhouse gases) keeping the surface and lower atmosphere warm. Increasing the concentration of greenhouse gases amplifies the greenhouse effect – making the planet warmer. Carbon dioxide concentrations are now higher than at any time over the last 800,000 years: the elevation, most marked over the last 50 years, is due to human activity, mainly the burning of fossil fuels. The Earth's global average surface air temperature has risen by >1°C since 1900. The Earth's surface area is $5.1x10^{14}m^2$ – so whilst a number like 1°C may not sound like much, it represents an enormous amount of additional heat in the system. This extra heat has profound and complex consequences in a planetary system that has not exceeded relatively narrow bounds for

time over an evolutionary scale. Global concern about climate change led to the Paris Agreement[3] which established a global framework to avoid dangerous climate change by limiting global warming to less than 2°C and intending to keep it within 1.5°C. The Agreement has been ratified by every country except Iran, Libya and Yemen, and aims to bolster national abilities to deal with the consequences of climate change. The Conference of the Parties (COP) is the main decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC), encompassing all countries that are Parties to the UNFCCC; COP assesses how well measures taken to limit climate change by the Parties match up to the overall goal of the UNFCCC, and is a venue where decisions are made. We are not doing well in this evaluation. Even if every new pledge made at the Glasgow COP26 climate negotiations in 2022 were met, the average global surface air temperature would rise 2·4℃-2·7℃ by 2100[4] exposing more than 3 billion people to mean average temperatures >29°C, with extreme heat events, like heatwaves, affecting far more.

High temperatures and heatwaves affect health. For example, recent European heatwaves were associated with thousands of excess deaths, causes of which included heatstroke and aggravation of existing conditions. Deaths directly due to adverse weather events are likely to be underestimated[5].

Climate Change and the nervous system: why we need to pay attention

Thermoregulation is a neural process

Under normal circumstances, humans maintain their body temperature within a narrow range that is optimal for protein integrity and function. One line of thinking suggests that evolution from early mammals to modern humans required, amongst many other steps, brain-led coordination of mechanisms permitting endothermic homeothermal life, balancing heat generation and heat loss, and producing a warm environment in which levels of neuronal activity did not depend on the external temperature, in turn generating advantages over ectothermal lifeforms (e.g. reptiles) and allowing occupation of different niches, such as hunting in non-forest environments. Running after prey required many adaptations. Whatever its origin, thermoregulation is a neurally-driven process[6] and is complicated[7,8]. Temperature-sensitive neurons are everywhere in the body (including the brain). The limbic system and anterior hypothalamus receive sensory inputs from these detectors via the spinal cord. There follows neural coordination of behavioural and autonomic physiological systems that activate warming (e.g. through shivering) or cooling (through cutaneous vasodilation and sweat production) as needed; local (skin) reflexes also operate. Other inputs that influence activity of temperature-sensitive systems include interleukin-1 and prostaglandin E, glucose and ion concentrations, osmolality and sex hormones. Response systems need muscle engagement, vasoactivity, and sweating. When temperature regulation fails, for example in heatstroke, other neural structures, such as the cerebral cortex, thalamus, basal ganglia and cerebellum[9,10], are also involved through multifactorial pathophysiology, sometimes constituting a posterior reversible encephalopathy syndrome [10].

Disordered thermoregulation in neurological disease

Because neural structures are central to thermoregulation, it is unsurprising that neurological diseases may compromise thermoregulation – and therefore undermine the ability to cope with rising temperatures and, especially, heatwaves. Disordered thermoregulation has been shown in several neurological diseases, including multiple sclerosis, synucleinopathies, Alzheimer's disease, spinal cord and autonomic dysfunction and peripheral neuropathies of a wide range of causes[6], and

is suspected to affect people with a number of rare neurogenetic conditions, such as Dravet syndrome[11], Phelan-McDermid syndrome[12], and many others. High ambient temperatures have been shown to aggravate symptoms in dementia, Parkinson's disease, multiple sclerosis, migraine and some epilepsies. Many medications directly or indirectly compromise thermoregulatory capacity[13-15], for example antipsychotic and anticholinergic agents, some antiseizure medications[16,17], and diuretics[18]. If thermoregulation is disordered, the function of temperature-sensitive components of the nervous system may, in turn, be disrupted. For example, ion channels, central to neuronal activity, demonstrate exquisite sensitivity to ambient temperature[19], and this effect also extends to channels mutated due to disease-causing genetic variants[20].

Vulnerability to adverse weather and climate change

Coping with temperature extremes, both high (which will become the greater challenge with global warming) and low, requires specific responses by humans. Responses may include donning or doffing clothing, moving to warmer or cooler environments, activation of external temperature-regulating systems, as well as autonomous measures, such as cutaneous vasodilation, evaporative cooling through sweat production, or shivering and non-shivering thermogenesis[6]. Environmental humidity multiplies the physiological stress of higher temperature, disrupting evaporative heat loss. Any of these processes might be compromised in neurological disease, quite separately from the presence or absence of compromised thermoregulation. For example, people with cognitive impairment, of any cause, may not take necessary behavioural actions, or may not be able to articulate their need to do so. Heat-induced weakness in multiple sclerosis may prevent movement to a cooler environment. Some people tolerate temperature extremes better for various reasons[21], with evidence that physical fitness improves acclimation capacity[6]. The built environment can amplify the impact of heatwaves, effects of which may last longer indoors than they do outdoors. Straitened economic circumstances due to loss of earnings related to neurological (and other illnesses) may reduce the ability to take countermeasures to climate challenges. Supply chains for essential medications, and healthcare services themselves, may be compromised by extreme temperatures, or climate-change related floods.

Climate Change and the neurology community: what we can do

The broader picture

Climate change is a current and growing threat to health[22]. Its pervasive consequences require us to prepare for both imminent acute challenges, which in the UK are mainly heatwaves, cold spells and floods, as well as longer term shifts in weather patterns and other extreme weather events. In addition to prominent calls for more attention and more action with regard to the health effects of climate change, for example from the Lancet Countdown[23], many governments have already developed, and continue to evolve, plans for health responses to climate change. In the UK, the Greener NHS programme is an example of longer-term planning to reduce the contributions of health care itself to climate change[24].

Plans are in place for acute challenges we have already faced and will continue to experience with increasing frequency and severity. There is an Adverse Weather and Health Plan (AWHP)[25], under the responsibility of the UK Health Security Agency (UKHSA), as part the National Adaptation Programme[26].

Whether or not it turns out that climate change carries specific risks for people who already have neurological diseases[27], or increases the risk of people acquiring neurological diseases, climate change will in any case have effects on the entire population, and especially on vulnerable groups such as the very young, the very old, and those with pre-existing medical conditions. It is therefore incumbent on us to think about climate change effects on people with neurological diseases, who may already carry significant health burdens. Our actions can follow generic guidance[28], but can also be tailored to individuals and diseases based on our shared expertise in those diseases, with examples from other disease areas already dealing with heatwaves[29]. As clinicians, we can read the room and provide information with sensitivity to the individual context[30]. Moreover, healthcare professionals are consistently rated as amongst the most trusted workers: we can contribute to actions against climate change at every level, from making climate change a component of the conversation with people with neurological diseases as part of duty of care, to extending that obligation to other forums for population and public health. Such action need not be political: promoting awareness, research and action around climate change is legitimately as much part of our daily work as advising patients about the adverse consequences of smoking, obesity and substance abuse. We already do this, typically through raising awareness, promoting actions and, especially, empowerment: we all know lecturing rarely works to achieve meaningful behaviour change. Such efforts are about health, health improvement and preventing health decline and aggravation of inequity due to the additional, predictable and enormous challenge from climate change. Promoting a healthier environment, and health equity, has long been a valid medical pursuit. As more research is undertaken into the effects on neurological diseases of climate change, we can make discussions at every level more specific and targeted, whilst retaining a broader advocacy role. Healthcare systems are themselves prominent generators of greenhouse gases. Whilst some national systems have declared their intent to become net zero emitters of greenhouse gases, emissions from others continue to rise. But healthcare systems are powerful and innovative: they can take a lead and learn from others at every level: for example, we can advocate for better environments and nutrition in hospital – for patients and staff; we can lobby for greener transport for all (5% of all road traffic in the UK is linked to the NHS); we can retain and improve telemedicine, learning from the pandemic, including maintaining practice that had had to become adapted to remote assessment at that time[31].

Practical actions

The Climate Change Act 2008 mandates responsibilities for actions to adapt to climate change. The Adverse Weather and Health Plan (AWHP)[25], though probably not familiar to most of us, is a rich resource not only describing the multi-agency plans for response to climate change, in particular for heat, cold and flooding, but also providing links to useful documents. Its goals, such as preventing increase in years of life lost due to adverse weather events, preventing associated mortality and morbidity, are stark declarations of the present dangers of climate change. Its objectives include improvement of preparedness, resilience and response to adverse weather events. The AWHP is the responsibility of the UKHSA Extreme Events and Health Protection team, within the UKHSA Centre for Climate and Health Security, and is intended not only to be relevant currently, but also for the long term. The related guidance describes actions needed before and during adverse weather events, for which there is a requirement for national and local organisations, including NHS bodies, to have contemporary delivery plans. Notably, section 5.4.2 states “All health and social care staff should be prepared for extreme heat and cold weather events and understand their impacts on health. They should understand the actions which need to be taken individually and organisationally to ensure the safety and health of their clients and patients during such events and the preparations that need to be taken in advance. There is an ongoing need to ensure that all staff working with patients and clients are trained both to understand the impact of extreme heat and cold on bodily

functions and to be alert to the physical and mental signs of impact on health. All staff should be made aware of the new weather and health alerting service and the good practice actions which follow on from these (introduced from summer 2023)"[25]. The CQC also considers adverse weather, and related planning and preparedness to its constituency, under regulations 12, 15 and 17. Related to the AWHP, a host of resources are available (Table 1).

Practical steps are offered in Tables 2 and 3. Many people with neurological diseases will already have specific advice provided in case of particular circumstances, for example rescue protocols providing advice on the emergency or supplemental use of benzodiazepines for people with epilepsy: such protocols should be adapted to include advice on management during adverse weather events, ideally with relevance to the predicted severity and patient's location. As disease experts, it falls to us to provide such information based on our understanding of the patient's condition and the best currently-available evidence for potential, or observed, effects of climate change (as we did for COVID-19). Be ready to speak with patients about climate change (see Box 1). Consider giving advice on storage of medications[32-34] (see Tables 2 and 3), as well as organisational preparedness for supply chain disruptions.

Advice should be explicitly linked to early warning systems for health and weather. In the UK, the heat-health alert system operates from 1 June to 30 September, and the cold-health alert system from 1 November to 30 March, with additional weather warnings through the National Severe Weather Warning Service. In addition, the UKHSA may issue a National Patient Safety Alert or Urgent Public Health Message for particular, severe weather events. The Heat-Health Alerts platform has a colour-coded rating system[35]. The UKHSA also provides heat-related mortality reports[36].

Despite all these structures and policies, evidence-based information and advice specifically for people with neurological conditions remains sparse. Other than for stroke and neurological infections, particularly West Nile virus, there has been remarkably little published research. Existing data can be conflicting, and interpretation requires care and appreciation that the pace of climate change has been such that older papers may have been measuring outcomes related to climate circumstances that we have already surpassed. Even the magnitude of global and local temperature changes observed over the last 40-50 years, and the increasing frequency and severity of extreme weather events, may be relevant: preliminary data suggests that in vitro exposure of human brain cells to changes in ambient temperatures of just 2°C can alter the expression of 10% of the genome, whilst intraventricular CSF temperature may change by that amount (2°C) with ambient indoor seasonal temperature changes. This should push us to listen to, and enquire about, our patients' concerns and experiences – the evidence base may not yet exist that we consider necessary to 'underpin' belief in such reports, but that does not invalidate such observations, which are already being made by, and raising concern amongst, members of disease-specific charities. Surveys we have undertaken show that people with neurological conditions, their carers, neurological healthcare professionals and scientists are as concerned about climate change as the general population. Patient groups may already be taking their own action[11], including providing members funding for air conditioning – a potentially life-saving, acute, expedient measure, but one that is not a sustainable global long-term solution.

We need to imagine the shape of net-zero neurology, as part of the overall NHS commitment to net zero. We can make a difference: desflurane is an enormously potent greenhouse gas anaesthetic agent – the work of the anaesthetic community has led to its planned removal from NHS practice[37], the first drug to be decommissioned for the sake of the climate. There are likely to be many opportunities to undertake research to better inform practice: perhaps not all neurological conditions, or their subtypes, will experience detrimental effects from climate change and better

understanding disease-specific impacts should permit better targeting of limited resources. We can make a difference in our own spheres of influence: we are all likely to have to change something for the NHS net zero target to be met, and why not do so in ways that produce co-benefits? For example, could we shift clinics during heatwaves from unbearably hot rooms to the evening, making the all round effort needed, with health co-benefits for patients and staff?

Climate anxiety

Thinking seriously about climate change can itself cause anxiety, in patients, healthcare professionals – and even climate scientists. Climate anxiety is common, especially amongst the young[38]. Some have described the process as part of an individual climate journey. We should think how the next generations of neurologists will be able to practice and do so in a liveable world. There are ways to reduce climate anxiety (Table 4).

Conclusion

We are changing the Earth at rates and magnitudes beyond which most life can easily adapt. These changes are so big that they may feel beyond comprehension – or beyond our willingness to accept what is happening. But inaction is not an option. We have a duty of care to our patients and to our colleagues. Mitigating climate change has to be a governmental responsibility – but as healthcare professionals, we all have a powerful voice worth using. We have to educate ourselves, and advocate for our patients, at all levels. We have to learn how to talk about climate change – at all levels – but we are used to dealing with complicated issues and sharing information in sensitive, nuanced and appropriately-weighted dialogue. It is up to us to act in our own professional arena. To lead the lives we want to lead, we have to change the lives we are leading.

Key Points

- Climate change is happening and will have detrimental impacts on incidence and symptoms of neurological diseases, and mortality from many such conditions.
- National systems and local processes, including NHS action plans, are in place to provide alerts and support in the event of adverse weather events.
- Providing information, advice and comprehensive management plans for adverse weather events is part of the duty of care for all healthcare professionals, including neurologists.
- Neurologists should use their powerful voice for advocacy for patients against climate change because climate change will affect the health of most people with neurological diseases.

References

1. https://climatereanalyzer.org/clim/t2_daily/ (Accessed 10.07.23)
2. https://royalsociety.org/topics-policy/projects/climate-change-evidence-causes/basics-of-climate-change/ (Accessed 10.07.23)
3. https://unfccc.int/process-and-meetings/the-paris-agreement (accessed 10.07.23)
4. Climate action tracker. https://climateactiontracker.org/publications/glasgows-2030-credibility-gap-net-zeros-lip-service-to-climate-action/ (Accessed 10.07.23)

5. Longden T, Quilty S, Haywood P, *et al.* Heat-related mortality: an urgent need to recognise and record. Lancet Planet Health. 2020 May;4(5):e171.
6. Cramer MN, Gagnon D, Laitano O, *et al*. Human temperature regulation under heat stress in health, disease, and injury. Physiol Rev. 2022 Oct 1;102(4):1907-1989.
7. Xu X, Rioux TP, Castellani MP. Three dimensional models of human thermoregulation: A review. J Therm Biol. 2023 Feb;112:103491.
8. Henderson MET, Halsey LG. The metabolic upper critical temperature of the human thermoneutral zone. J Therm Biol. 2022 Dec;110:103380.
9. Jones DG, Ramineni A, Lerner DP, *et al*. Hyperthermic Brain Injury: Characteristic Magnetic Resonance Imaging Findings and Implications for Pathophysiology. Neurohospitalist. 2022 Jul;12(3):575-576.
10. Shimada T, Miyamoto N, Shimada Y, *et al*. Analysis of Clinical Symptoms and Brain MRI of Heat Stroke: 2 Case Reports and a Literature Review. J Stroke Cerebrovasc Dis. 2020 Feb;29(2):104511.
11. Bjurulf B, Reilly C, Hallböök T. Caregiver reported seizure precipitants and measures to prevent seizures in children with Dravet syndrome. Seizure. 2022 Dec;103:3-10.
12. Srivastava S, Sahin M, Buxbaum JD, *et al.* Updated consensus guidelines on the management of Phelan-McDermid syndrome. Am J Med Genet A. 2023 Jul 1. doi: 10.1002/ajmg.a.63312
13. Cuddy ML. The effects of drugs on thermoregulation. AACN Clin Issues. 2004 Apr-Jun;15(2):238-53.
14. Layton JB, Li W, Yuan J, *et al*. Heatwaves, medications, and heat-related hospitalization in older Medicare beneficiaries with chronic conditions. PLoS One. 2020 Dec 10;15(12):e0243665.
15. Stöllberger C, Lutz W, Finsterer J. Heat-related side-effects of neurological and non-neurological medication may increase heatwave fatalities. Eur J Neurol. 2009 Jul;16(7):879-82.
16. Borron SW, Woolard R, Watts S. Fatal heat stroke associated with topiramate therapy. Am J Emerg Med. 2013 Dec;31(12):1720.e5-6.
17. Knudsen JF, Thambi LR, Kapcala LP, *et al*. Oligohydrosis and fever in pediatric patients treated with zonisamide. Pediatr Neurol. 2003 Mar;28(3):184-9.
18. Bongers KS, Salahudeen MS, Peterson GM. Drug-associated non-pyrogenic hyperthermia: a narrative review. Eur J Clin Pharmacol. 2020 Jan;76(1):9-16.
19. Fletcher EV, Kullmann DM, Schorge S. Alternative splicing modulates inactivation of type 1 voltage-gated sodium channels by toggling an amino acid in the first S3-S4 linker. J Biol Chem. 2011 Oct 21;286(42):36700-8.
20. Peters C, Rosch R, Hughes E. *et al*. Temperature-dependent changes in neuronal dynamics in a patient with an SCN1A mutation and hyperthermia induced seizures. Sci Rep. 2016 Sep; 6, 31879.
21. Schneider SM. Heat acclimation: Gold mines and genes. Temperature (Austin). 2016 Sep 27;3(4):527-538.
22. Costello A, Romanello M, Hartinger S, *et al*. Climate change threatens our health and survival within decades. Lancet. 2023 Jan 14;401(10371):85-87.
23. Romanello M, Di Napoli C, Drummond P, *et al*. The 2022 report of the Lancet Countdown on health and climate change: health at the mercy of fossil fuels. Lancet. 2022 Nov 5;400(10363):1619-1654. Erratum in Lancet. 2022 Nov 12;400(10364):1680. Erratum in: Lancet. 2022 Lancet. 2022 Nov 19;400(10365):1766.
24. https://www.england.nhs.uk/greenernhs/ (Accessed 10.07.23)

25. UK Health Security Agency. Adverse Weather and Health Plan. https://www.gov.uk/government/publications/adverse-weather-and-health-plan (Accessed 10.07.23)
26. Department for Environment, Food & Rural Affairs. Third National Adaptation Programme (NAP3) - GOV.UK (www.gov.uk) (Accessed 24.07.23)
27. Louis S, Carlson AK, Suresh A, *et al*. Impacts of Climate Change and Air Pollution on Neurologic Health, Disease, and Practice: A Scoping Review. Neurology 2023 Mar; 100(10):474-483.
28. https://www.metoffice.gov.uk/weather/warnings-and-advice/seasonal-advice/health-wellbeing/tips-for-keeping-older-people-cool (Accessed 10.07.23)
29. https://app.newspage.media/the-ed-society/news-story/no-sweat-why-the-heatwave-can-be-fatal-for-those-affected-by-rare-condition-ectodermal-dysplasia?fbclid=IwAR17HKNAe0g8VmZAn4zPtnPKCOYtiV40p2b6jRsaEAa_UFtvWd4kvCmjIy0 (Accessed 10.07.23)
30. https://blogs.bmj.com/bmj/2021/10/07/talking-to-patients-about-the-climate-emergency/ (Accessed 10.07.23)
31. Tarolli CG. Practicing in a Pandemic: A Clinician's Guide to Remote Neurologic Care. Neurol Clin Pract. 2021 Apr;11(2):e179-e188.
32. Itin C, Liani M, Zur M, *et al*. Stability of Diazepam Solution for Injection Following Long-Term Storage in an Ambient Temperature of the Mediterranean Climate. Pharm Res. 2021 Feb;38(2):361-367.
33. Cloyd JC, Gumnit RJ, Lesar TS. Reduced seizure control due to spoiled phenytoin capsules. Ann Neurol. 1980 Feb;7(2):191-3.
34. Crichton B. Keep in a cool place: exposure of medicines to high temperatures in general practice during a British heatwave. J R Soc Med. 2004 Jul;97(7):328-9.
35. Met Office. https://app.powerbi.com/view?r=eyJrIjoiZGI5MTA1NTEtZmE4NC00NTk3LTg5NjQtZjMyNDQ5YTgyMjI2IiwidCI6ImVlNGUxNDk5LTRhMzUtNGIyZS1hZDQ3LTVmM2NmOWRlODY2NiIsImMiOjh9 (Accessed 24.07.23)
36. UKHSA. Heat mortality monitoring reports - GOV.UK (www.gov.uk) (Accessed 24.07.23).
37. https://www.england.nhs.uk/greenernhs/2023/01/putting-anaesthetic-emissions-to-bed/ (Accessed 10.07.23)
38. Hickman C, Marks E, Pihkala P, *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-e873.

Further Reading

Maslin MA. How to save our planet. Penguin Life. Published: 2021. ISBN: 9780241472521

Competing Interests

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Tables

Table 1. Resources available for information, guidance and data on climate change and healthcare

Resource	Comments
https://www.metoffice.gov.uk/	Definitive, informative and comprehensive resource on the weather and climate change
https://www.gov.uk/government/publications/adverse-weather-and-health-plan	A broad and informative source of information about policies and guidance
https://www.gov.uk/government/publications/heat-mortality-monitoring-reports	Annual information on excess deaths during episodes of heat, informing public health actions
https://www.nhs.uk/conditions/heat-exhaustion-heatstroke/	Useful to share with patients, families and carers: symptoms, signs, immediate actions
https://www.nhs.uk/live-well/seasonal-health/heatwave-how-to-cope-in-hot-weather/	Useful to share with patients, families and carers: tips and actions
https://www.gov.uk/government/collections/hot-weather-and-health-guidance-and-advice	Lists information resources for professionals and the public
https://www.gov.uk/government/publications/hot-weather-and-health-supporting-vulnerable-people	Very useful set of documents with plentiful advice for a range of audiences
https://www.gov.uk/government/collections/cold-weather-plan-for-england	Cold weather advice resource
https://www.gov.uk/government/collections/flooding-health-guidance-and-advice	Flooding advice and guidance
https://www.metoffice.gov.uk/weather/warnings-and-advice/seasonal-advice/health-wellbeing/tips-for-keeping-older-people-cool	Additional information, useful for everyone, not just older individuals
https://www.gov.uk/government/publications/hot-weather-and-health-supporting-vulnerable-people/supporting-vulnerable-people-before-and-during-hot-weather-healthcare-professionals	Wide-ranging advice and resource hub
https://www.sps.nhs.uk/articles/storing-medicines-at-ambient-temperatures/	Informative document with practical advice, likely to be valuable for pharmacies, but also for neurologists advising patients
https://www.england.nhs.uk/greenernhs/	Portal for the ambitious net zero plans for the NHS in England
https://ukhealthalliance.org/	Organisation for health professionals, raising awareness, empowering and helping to influence the agenda
https://www.rcplondon.ac.uk/projects/royal-college-physicians-and-climate-action	Summarises the RCP's position

#ShowYourStripes	A simple, free graphic to bring home points about climate change and the need for urgent action

Table 2. Advice and guidance for patients with neurological diseases

Domain	Advice or guidance	Reference
Climate change information	Increasingly, neurologists will need to be able to discuss climate change with patients, families and carers. The UK is particularly at risk for adverse weather events, flooding and drought Direct carers and providers to existing resources.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7737930/ And see Table 3. https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-2022 https://www.gov.uk/government/publications/hot-weather-and-health-action-cards
Disease-specific concerns	There is a lack of data about specific consequences of climate change for particular neurological diseases in general, particularly for actions to be taken to reduce impacts. Ensure patients, families and carers are aware that some neurological conditions may have particular susceptibility to extreme weather events, such as people with autonomic dysfunction, disordered thermoregulation and some epilepsies.	Contribute to efforts to gather information Survey clinic populations using validated questionnaires for thermal comfort
Medication management	Little information on thermostability under extreme weather events; ensure information about storage is read.	https://www.sps.nhs.uk/articles/storing-medicines-at-ambient-temperatures/
Heatwave effects	Provide information to patients/families/carers, informed by clinical judgement on vulnerability Promote practices that assist cooling and night time sleep.	https://www.nhs.uk/conditions/heat-exhaustion-heatstroke/ https://www.nhs.uk/live-well/seasonal-health/heatwave-how-to-cope-in-hot-weather/ https://www.gov.uk/government/collections/hot-weather-and-health-guidance-and-advice

Cold spell effects	Cold spells may also occur as extreme weather events overall become more frequent.	https://www.nhs.uk/live-well/seasonal-health/keep-warm-keep-well/
Climate Anxiety	Assist patients experiencing climate anxiety.	https://www.rcpsych.ac.uk/improving-care/sustainability-and-mental-health/sustainability-resources
Promote health and wellbeing	Sustainable practice, reducing climate anxiety with environmental and mental health co-benefits.	https://sustainablehealthcare.org.uk/green-walking-guide https://www.who.int/europe/health-topics/environmental-health#tab=tab_1 https://londonplus.org/london-social-prescribing-network/social-prescribing-resources/social-prescribing-active-travel-toolkit https://www.gov.uk/government/publications/everybody-active-every-day-a-framework-to-embed-physical-activity-into-daily-life
Promote sustainable transport	Transport is the sector contributing to UK greenhouse gas emissions, and contributes to air pollution and reduced physical activity: promote sustainable transport, especially where possible on foot or bicycle.	https://www.gov.uk/government/publications/air-pollution-applying-all-our-health
Promote healthier diets and healthier homes	Benefits both for the environment and patient health.	https://www.gov.uk/government/publications/the-eatwell-guide https://bmjopen.bmj.com/content/10/8/e037554 https://www.e-lfh.org.uk/programmes/cold-homes/ https://www.nice.org.uk/guidance/NG6
Co-creation of climate change actions	There is a lack of engagement of physician-led organisations with patient and third sector groups.	We can learn from people with neurological diseases about managing under various challenges, such as not being able or allowed to drive

Table 3. What can we do as neurologists?

Domain	Current State or Action	Reference
Understand climate change impacts on health broadly	Inform yourself and keep up-to-date: the climate is changing faster than some models predicting, mandating regular learning.	https://www.gov.uk/government/publications/climate-change-applying-all-our-health/climate-and-health-applying-all-our-health https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(23)00087-6/fulltext https://www.e-lfh.org.uk/new-environmentally-sustainable-healthcare-elearning-is-available/
Understand climate change impacts on people with neurological diseases	Listen to the experience of patients; interpret and provide informed advice linked to adverse weather event resources. Regionalise and localise information using available resources.	https://www.climatejust.org.uk/map https://www.london.gov.uk/programmes-and-strategies/environment-and-climate-change/climate-change/climate-adaptation/climate-risk-map
Be informed about conditions related to climate change and adverse weather events	Heat exhaustion, heatstroke will become increasingly common. Diseases we have less commonly encountered may be seen (e.g. tick-borne encephalitis; arboviruses dengue, zika, yellow fever and chikungunya).	https://pubmed.ncbi.nlm.nih.gov/37260431/ https://researchportal.ukhsa.gov.uk/en/
Consider changes to individual patient emergency plans and longer term management	Provide advice proactively; direct patients/families/carers to relevant resources, for example heat-health alerts.	See Figure 1 and Table 2.
Work out climate change impacts on your own practice	There are co-benefits to more sustainable practice – such as reduced exposure to pollution, levels of	https://www.gov.uk/government/publications/air-pollution-applying-all-our-health https://www.susqi.org/ ; https://www.susqi.org/case-studies https://www.england.nhs.uk/greenernhs/whats-already-happening/pedal-power-for-cleaner-healthcare-delivery/

	which may be aggravated in heatwaves.	
Determine your own thermal comfort and that of your team and service	Use information to restructure service; be aware of environmental impacts on clinical tests. Improve local air quality.	Modest investment in CE-marked devices that monitor local temperature, humidity, CO_2 concentration. Share your results. https://www.actionforcleanair.org.uk/health/clean-air-hospital-framework
Contact your local green / sustainability champion – or become one	Other national professional organisations have worked to promote sustainability.	https://anaesthetists.org/Home/Resources-publications/Environment/Environmental-champions-network https://www.greenimpact.org.uk/giforhealth
Engage with your Trust's mandatory sustainability plan	NHS England, all trusts, Foundation trusts, and integrated care boards have a duty to contribute towards statutory emissions and environmental targets: find out your employer's plan and be part of the process.	https://www.england.nhs.uk/greenernhs/get-involved/organisations/
Set standards for sustainability as you do for clinical practice	Promote and permit climate change conversations; support your team and trainees; setting the tone and example in conversation around climate change and plant-based meals; not driving to work; reducing professional contributions to climate change – which meeting will help you or others? Are you going just	https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(22)00304-7/fulltext https://blogs.bmj.com/bmj/2021/06/07/infusing-climate-change-and-sustainability-into-the-medical-school-curriculum/ https://www.youtube.com/watch?v=9PTpylVotd8 https://www.prescqipp.info/our-resources/webkits/adherence-and-waste/

	because you always do? Can you attend remotely – still taking study leave and joining sessions properly? Reduce pharmaceutical burdens on the patient and on the environment. Rationalise prescriptions.	
Learn to discuss climate change with your patients	Clinicians remain trusted sources of information. Establish the best ways to convey climate change information. Consider who will be the most vulnerable in your practice.	https://blogs.bmj.com/bmj/2021/10/07/talking-to-patients-about-the-climate-emergency/ https://www.hsph.harvard.edu/chc/resources/climate-communication-tips/ https://blogs.bmj.com/bmj/2021/01/22/what-can-clinicians-say-to-patients-who-ask-about-climate-change/ https://ukhealthalliance.org/news-item/how-to-discuss-the-climate-crisis-with-patients/ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7737930/ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9029888/
Learn to advocate for action on climate change as a health measure at all levels	The NHS, at many levels, has a powerful advocacy voice in the local community.	https://climateoutreach.org/reports/how-to-have-a-climate-change-conversation-talking-climate/ https://www.health.org.uk/news-and-comment/charts-and-infographics/the-nhs-as-an-anchor-institution https://networks.sustainablehealthcare.org.uk/resources/sustainable-system-wide-commissioning-guide-ccgs
Join or support relevant networks	Both individual and collective actions are important, the latter providing mutual support.	Association of British Neurologists Sustainability Special Interest Group; https://www.bna.org.uk/about/policy/green-neuroscience/ https://networks.sustainablehealthcare.org.uk/networks?page=0
Contribute to research and promotion of neurology actions	Little is known about climate change impacts on most neurological diseases and sub-specialties.	Join efforts to increase knowledge. Email the author if you are interested to contribute to gathering neurological information on climate change

Table 4. Managing climate anxiety

Domain	Examples and references
Acknowledge feelings as a start to managing anxiety	https://www.mdpi.com/1660-4601/18/18/9636 Cunsolo, A., Ellis, N.R. Ecological grief as a mental health response to climate change-related loss. *Nature Clim Change* **8**, 275–281 (2018). https://doi.org/10.1038/s41558-018-0092-2
Take action – within your abilities	Adopt simple habits that contribute to empowerment, and reduce emissions, often bringing co-benefits. Fly less (is every conference abroad really essential to attend?); insulate your home; reduce food waste and energy consumption; eat a more plant-based diet; choose responsible banks (Triodos and The Cooperative stand out) and energy producers; install solar panels for hot water and electricity; cycle to work; take part in advocacy; donate. Focus on areas for your action. How can you best use your interests and abilities? Divide actions into small, medium and large – can you take one of each? There is still time to tackle climate change: remain hopeful. https://www.nature.com/articles/s41558-023-01617-4
Go outdoors	Reframe your approach to nature. Green spaces combat climate change and have health benefits, including helping to tackle climate anxiety. (https://www.wbur.org/radioboston/2021/09/08/pining-for-the-forest ; https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6553580/ ; https://doi.org/10.3389/fpsyg.2019.00722)
Share – concerns and responses	Speak about your concerns. Work with others (https://link.springer.com/article/10.1007/s12144-022-02735-6) Support others (https://www.rcpsych.ac.uk/mental-health/parents-and-young-people/young-people/eco-distress-for-young-people). Take an action pledge (https://climate-pact.europa.eu/pledges_en).
Look beyond the usual	Read about inspiring actions taken by those most at risk, especially those in the Global South, those with quieter voices and those habitually side-lined in the media. Consider the impact of the language used. https://unearthmag.com/2021/02/21/activism-in-the-global-south-unrecognized-climate-voices/ https://doi.org/10.1016/j.gloenvcha.2022.102555
Inform yourself – but also switch off	Whilst the choice of reliable sources, especially those with offers of solutions (e.g. https://www.wwf.org.uk/what-we-do/climate-change-and-energy) is important, it is also vital to periodically disconnect from what may seem like an endless litany of doom.

Figure Legend

Ideas for discussion of climate change in clinic