

26<sup>th</sup> November 2022

Dr Simon Quilty  
Specialist Physician  
C/o Purple House, Alice Springs

Thank you for your letter of 25 November 2022, asking me to provide answers to a number of questions set out.

I acknowledge for the purpose of Rule 31.23 of the Uniform Civil Procedure Rules 2005 that I have read the Expert Witness Code of Conduct in Schedule 7 to the said rules and agree to be bound by it.

Using the questions posed, my response is as follows:

**1. Your current occupation and employment**

Attached to this statement is a copy of my Curriculum Vitae, setting out my tertiary qualifications and work as a medical doctor in New South Wales and the Northern Territory.

Since August 2022, I have been employed as a Visiting Medical Officer (VMO) at Bellingen River District Hospital, NSW.

I continue to work as a visiting doctor in the Northern Territory and am currently contracted as an advisor to Purple House (Western Desert Nganampa Walytja Palyantjaku Tjutaku Aboriginal Corporation). I am also a Senior Staff Specialist at Alice Springs Hospital and Research co-Lead of the Central Australian Regional Health Service, completing my tenure this month and moving to an ongoing visiting medical officer contract at Alice Springs Hospital.

I am a Board Member and Chair of the Rural Specialist Group Board Member and Chair of the Rural Specialist Group Rural Doctors Association of Australia.

I have academic affiliation with the Australian National University.

## **2. Your tertiary qualification experience in medicine and the Northern Territory**

In 1997, I completed a Bachelor of mechanical and biomedical Engineering (B. Eng Hon1, 1997). I then worked with a biotech start-up in Sydney before undertaking a combined Medical Degree (MBBS) and Research Masters in Public Health at Sydney University (MPhilPH), qualifying with a dual degree from the University of Sydney in 2004.

The research I conducted for the MPhilPH was based with NSW Justice Health, and I spent two years undertaking research and clinical training at Long Bay Prison Hospital.

After qualifying, I moved to Darwin in late 2004 where I commenced working as a junior doctor, before completing another 4 years as a registrar in Darwin and Alice Springs.

I completed four years of physician training in Newcastle and received a fellowship as a General Physician with the Royal Australian College of Physicians in 2013.

I then became the first specialist doctor to work remotely in the NT when I commenced a general specialist service at Katherine Hospital, where I worked as the Head Physician until 2020. During this time, I commenced a cardiology service, a remote satellite oncology unit, a remote outreach program covering all communities of the Katherine region, a palliative care service, and developed five new registrar training posts at Katherine Hospital.

My health team and I received multiple awards for achievements in Katherine.

- 2017 - Medal for clinical services to rural and remote Australia, Royal Australian College of Physicians (RACP)
- TEHS Quality Award for Innovation for KH Remote Outreach service, Issued by NT Department of Health, TEHS · 2017
- TEHS Quality Award for Innovation for KH Remote Outreach service, Issued by NT Department of Health, TEHS · 2018
- Chief Minister's Award for Excellence in the Public Sector - Telehealth (co-lead), Issued by NT Department of Health · 2016
- Northern Territory Clinical Educator of the Year Award, Issued by Northern Territory Medical Education and Training Centre · 2016

I developed a comprehensive remote training pathway for medical students and physician trainees and have had academic postings with Menzies School of Health Research, Flinders University, and the Australian National University. From March to September 2019 I was on sabbatical at UCL studying Global Health and Climate Change.

I am involved in ongoing research implementing innovative social and technological solutions to the challenges of improving Indigenous health in Australia, particularly in relation to sustainable housing.

I moved to Alice Springs in early 2020 and commenced as Senior Staff Specialist and Director of Physician Education.

In 2021 I took on the role of Medical Advisor for Purple House, a remote dialysis provider in 19 remote communities across the north of Australia, and research lead at Central Australian Health Services. I also commenced in the role of Research co-lead for the Central Australian Region Health Service.

### **3. Reason for your interest in practicing medicine in the Northern Territory**

As a child aged between 4 and 10, my parents took the family on numerous extended holidays in the Northern Territory and around Australia. They were formative years for myself and my siblings and I vividly remember time visiting remote communities. My sole reason for being a doctor was to practice medicine in a way that would positively impact on Aboriginal Australians living remotely.

### **4. Your research interests, attaching any relevant articles**

As is clear from my background in engineering, medicine and public health, my research interests and expertise go beyond pure medicine. Public health policy refers to the laws, actions, and decisions made by Government and institutions, with the purpose of promoting general and specific health goals. This includes issues affecting education and housing. And in the remote NT, it is my opinion that there is a fundamental lack of 'home' for many people displaced on their ancestral lands – a safe place where individuals and families have agency

to live fulfilling lives. I believe addressing this deficit is key to resolving health and social inequities for these communities.

Given my degree in engineering and deep interest in climate research, I have a particular research interest and expertise in the way in which architecture and housing policy affects Aboriginal people in remote areas. My understanding of the huge and negative impact of climate change has led me to press for planning and action to assist remote communities prepare for a hotter future.

I attach a list of published articles and note that it includes recent articles, co-published with indigenous leader Norman Frank Jupurrurla, a Warumungu Elder and Director of the Julalikari Council Aboriginal Corporation in Tennant Creek, NT.

#### **5. Any work you have done in Central desert communities, including Yuendumu**

In 2020 I was the informal clinical lead in the development of a General Medicine outreach service in Central Australia for the Central Australian Health Service (which was ultimately thwarted by COVID) and was the visiting specialist to Yuendumu Clinic. Through this service, I also visited Nyirripi, Willowra, Ali Curung and Ti Tree.

I was in Lajamanu (not in Central Desert communities but of relevance to Yuendumu as its neighbouring Warlpiri town) for the COVID outbreak as part of the NT Health Emergency Response team in December 2021. I had been informally invited to participate in the Alice Springs Hospital team of 6 people (sent to support the Top End Health Service Team) by Dr. Samuel Goodwin, Executive Director of Medical Services for Central Australian Health Service. Dr. Goodwin understood my connections to Lajamanu and requested I attend to provide cultural engagement at a time when the community was experiencing an unprecedented pandemic and lock-down that coincided with an extreme heat wave (from 2014 onwards, I provided an outreach service to Lajamanu and visited the community on a monthly basis. I came to know many people in the community, including most of the elders. Jerry Jungula Patrick was a cultural mentor to me. I learned to speak staccato Warlpiri as a result of this experience and thanks to the patience of many Warlpiri people who I treated at Katherine Hospital).

I was in Yuendumu with Purple House for COVID disease outbreak for one week in February 2022.

I was in Kintore with Purple House for COVID disease outbreak for one week in February 2022. I also visited Kintore to support Purple House on other occasions in the previous year.

#### **6. Your observations of the significance of community control in the effective running of health clinics**

I have an insight into the running of remote community clinics. As a medical student, I spent 3 months working and learning at the clinic in Gapuwiyak in Central Arnhem Land in 2001. I spent approximately six months in 2006 working for Urapuntja Health Service in Utopia as the solo remote community doctor. During the nearly 8 years that I spent in Katherine, I worked closely with every remote community in the region through the outreach service I had developed, and did everything I could to support the Aboriginal Health Practitioners, nurses and doctors working in these clinics. The practice of remote area healthcare is extremely challenging clinically, logistically, culturally, environmentally and from a governance perspective.

It is my absolute conviction that community control is fundamental to ensure the continued provision of culturally safe healthcare. I would like to acknowledge that there are some very highly functioning Government Clinics in Central Australia (for instance, Nyirripi and Willowra from 2020-2021), however, ensuring the community has leverage over culturally safe provision of care is a fundamental imperative.

Acknowledging the history of colonisation and how each community clinic came to exist is necessary to appreciate the importance of this. For instance, in Lajamanu, a community that forced Warlpiri people living in Yuendumu in the late 1940's to relocate to Hooker Creek which is on Gurindji ancestral land, the clinic's initial commencement was based on healthcare from another era.

Across Australia and throughout the western world during this period of the mid twentieth century, western-minded associations between morality, health and disease were still our nation's cultural norm. Being sick equated to being dirty. Many diseases had limited or no treatments, and infectious diseases including syphilis, tuberculosis and leprosy were feared and had moral and religious dimensions.

The early clinics in remote communities were set up within this world view. Early Public Health legislation particularly around the diseases mentioned above were often one of the foundational reasons that clinics were opened in remote communities. (Sathre. *Illness is a Weapon*. 2013) Treatment was initially enforced upon First Nations people across the Northern Territory. For instance, the Leprosarium built in Darwin Harbour was placed there to prevent those incarcerated from escaping treatment. Mr. Judpurra Little, whom I came to know very well during his admissions to Katherine Hospital and my regular outreach visits to his home in Bulla Community, told me of his time incarcerated on this island, and how this subsequently led him eventually to study and become Australia's first Aboriginal Health Practitioner under Dr. John Hargreaves who originally diagnosed and treated his condition. He both resented and feared the enforced treatment he received, and appreciated the outcome. Mr. Judpurra Little's journey through western healthcare of the day demonstrates the deep and often unsettling complexities of contemporary healthcare services in remote Australia.

For instance, I have been told that people suffering from tuberculosis were forcibly made to attend the Lajamanu clinic with the threat of an electric cattle prod right up until the early 1980s', and that police were involved in such enforced compliance. Until this day, it is my opinion that the NT has the most punitive Public Health legislation for the treatment of tuberculosis of any state in Australia, and I have witnessed threats made by doctors to patients suffering tuberculous illness of being incarcerated if they did not comply.

Many of the First Nations people I have provided western healthcare to have lived experience of healthcare brutality, and all have had parents or grandparents who have experienced such brutality. Most First Nations people that I provide care to have very strong ancestral beliefs and understandings about disease process and healing. Most First Nations people that I provide care to also appreciate that western medicine has real value.

In the Katherine region where I am familiar with all clinics, every single clinic except Pine Creek and Mataranka was community controlled. In Central Australia, most of the clinics are government-controlled; some function very well, and others have room to improve. It is my opinion that the closer to home this community control can be, the better. For instance, Warlpiri people being represented on the Katherine West Health Board which is an organisation covering Warlpiri, Gurindji, Ngarinman, Ngaliwuru and Bilara homelands.

Given the extreme day-to-day clinical and logistic operations of these clinics, all of them fluctuate in functionality and capacity over time. There is often extreme staff turnover and allowing the community to keep a clinic in-check is very important. Clinics can occasionally 'go rogue' as the extreme challenges facing non-Indigenous staff overwhelm their individual capacity to cope – staff who often deeply suffer as a result of their positions and should never be blamed. However, if a clinic is not providing culturally safe care, then the community's access to healthcare is compromised.

A clear example of such functionality of each remote clinic could be seen in COVID vaccine uptake rates. It was clear to me that those communities across the Katherine region and the northern Central region that I understood to have high-functioning clinics providing culturally safe care had higher vaccine uptake than those that were not as highly-functioning. It is not a straightforward relationship between quality of service and vaccination rates and is biased by other factors such as remoteness and recency of colonisation, but in my opinion, vaccination rates were a general reflection of the real capacity of the clinics to engage with their communities. A clinic that is trusted by its community is able to benefit that community to a much greater extent than one that is not.

#### **7. Your observations of the significance of Purple House to the communities in the Central desert, including Yuendumu**

The Purple House commenced operating in 2004, and offers remote dialysis, social support, aged-care and NDIS services, and runs a bush medicine social enterprise called Bush Balm. Bush balm is offered free to all Aboriginal people on dialysis who desire it in Alice Springs, and is available for sale through an online outlet and various shops around Australia. Many of

the patients that I treat at Alice Springs Hospital have a tub of Purple House bush balm by their bed.

Attached to this statement are relevant pages from the website of the Purple House, setting out its background.

As the website makes clear, before the Purple House was established Pintupi people from the Western Desert of Central Australia were forced to leave their country and families to seek treatment for end-stage renal failure in Alice Springs or Darwin. Since the opening of the first dialysis clinic in Kintore in 2004, Purple House has expanded to run 19 remote clinics, including in the Central desert towns of Ntaria (Hermannsburg); Yuendumu; Lajamanu; Ltyentye Apurte (Santa Teresa); and Mt Liebig. It also has two mobile dialysis units called 'Purple Trucks', which allow patients to head back home to visit family, for festivals, funerals and other cultural business.

Purple House is entirely Indigenous-run and owned with an elected Pintupi Board of Directors. The Purple House is supported by the Commonwealth Government, as well as philanthropic and self-generated funds.

#### **8. Your observations of the relationship between community members and Purple House staff?**

The Purple House is an organisation founded upon Pintupi values, and as a result, all staff are inducted to employment to understand and operate within an Anangu paradigm. The cultural training at Purple House is not only deep but also fascinating and fun.

The connection between Purple House patients and staff is wholistic and very generous. Patients identify their needs and priorities, and Purple House staff are employed to provide the solutions.

The relationships that I have observed between community members and Purple House staff are built upon a unique governance system that respects and operates between both Anangu (First Nations) and Kartiya (non-Indigenous) ways. Day-to-day interactions between staff and

patients are joyous and fun, but difficult conversations around the complex dynamics between Anangu and Kartiya are also always embraced.

**9. Your observations of the qualities of Purple House as an organisation that assist it to operate effectively in the community (eg staffing/size/training/architecture)**

**Operations:**

The provision of dialysis in remote communities is the most clinically, logistically, infrastructurally and culturally complex health service remit of any healthcare organisation in Australia. The models upon which Purple House is built are based upon tapping into, supporting and trusting the capacity of each employee to contribute.

**Staffing:**

Purple House operates unlike any organisation I have seen or worked for. There is no hierarchy, and there are deeply shared values between all staff that unite around common objectives. The organisation fundamentally values both its staff and patients. The sole objective of the organisation is to realise the directions of the board, and this is understood by all staff members.

**Size:**

Purple House is continuing to expand and currently employs 200 people across Australia.

**Training:**

All staff are given autonomy and encouraged to engage in the operations as per their strengths, within the context of what is needed to be done day-to-day. Training for all staff begins with an induction which helps new employees understand how the organisation was formed, where it is going, and the absolute imperative of doing things the 'Right Way' (aka, Anangu and Kartyia shared values, where Anangu set the direction). Purple House supports staff and clients to further develop their lives and skill sets. For instance, an opportunity arose for a Pintupi Language Group which now runs each Tuesday and provides renal patients with linguistic employment and develop tools for Pintupi people to understand western concepts through the Group's animated outputs.

Architecture and infrastructure:

The Purple House began when the Pintupi rented a house in suburban Alice Springs and placed a dialysis machine in a bedroom. Having created their own space in Alice Springs, they added washing machines, firepits, a doctors room and a music machine. In the clinics that are in remote areas the formal architecture has been dependent on budget (many projects were funded through community resources, fundraising and Rotary clubs) however all have a welcoming atmosphere and an attempt to combine western clinical infrastructure and standards with cultural imperatives. Local ownership is evident and each dialysis unit is different. The clinics are owned by the communities that they serve from the foundations and up.

#### **10. Your observations of how health staff based in remote communities promote a positive relationship with the broader community**

In a highly functioning clinic, the single most important factor of positive healthcare service relationship with the community is clinical and executive leadership by and stability of local Indigenous employees who set and maintain the culture.

Longer tenure and regularly returning non-Indigenous staff promote relationships with community members and local Indigenous staff. This allows longer term and returning staff opportunity to develop relationships within the community, learn the history of the community, understand its political and social dynamics, understand the diversity of beliefs of traditional and western healing practices that define these clinics, and learn to speak some of the local language.

Positive and healthy relationships need to be built one person and one family at a time. Given that most clinics wax and wane in their functionality, newly arrived staff are either oriented to the local community by their organisation or by longer-tenured colleagues. This is not always available.

The promotion of a positive relationship between clinic and community is demonstrated by local institutional expectations of respect, relationships and continual community engagement.

The community reputation of a clinic can be damaged if repeated impolite behaviour, culturally inappropriate or insensitive practices, lack of staff-community relationships, reduction of local employment, real or perceived racism, or poor clinical care is not acknowledged, addressed and rectified.

## **11. The link between housing and health inequities**

There is a difference between a house and a home. A house is a structure. A home is a place of safety and belonging. Many if not most remote houses are not homes. There are strong links between poor quality housing and poor health outcomes (King M. Indigenous health part 2: the underlying causes of the health gap. Lancet 2009). Poor quality housing can be divided into overcrowding, poor design and construction, inadequate health infrastructure and essential services including power and water, and poor maintenance.

### **1. Economic poverty and housing**

The remote Northern Territory has the poorest living standards in Australia. For instance, the Australian Bureau of Statistics ranks suburbs' poverty (Relative Index of Socioeconomic Advantage and Disadvantage) by percentile. There are 4,111 suburbs in NSW, five of which are in the bottom 1% of poverty. There are only 250 suburbs in the NT, 72 of which are in the bottom 1% - each one of these 72 suburbs are remote communities. There are 13,691 suburbs in Australia and of the ten poorest, 9 of them are in remote NT. (Australian Bureau of Statistics)

Yuendumu is 47<sup>th</sup> poorest of the 13,691 suburbs in Australia (there are 35 remote communities in the NT that are poorer than Yuendumu). There are 892 people living in the town, only four men and 14 women over the age of 65 (people do not live long lives), and 338 youth or children. The average income of an adult in Yuendumu is \$254 per week. Rent is approximately 10% of income, and power is another approx. 10% of income, leaving \$200 per week per adult. The cost of goods including fuel and food in the community is at least double what it is in Alice Springs, meaning that the real value of \$200 is less than \$100 in

Alice Springs. For the equivalent of \$100 per week an adult has to feed themselves and their children. The poverty is so bad that living on the breadline is to the point of malnutrition. For instance, people can not afford the fuel to go hunting. Large tins of plain flour and sugar have become a staple – food that is very cheap, does not need to be refrigerated, and that is highly diabetogenic.

## 2. Overcrowded housing

The housing inequity for remote communities begins with a lack of enough houses. Overcrowding and homelessness are extreme problems in towns and remote communities. Over-crowded housing leads to spread of infectious diseases including but not limited to respiratory infections such as COVID and tuberculosis, streptococcal skin diseases which lead to rheumatic heart and kidney disease, scabies. It is therefore not at all surprising that remote Indigenous communities have the highest rates of rheumatic heart disease and kidney disease anywhere in the world, suggesting that these houses are probably some of the most overcrowded in the world (Carapetis J. Rheumatic fever in Indigenous Children. *Journal of Paediatrics and Child Health*, 2010).

## 3. Housing design and construction

Housing standards are incredibly poor in the NT, with many dwellings being completely uninsulated and very poorly designed. A western-facing wall without eaves can heat up in the afternoon sun to over 60 degrees Celsius and radiate heat into the house all night, making the internal cavity of the house substantially hotter than the outside and necessitating very high air conditioning running costs to keep the inside thermally safe. The current housing standards in the NT are below national standards, with the National Energy Rating Scale (NatHERS) in the NT being mandated at 5.0 compared to 6.0 for the rest of Australia. Many of the older housing stock (which make up possibly the majority of remote houses) would not even meet a NatHERS of 1.0, meaning that the residents have to pay much more money to keep their house thermally safe in very hot weather.

## 4. Essential services – power and health infrastructure

As the research team I have been working with at Australian National University has demonstrated, Indigenous communities in the NT are thought to be the most energy insecure in the world, and hot weather exacerbates this insecurity (Longden T. Energy insecurity during temperature extremes in remote Australia. *Nature Energy*, 2022). Due to pre-paid nature of electricity purchase in communities (that at least lets people choose between power and food), when the prepay runs out the power switches off. Fridges turn off. In some communities, the cost of not only purchasing but also running a fridge that switches off so regularly mean that many dwellings do not even aspire to have a fridge (the last study of remote housing found that only half of dwellings had a fridge (Bailie. Environmental health survey year 2 evaluation. Indigenous housing authority of the Northern Territory. 2002).

Much of the medications required to treat diseases of very high prevalence in remote NT require cool storage of medicines. And of course, access to fresh food is much more important than medicines to people who are hungry. Medications required to treat diseases related to poverty can not be safely stored and spoil in the heat.

And so on for washing machines, vacuums, lawn mowers in towns surrounded by brown snake country, etc.

## 5. Housing maintenance

When I attended Lajamanu in December 2021 on the NT Health Pandemic Response Team, I went door-to-door to most of the houses in the community collecting nasal swabs. I knew many residents and was regularly invited inside. A few houses had missing doors. Most houses had opted to board up windows with plywood to install wall-mounted air conditioners because none of the houses are supplied by NT Housing with air conditioners in Lajamanu, as per NT Department of Housing regulation (Quilty. Climate, housing, energy and Indigenous health: a call to action. *Medical Journal of Australia*, 2022). Without these self-funded and self-installed inefficient wall-mounted units, the houses would have been too hot to safely reside in during extreme heat. Thus, almost all houses not only had no natural light, but also no natural ventilation. I estimate that between 5-10% of houses had toilets that were blocked and not functioning. Houses had up to 25 residents per dwelling (an average of approximately 13, excluding houses that non-Indigenous people were living in). This was during a week of

an extreme heatwave in Lajamanu where temperatures reached 47°C and not a day was below 40°C with high humidity. The impact of COVID on remote communities in the summer of 2021-22 was predictable with extremely fast-paced spread. Fortunately, it was the omicron variant. None of these maintenance issues had been corrected prior to the pandemic's arrival.

**12. Problems with current housing and the way in which it might impact on physical and mental health, particularly of children and young people aged up to 20 (Kumanjayi was 19 years of age when he passed away).**

I note that Kumanjayi had a history of physical health problems impacting on his learning, including hearing loss and poor impulse control, possibly linked to a suspected diagnosis of FASD.

Rates of ear disease and associated hearing loss are extreme among Aboriginal and Torres Strait Islander children, including in the central desert area. This is primarily because of overcrowding and poor housing. There is ample research to link those hearing issues and poor education outcomes and behaviour difficulties.

Overcrowding can also result in environmental stressors, such as from a lack of privacy, which can have an impact on mental health. Family members are more likely to be exposed to stressors like family violence, which causes trauma and has a long term impact on behavioural issues.

As a parent of three teenage girls who have all grown up in the Northern Territory, I cannot comprehend the extent of what I presume is extreme global developmental damage that results from the appalling state of housing on young peoples' upbringing, education and future aspirations in remote communities.

**13. Any other issues of assistance to the Coroner in understanding the causal link between poor health/housing and outcomes for teenagers like Kumanjayi.**

When I first saw the video-worn footage of the officers involved in the shooting of Kumanjayi Walker, I was immediately struck by the fact that there were no lights on in the

house. I suspect that at the time, the power to the house was out because the residents had run out of pre-paid power. I note also that the shooting happened during hot weather. Having myself delt with potentially violent situations within hospitals, it is my opinion that darkness would almost certainly increase the risk of injury in such situations.

Climate change and the increasing severity and duration of very hot weather is already exacerbating every aspect of remote community poverty and wellbeing – children’s education, housing safety, health and wellbeing, food security, violence and crime (Mahendran. Interpersonal violence associated with hot weather. Lancet Planetary Health, 2021).

There are also indirect impacts of climate change on health that are more widespread but harder to see. In research that we have recently published, 34% of doctors in the Northern Territory reported that they were either considering or in the process of leaving the NT as a direct result of their concerns of the impacts of climate change (on things such as liveability, real estate value, employment impacts etc) (Pendry and Quilty. Is climate change exacerbating healthcare workforce shortages for underserved populations? Lancet Planetary Health, 2021).

There is insufficient planning to deal with the major impacts of climate change on housing in remote NT.

Sincerely,



Dr. Simon Quilty

FRACP, MPhilPH, MB BS, BEng

## LIST OF PUBLICATIONS

1. Steere, Goodwin, Gardiner, Quilty. COVID on country: an innovative model safely supporting high-risk patients in Central Australia. *Rural and Remote Health*, 2022.
2. Quilty, Jupurrula, Bailie, Gruen. Climate. housing, energy and Indigenous health – a call to action. *Med J Aust*, 2022.
3. Pendry, Lucas, Quilty. Surveying the changing climate of NT workforce retention. *Aust J Rural Health*, 2022.
4. Longden, Quilty et al. Energy insecurity during temperature extremes in remote Australia. *Nature Energy*, 2021.
5. Quilty, Frank Jupurrula. Climate change: a Wumpurrarni-kari and Papulunyi-kari shared problem, *J Paed Child Health*, 2021.
6. Weeramanthri, Quilty, Campbell. Climate, extreme heat and human health – risks and lessons for Australia. *Med J Aust*, 2021.
7. O'Donnell, Honan, Quilty, Schultz. The effect of heat events on prehospital and retrieval service utilisation in rural and remote areas: a scoping review. *Prehosp Emerg Med*, 2021.
8. Pendry, Quilty, Lucas. Is climate change exacerbating healthcare workforce shortages for underserved populns? *Lancet Plan Health*, 2021.
9. Longden, Quilty, Hunter, Gruen. Heat related Mortality: an urgent need to recognise and record. *Lancet Plan Health*, 2020.
10. Quilty et al. Addressing profound Disadvantage to improve Indigenous Health and reduce hospital admissions: a collaborative community based approach. *Int J Enviro Pub Health*, 2019.
11. Quilty. Response – Management and outcomes of prosthetic valve thrombosis: An Australian case study. *Heart Lung Circ*, 2019.
12. Watson, Quilty. Providing palliative care closer to home: retrospective analysis from a remote Australian hospital. *Int Med J*, 2019.
13. Scrymgour, Nuanan, Sansburg, McLauchlan, Jones, Quilty. Pharmaceutical quality of antibiotics in Small Island Nations in the Western Pacific region: a pilot survey. *J Pharm Prac Rev*. 2019.
14. Quilty et al. Crusted Scabies in the Katherine Region – time for disease eradication. *Med J Aust*. 2017.
15. Quilty et al. Factors contributing to frequent attendance to the emergency department of a remote NT hospital. *Med J Aust*. 2016.
16. Quilty, Bachmayer. Telehealth in the remote NT: bridging the gap. *Med J Aust*. 2015.

17. Quilty et al. Rural general physicians: improving access and reducing costs of healthcare in the bush. *Aust Health Rev.* 2014.
18. Quilty. Medications shortages in Australia – the reality [editorial]. *Aust Med J.* 2014.
19. Quilty, Pearce. Drug shortages and medication quality: integrally related. *Int Med J* 2014.
20. Wongseelashote, Quilty. Cane toads, bush tucker: starvation ketoacidosis in a bushwalker. *Med J Aust*, 2013.
21. Pearce, Quilty, Kewley, Harris. Sustainable pharmaceutical supply6 (letter). *Med J Aust.* 2012.
22. Quilty et al. A Pandora’s Box: Sustainable pharmaceutical supply, *Med J Aust*, 2011.
23. Colins, Quilty. Prevalence of pseudohypertension in contemporary patient cohort undergoing cardiac cath. *Heart Lung Circ.* 2013.
24. Quilty, Kwok, Currie. High incidence of MRSA sepsis and death in patients with febrile neutropenia, *Int J Med.* 2009.
25. Singhal, Quilty, George. A tale of two cancers: Collision presentation of ovarian carcinoma and lymphoma: *Aust NZ J OG.* 2009.
26. Quilty, Anderson, Hewitt. Deprivation in the desert: a case report from Central Australia; *Lancet.* 2006.
27. Quilty, Levy. The magnitude of experience of parental incarceration in Australia *J. Psych, Psychol Law* 2005.
28. Quilty, Levy, Barrat, Howard, Butler. Children of prisoners: a growing public health problem; *Aust NZ J. Public Health*, 2004.
29. Levy, Quilty. Pox in the docks: varicella outbreak in an Australian prison system *Public Health* 2003.

**The Conversation (theconversation.com) Publications (Quilty):**

1. How climate change is turning remote indigenous houses into hot boxes. 2022
2. Too hot, heading south: how climate change may drive one-third of doctors out of the NT. 2021
3. As heatwaves become more extreme, which jobs are riskiest? 2021.
4. How a rethink of emergency care is closing the gap, one person at a time. 2019.
5. Why the housing shortage exacerbates scabies in Indigenous communities. 2017.





# Energy insecurity during temperature extremes in remote Australia

Thomas Longden<sup>1,2</sup>, Simon Quilty<sup>3</sup>, Brad Riley<sup>4,5</sup>, Lee V. White<sup>2,5</sup>, Michael Klerck<sup>4,6</sup> ✉, Vanessa Napaltjari Davis<sup>6</sup> and Norman Frank Jupurrurla<sup>7</sup>

**Indigenous communities in remote Australia face dangerous temperature extremes. These extremes are associated with increased risk of mortality and ill health. For many households, temperature extremes increase both their reliance on those services that energy provides, and the risk of those services being disconnected. Poor quality housing, low incomes, poor health and energy insecurity associated with prepayment all exacerbate the risk of temperature-related harm. Here we use daily smart meter data for 3,300 households and regression analysis to assess the relationship between temperature, electricity use and disconnection in 28 remote communities. We find that nearly all households (91%) experienced a disconnection from electricity during the 2018–2019 financial year. Almost three quarters of households (74%) were disconnected more than ten times. Households with high electricity use located in the central climate zones had a one in three chance of a same-day disconnection on very hot or very cold days. A broad suite of interrelated policy responses is required to reduce the frequency, duration and negative effects of disconnection from electricity for remote-living Indigenous residents.**

Indigenous communities in remote Australia face temperature extremes that can increase their use of electricity and amplify their risk of being disconnected. Energy is a necessary resource for work, education, participation in social life and for maintaining healthy living practices at home<sup>1–6</sup>. Energy insecurity remains a pressing issue globally, including in countries with an abundance of wealth and resources<sup>4,7–10</sup>. It can be defined as ‘an inability to meet basic household energy needs’<sup>5</sup> and is broadly synonymous with the concept of energy poverty<sup>11–13</sup>. Insufficient access to energy has been linked to poor health (both mental and physical) as energy is required to maintain essential services, including food security, lighting, essential medical equipment and thermal comfort/safety during extreme weather<sup>4,5,14–22</sup>.

There is a need to better understand the extent of energy insecurity experienced by Australia’s remote Indigenous communities, in particular the role that temperature plays in shaping energy insecurity. The vulnerabilities associated with energy insecurity vary spatially on the basis of underlying characteristics, which can be highly regionalized and locally specific<sup>23</sup>. Socio-economic, demographic and behavioural factors, as well as occupancy and structural characteristics (including the size, type and quality of housing stock and appliances), are all key drivers of energy consumption; while the prevailing temperature can affect the security of electricity supply due to the cost of heating or cooling<sup>24,25</sup>.

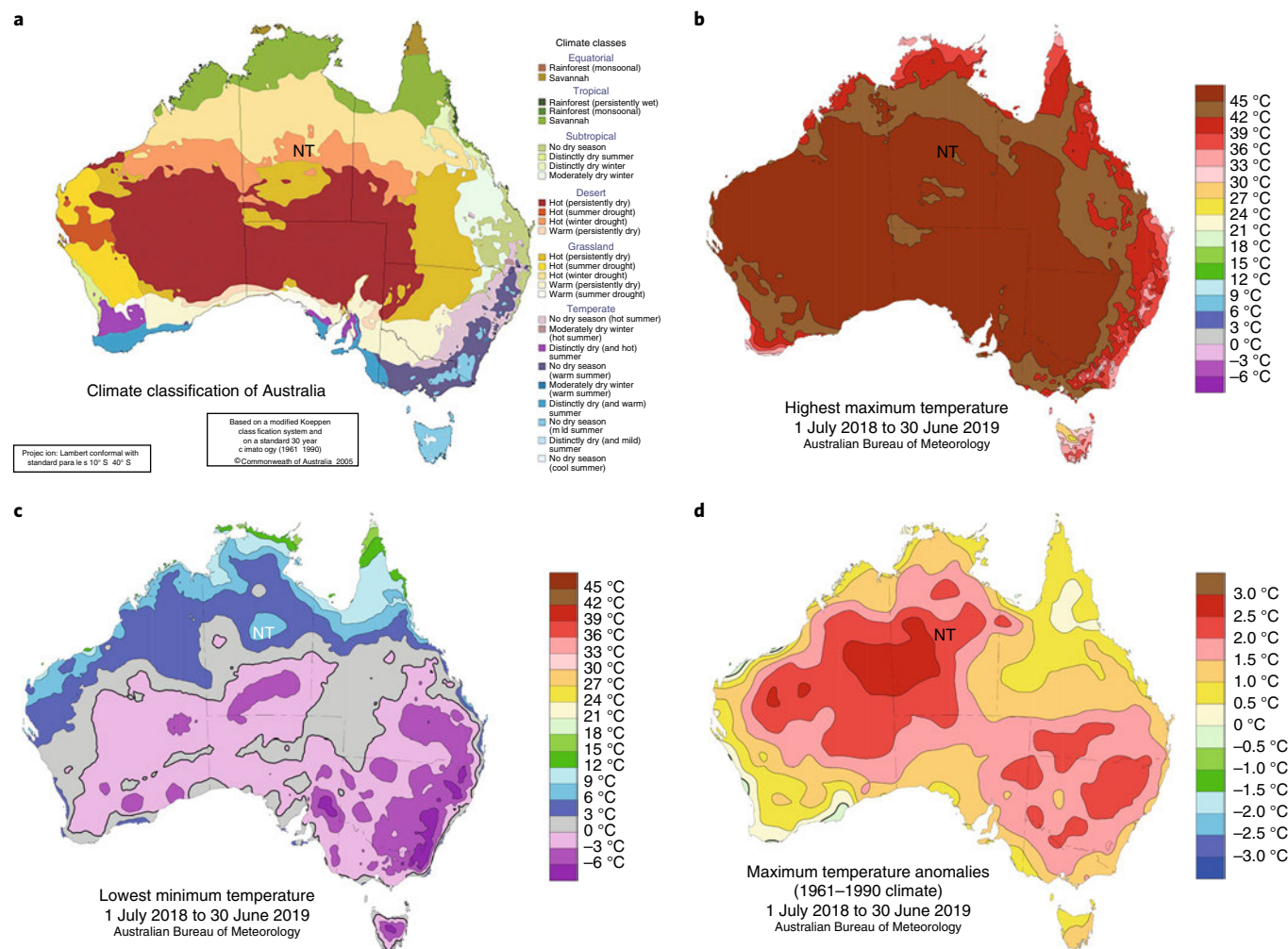
Temperature extremes are likely to act as a risk multiplier, worsening energy insecurity for those at greatest risk as ‘vulnerable households typically live in poorer quality housing, and have least resource or opportunity to invest in improvements to its efficiency and heating technology’<sup>6</sup>. The importance of access to energy has prompted governments worldwide to implement policies maintaining this access, many with special attention to reducing the health effects of heat and cold<sup>7,26,27</sup>.

The climate of the Northern Territory (NT) ranges from equatorial and tropical regions in the north to hot dry grassland regions in Central Australia (Fig. 1a). Remote Indigenous communities in the NT are mostly off-grid and unregulated by the guidelines of the Australian Energy Regulator<sup>28</sup>. In a situation unusual in Australia, remote living residents prepay for access to electricity and regularly experience disconnection on non-payment. Distant from Australia’s urban centres and major electricity grids, these communities have long relied on diesel and gas-fired generators. In recent years, there has been incremental integration of renewable energy into these isolated, high-cost electricity networks.

Australia’s remote Indigenous communities face some of the highest temperatures nationally and are vulnerable to the effects of a warming climate (Fig. 1b–d)<sup>29</sup>. Exposure to extreme temperatures has been associated with a range of adverse health outcomes and death<sup>22,30–33</sup>. In the three hottest climate zones in Australia, between 4.5 and 9.1% of all deaths were associated with heat-related mortality, which is an estimate that is much higher than in other Australian regions (2% nationally)<sup>31</sup>. The challenge of maintaining thermal comfort and safety during temperature extremes is a pressing issue for author N.E.J.: “We can’t do anything about climate change except turn the power up, but it costs a lot too, don’t forget that. Electricity, you’re using more power when you turn that air conditioner up!” Temperatures over 35 °C, and even over 40 °C, are increasingly common in the NT as the climate changes (Fig. 1d). There is a need to better understand how extreme temperatures already shape the experience of energy insecurity in remote Indigenous communities.

Because of the health implications of energy disconnection and the subsequent loss of essential services, there are questions around how strongly disconnection events relate to temperature and whether disconnections occur more frequently during extreme

<sup>1</sup>Crawford School of Public Policy, Australian National University, Canberra, Australian Capital Territory, Australia. <sup>2</sup>Zero-Carbon Energy for the Asia-Pacific Grand Challenge, Australian National University, Canberra, Australian Capital Territory, Australia. <sup>3</sup>Research School of Population Health, Australian National University, Canberra, Australian Capital Territory, Australia. <sup>4</sup>Centre for Aboriginal Economic Policy Research (CAEPR), Australian National University, Canberra, Australian Capital Territory, Australia. <sup>5</sup>School of Regulation and Global Governance (RegNet), Australian National University, Canberra, Australian Capital Territory, Australia. <sup>6</sup>Tangentyere Council Aboriginal Corporation, Alice Springs, Northern Territory, Australia. <sup>7</sup>Julalikari Council Aboriginal Corporation, Tennant Creek, Northern Territory, Australia. ✉e-mail: [michael.klerck@tangentyere.org.au](mailto:michael.klerck@tangentyere.org.au)



**Fig. 1 | NT compared with other Australian regions. a**, Climate zones. **b**, Highest maximum temperatures. **c**, Lowest minimum temperatures. **d**, The 12-monthly mean maximum temperature anomaly for Australia compared with 1961 to 1990. Panels reproduced with permission from the Australian Government Bureau of Meteorology under Creative Commons license CC-BY 3.0 AU: **a**, ref. <sup>73</sup>; **b**, ref. <sup>72</sup>; **c**, ref. <sup>74</sup>; **d**, ref. <sup>75</sup>.

temperatures. In this paper, we assess the relationship between temperature, electricity use and disconnection using daily smart meter data for 28 remote Indigenous communities in the NT, all of which are using prepayment metering. We then present how many disconnection events occur during example temperatures to indicate the extent and severity of energy insecurity attributable to temperature extremes. Quantification of energy insecurity and how it is related to temperature thresholds could support future policy responses.

### Energy injustice and a history of policy exceptionalism

Similar to Indigenous peoples worldwide, communities in the remote NT have long been at greater risk across the three dimensions of energy injustice. Energy justice is concerned with the distribution of costs, benefits and risks in energy transitions and is a principle that arises from theories of distributional justice<sup>2,6,9,34-37</sup>. Distributional injustices in energy systems can be produced by systemic inequalities that arise from ongoing procedural injustices (which is a concept rooted in the failure to accord some groups of people equal rights and respect)<sup>38</sup> and recognition injustices (when certain groups face a lack of cultural respect and are excluded from decision-making)<sup>39</sup>. Procedural injustices extend to differences in legal rights; distributional injustices are reflected in differences in the quality of housing that affects energy use; and injustices in recognition include a lack of acknowledgement of the unique needs

of specific communities, including those associated with energy access, use and practices<sup>16</sup>. Some groups, such as remote Australian Indigenous communities, consistently have less access to energy efficient housing, less ability to shape the electricity systems that they are connected to and less ability to pay for higher electricity costs that may result from certain systems<sup>6,9</sup>. These aspects tend to be intertwined.

For author V.N.D., who works on issues related to energy, housing and social justice in Central Australia, maintaining access to electricity during temperature extremes represents a complex suite of interrelated challenges: “Older houses had solar hot water and pot belly stoves for the winter. We could collect wood and the sun heated the water. The new houses built by the Government since the Intervention (in 2007) have electric hot water heaters and no pot belly stoves. When the old houses were upgraded, pot belly stoves were removed. Our houses don’t have heating anymore. Most residents don’t have much money, so residents buy cheap fan heaters and air-cons. The problem with these is that they are expensive to run. Our houses have become expensive to heat and expensive to cool and we run out of money for electricity. When the power goes off it is bad for our health, the food gets spoiled, we can’t wash our clothes and we can’t wash our kids.”

Residents of remote communities live in extremely challenging socio-economic circumstances and in housing that can be extremely

crowded (see Supplementary Table 1 for example statistics from the 2016 census). Housing quality is often poor across these remote communities. Approximately half of Indigenous households in the NT fall below the poverty line. The National Indigenous Reform Agreement (Closing the Gap), the core of the Australian Government's agenda to address social and health inequities facing Indigenous Australians, identifies 'healthy homes' as a key priority for healthy living practices<sup>40,41</sup>. Nine priorities are identified, with six pertaining to electricity systems, which are power connection, electrical safety, heating for showering, facilities to wash children, laundry facilities and facilities to store food and prepare food (including refrigeration)<sup>41</sup>.

Moreover, Aboriginal and Torres Strait Islander peoples have experienced frequent changes in the policy environment regulating their lives and lands, via a non-Indigenous regime of law. Many communities in the NT have been subject to frequent changes in regulatory practices for electricity and regressive changes in procedural and recognition justice aspects, such as cycles of gain then subsequent loss of representation in governing bodies<sup>37</sup>. Some of this complex regulatory and legislative history is summarized in a non-exhaustive timeline of key developments in policy affecting Indigenous peoples in the Territory between 1967 and 2021 (Fig. 2). This includes the unilateral introduction of a 'user-pays' model for energy provision in 1992. Author and Warumungu elder N.F.J. has lived experience of these deep structural imbalances that impact, too-often detrimentally, on the lives and livelihoods of Indigenous communities in the NT: "I reckon the Government doesn't want to listen to Wumpurrarni (Indigenous) people because I reckon they've had enough and they're just ignoring us now, they think we get everything for free but we struggle for that. Policy is like a bible, for Government, it tells them how they run things, how they can do things. If they don't have a policy, they don't know how things run. And if they have a policy they can jam you and that's what happens to us, they jam us all the time."

### Limited protections and prepaying for power in the remote NT

Prepayment for electricity is uncommon in urban Australia. It is heavily regulated in most jurisdictions on the basis of concerns for wellbeing<sup>42–45</sup>. It remains disproportionately common in small and widely dispersed remote communities across the NT, Queensland, Western Australia and South Australia. In the NT prepayment is not limited to urban town camps and remote communities. It is also used in urban and regional settings, including Darwin, Palmerston, Nhulunbuy, Katherine, Tennant Creek and Alice Springs. Many of these communities have prepaid electricity services as their only option for service provision<sup>46</sup>. There is considerable variation in the operation of services and available protections for prepayment consumers subnationally. As an example, in other parts of Australia where consumers are protected by the Australian Energy Regulator guidelines, people cannot be disconnected from electricity when life support medical equipment is being used<sup>43</sup>. This protection is not comprehensively applied in remote NT communities<sup>47,48</sup>.

In previous international studies, rates of disconnection among prepayment households ranged from 10% to 53% for the UK, Germany and New Zealand<sup>49–52</sup>. Prepayment disconnection numbers for Australia are not systematically collected or reported by regulators or providers and estimates are scarce. Previous analysis in the NT found prepayment disconnection rates between 59% and 91% (ref. <sup>53</sup>). In comparison, the rate of 'raised disconnections' for postpayment households in other Australian regions that are most at risk of disconnection ranged from 3% to 30% with large variation in disconnection rates associated with local and regional socio-economic characteristics and whether smart meters were commonly used<sup>54</sup>. The St Vincent de Paul Society and Alviss Consulting report defines a 'raised disconnection' as the case when

a 'retailer raises a service order with the relevant network business'. These raised disconnections may be rejected, cancelled or completed. They may be rejected on the basis of an invalid address or when disconnection is prohibited for medical reasons. And the disconnection request can be cancelled by the retailer when the payment issue has been resolved. This can be a full payment or the establishment of a payment plan<sup>54</sup>. These rates of disconnections are the higher end of estimates as they are those that were found for the top 30 postcode regions from four Australian areas (that is, New South Wales, Victoria, South East Queensland and South Australia). Across the eastern (and most populous) parts of Australia, the rate of completed disconnections for postpayment households was 1% (ref. <sup>55</sup>).

While data are scarce, issues with prepayment and disconnection in other regions of Australia have been noted by key organizations, including the Essential Services Commission of South Australia<sup>44</sup>, Energy and Water Ombudsman New South Wales<sup>45</sup>, the Queensland Council of Social Service<sup>56</sup> and Bushlight<sup>46</sup>. The last two raised these concerns specifically in relation to remote Indigenous communities.

### Disconnection as an indicator of energy insecurity

While energy insecurity describes more than disconnection rates alone, having an electricity connection is the first part of being able to access electricity to meet household energy needs. Here we assess disconnection rates as a proxy for energy insecurity, while noting that other factors also contribute to the disconnection rates observed. This may include housing design, construction and insulation; sociodemographic factors such as income and health; and entrenched regulatory structures.

When the households in our dataset run out of credit, they face immediate disconnection between 10:00 and 14:00. Outside these hours, credit is extended and the accumulated debt is automatically deducted from the subsequent purchase of energy credit. Energy services are not recommenced until the accrued debt is paid<sup>57</sup>.

For the houses in our study with complete data for the 2018–2019 financial year (July 2018 to June 2019), 91% of households experienced a disconnection. Most disconnections were same-day disconnections (92% of the total) where the meter was reconnected when credit was restored on the same day. A total of 71% of households experienced a same-day disconnection more than ten times in a 12-month period. These rates of disconnection are much higher than Australian and international examples (mentioned above). On average, a same-day disconnection lasted for almost 3 h. Multi-day disconnections were less common (0.9% of days), but two thirds of households experienced this type of disconnection, which lasted overnight or longer. Of all households, 7% experienced a multi-day disconnection more than ten times in 1 year. These disconnections could last for many days (the all-region average was almost 4 days). Table 1 shows how these disconnections differed by climate zones.

### Electricity use during temperature extremes

To confirm our expectation that temperature affects electricity use, we used linear regression with panel-corrected standard errors to provide estimates for seven daily temperature ranges. These temperature ranges are specified in the regressions as the daily average temperature for the same day as electricity use and the daily average temperature for the 2 days before. We estimate these regressions for all climate regions pooled together, and for each climate region separately. The regressions were also estimated for all houses and then re-estimated for different levels of the average daily use of electricity. Our data did not include any information on household characteristics, so we have used the average level of daily electricity use to group the households. Determinants of the average daily load include occupancy and the use of appliances. For more information, refer to the methods section for more details on the grouping of households with high/low electricity use.

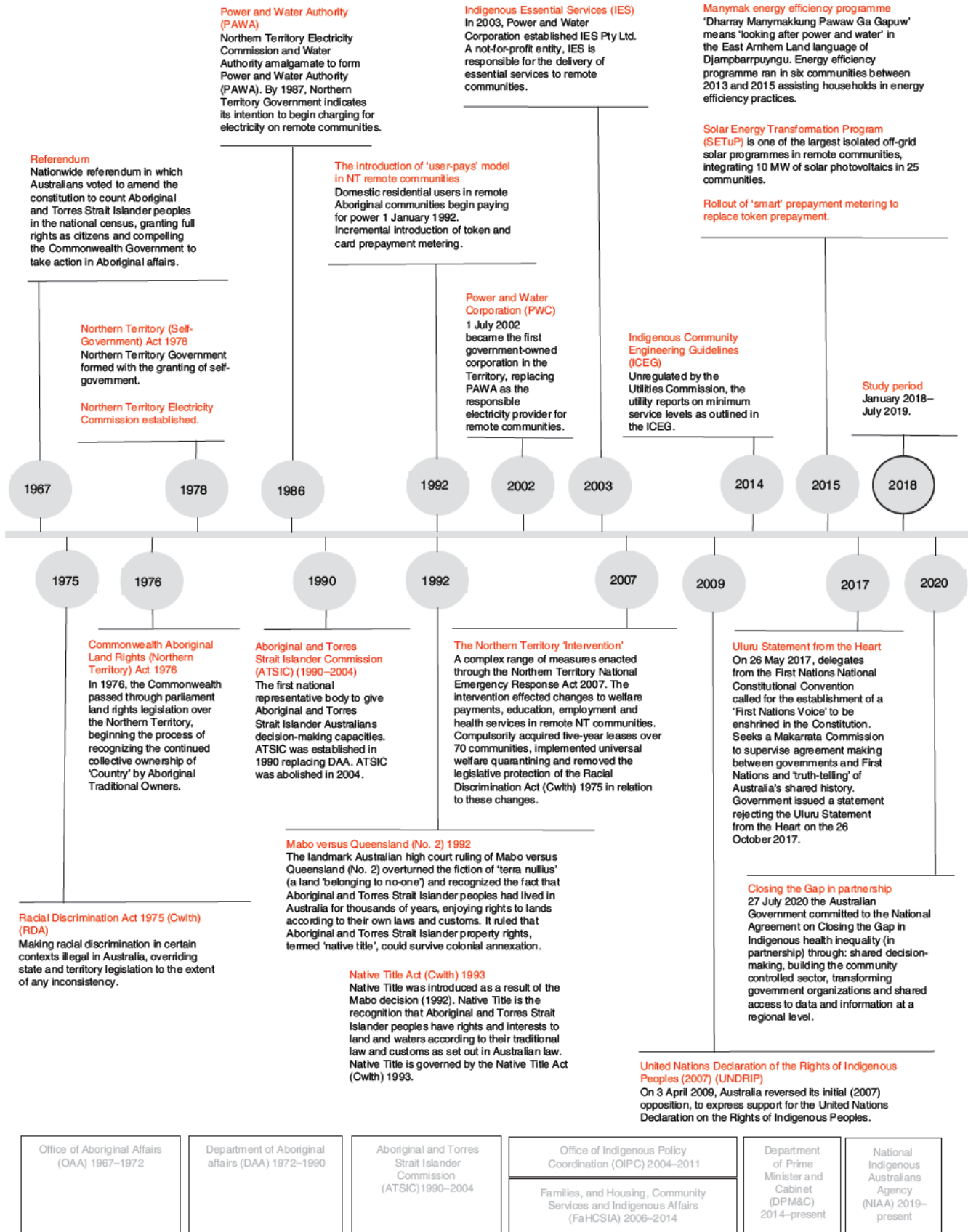


Fig. 2 | Timeline of the complex history of Indigenous policy in Australia. Key developments in Indigenous policy, including remote community energy policy, between 1967 and 2021. Boxes at the bottom are the federal departments or agencies responsible for Indigenous policy.

**Table 1 | Disconnection rates by climate zone between July 2018 and June 2019 ( $n = 1,045,725$ )**

	Equatorial climate zone (most northern)	Coastal tropical climate zone	Savannah tropical climate zone	Hot persistently dry grassland climate zone (most southern)	All regions
<b>Same-day disconnections</b>					
Percentage of households experiencing a same-day disconnection at least once	85	94	90	90	89
Percentage of households experiencing a same-day disconnection at least ten times	60	77	75	75	71
Percentage of days in the sample with a disconnection	7	11	11	10	10
Average length of disconnection (hours)	2.92	2.89	2.69	2.19	2.67
<b>Multi-day disconnections</b>					
Percentage of households experiencing multi-day disconnection at least once	47	68	71	83	66
Percentage of households experiencing multi-day disconnection at least ten times	2	4	9	16	7
Percentage of days in the sample with a disconnection	<1	1	1	2	1
Average length of disconnection (hours)	102.23	87.82	73.29	125.49	98.48
<b>Any type of disconnection</b>					
Percentage of households experiencing any type of disconnection at least once	87	95	91	92	91
Percentage of households experiencing any type of disconnection at least ten times	63	80	78	78	74
Percentage of days in the sample with a disconnection	7	11	12	12	10
Average length of disconnection (hours)	8.60	8.46	8.39	17.66	10.62
<b>Daily electricity use and expenditure</b>					
Daily electricity use (kWh) (s.d.)	21.25 (16.46)	23.29 (15.24)	25.73 (16.86)	26.95 (22.05)	24.13 (17.75)
Daily expenditure (AUD\$) (s.d.)	6.09 (4.71)	6.67 (4.37)	7.37 (4.83)	7.72 (6.31)	6.91 (5.08)
Count of observations for balanced panel for 2018–2019 financial year	306,600	229,585	296,380	213,160	1,045,725

The regression estimates confirm that electricity use differs notably by temperature, climate zone and month (Fig. 3). Estimates for temperature-related increases in electricity use are shown in Fig. 3, with the number of days that these temperatures occurred and the estimates for the monthly change in electricity use (without the daily temperature effect). These estimates for temperature and monthly effects should be interpreted in relation to the reference temperature range (daily average temperatures between 20°C and 25°C).

Given that the climate across the northern half of the NT is characterized by tropical heat (and mild cool nights only during a short winter season), daily electricity use was on average higher in the hottest periods of the year (November to March). This seasonal increase in electricity consumption was most pronounced in high-use households, which also experienced a reciprocal reduction in monthly electricity consumption in the cooler months. As expected in the NT, which generally has a prevailing hot climate, household energy expenditure is greatest during hotter weather due to the need for cooling.

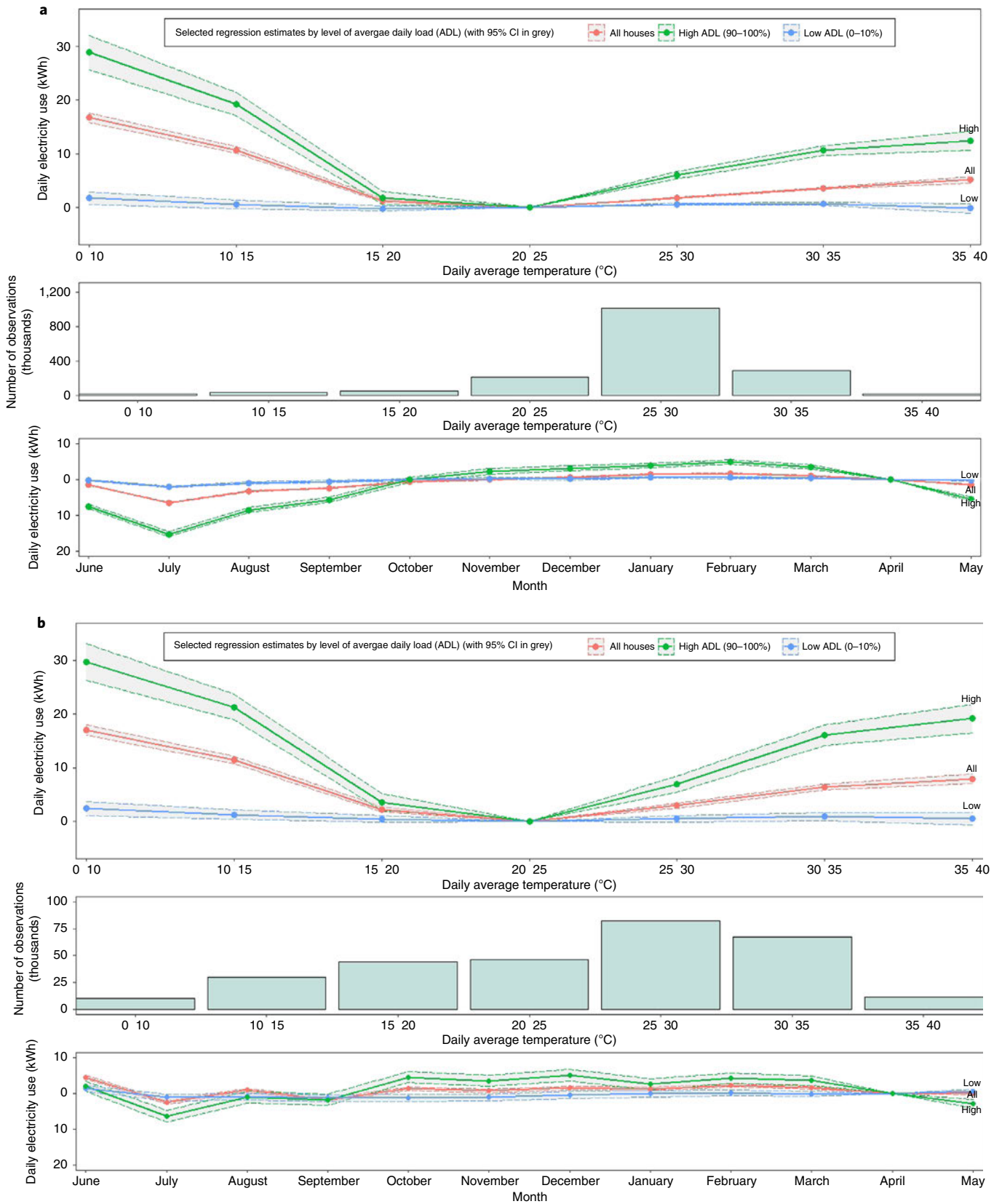
Beyond seasonal effects, the need for heating and cooling can influence the daily use of electricity. The hot persistently dry grassland climate zone is the region that predominantly determines the all-regions result (Fig. 3b). It is the combination of the Central Australian climate zones shown in Fig. 1a. For this climate zone, which unlike the other regions experiences cold nights, the

households with the highest electricity use (top tenth percentile of average daily load) increased their electricity use by 30 kWh (on average) on the coldest of nights (between 0°C and 10°C). The average increase was 17 kWh across all houses in this climate zone. Extremely hot days with average temperatures between 30°C and 40°C corresponded to a 16–19 kWh increase (on average) for the households with the highest electricity use. When considering all houses, the average increase was 6–8 kWh.

### Disconnection during temperature extremes

To assess the question of whether temperature influences the probability of disconnection, we used random-effects probit regressions to estimate the probability of same-day and multi-day disconnections. Figure 4 shows the estimates for temperature-related increases in the probability of a same-day disconnection, which includes daily estimates and the estimates for the monthly change in disconnections (without the daily temperature effect). The estimates are interpreted in relation to a reference temperature range (daily average temperatures between 20°C and 25°C). These estimates are also re-estimated by the level of electricity use and climate zones.

The probability of a same-day disconnection occurring on any given day (except during weekends and public holidays when disconnection is prohibited) is high (0.04–0.06) and increases on the first day that credit can expire, predominantly the next business day (approximately 0.19). This is captured in our results, with a large



**Fig. 3 | Daily electricity use by temperature and month. a**, All regions. **b**, Hot persistently dry grassland climate zone. These are the coefficient estimates and 95% confidence intervals from multiple regressions for a sample with 1,674,786 daily observations across 3,300 houses. Regressions were grouped by percentile of electricity use (that is, average daily load) and climate zones. Estimates for all houses, low-electricity-use households and high-electricity-use households are shown here (Supplementary Tables 2–6 have all of the electricity use estimates). Temperature bins are specified using daily average temperatures (in °C). Temperature-based estimates are for a three-day period (that is, temperature on the day of electricity use and the two days before). Temperature estimates are interpreted using 20–25 °C as the reference temperature range. Monthly estimates are interpreted using April as the reference month.

increase in disconnections occurring on Monday and the day after a public holiday (Fig. 4). There is a significant relationship with temperature that is most notable for the households with the highest electricity use in the two southern climate zones.

For the full sample, there was a one in seventeen chance (probability of 0.06) of a same-day disconnection occurring on moderate days with average temperatures between 20°C and 25°C. This increased to a one in eleven chance (probability of 0.9) on hot days with average temperatures between 35°C and 40°C. A series of cold nights had a significant effect with an almost one in six chance (probability of 0.18) of a same-day disconnection occurring on cold days with average temperatures between 0°C and 10°C.

The households with the highest electricity use had a much greater probability of same-day disconnection. For this group, there was almost a one in seven chance (a probability of 0.15) of experiencing a same-day disconnection on moderate days with average temperatures between 20°C and 25°C. This increased to one in three (probability of 0.35–0.39) for the coldest temperatures (0°C to 15°C) and one in four (probability of 0.24 to 0.27) for the hottest temperatures (30°C to 40°C).

Climate zones also influenced the probability of a same-day disconnection occurring (Fig. 4b and Supplementary Information). For households with the highest electricity use in the southern-most climate zone (that is, hot persistently dry grasslands shown in Fig. 4b), a one in seven chance (probability of 0.14) of same-day disconnection for temperatures between 20°C and 25°C, increased to one in three (probability of 0.31) for the coldest temperatures (0°C to 10°C) and one in four (probability of 0.23) for the hottest temperatures (30°C to 40°C). For the households with the highest electricity use in the savannah tropical climate zone, there was a one in four chance (probability of 0.23) of disconnection for temperatures between 20°C and 25°C, which increased to one in three (probability of 0.37 to 0.39) for the hottest temperatures (3°C to 40°C).

Only a weak relationship between temperature and multi-day disconnections was found. The estimation results are provided in Supplementary Table 12. While rarer (approximately one-tenth as common), multi-day disconnection events lasted for an average of 4 days (Table 2).

### Number of disconnections during temperature extremes

Temperature-related disconnections are driven by an increased need for electricity to maintain thermal comfort and safety during extreme temperatures. We now focus on the proportion of disconnections that occurred during hot and cold temperatures for two reasons. First, these are critical events where expenditure on energy has increased due to cooling/heating, leading to a disconnection that compromises the other functioning of the home, including refrigeration, lighting and life support medical equipment (for example, oxygen concentrators, sleep apnoea machines, home renal dialysis equipment). Second, there is a concern about the impact on health. Protections internationally include several examples of restricting disconnection for vulnerable customers, including on the basis of health risks and outdoor temperatures<sup>7,26,48</sup>. These protections can include disconnection prohibitions based on the time of year (for example, no disconnections during winter months in cold climates), on reaching specific temperature thresholds, and on declarations of

extreme weather events (for example, no disconnections during a declared heat wave event)<sup>26</sup>. Using example temperature thresholds to determine the number of temperature-related disconnections, we find that over 49,000 incidences of disconnection (29% of disconnections) occurred during hot and cold temperature extremes (Table 2). We examine both 35°C and 40°C as the threshold for extreme heat.

### Discussion

We begin to address the need to better understand how temperature affects energy insecurity in Australia's remote communities by examining (1) whether temperature affects electricity use, (2) whether temperature influences the probability of disconnection and (3) the proportion of temperature-related disconnections (that is, disconnections that occur during extreme temperatures). Temperature is confirmed to effect electricity use. Correspondingly, disconnections are more likely during extreme temperatures. We find that in the 28 remote Indigenous communities that are the focus of this study, disconnections increase from an already high baseline of one in seventeen during mild temperatures (20–25°C), to a one in eleven chance of disconnection during hot days (34–40°C) and a one in six chance during cold days (0–10°C). Disconnection occurs more frequently for households with the highest electricity use in the central climate zones, which had a one in three chance of a same-day disconnection on very hot or very cold days. This indicates that households are having trouble cooling/heating their homes, which in turn compromises access to other essential services including refrigeration, lighting and essential medical devices. While the level of energy service that is viewed as 'essential' can vary over time and with changing social norms<sup>58</sup>, a complete loss of access to energy services constitutes a level of energy insecurity that can harm wellbeing<sup>2</sup>. In the financial year July 2018 to June 2019, disconnection was experienced by 91% of households in the remote NT communities that we have data for.

There are multiple levels of energy injustice in remote Indigenous Australia, and the effects of climate change will exacerbate pre-existing energy insecurity and subsequent effects on health and wellbeing. In considering how to address these issues, it needs to be recognized that there is a disproportionate prevalence of prepayment metering in remote Indigenous communities compared to the rest of Australia<sup>46</sup>. There are questions about whether prepayment is a good option for remote communities that already face compounding distributional injustices. While some studies find that prepayment may be preferred to the accrual of unsustainable debts<sup>50,51</sup>, this is only a weak endorsement of prepayment when compared to worse options. The framing of household electricity payment for communities needs to be extended beyond individual fiscal responsibility to incorporate a broader economic lens that accounts for the effects of frequent disconnection from the services that energy provides on Indigenous wellbeing.

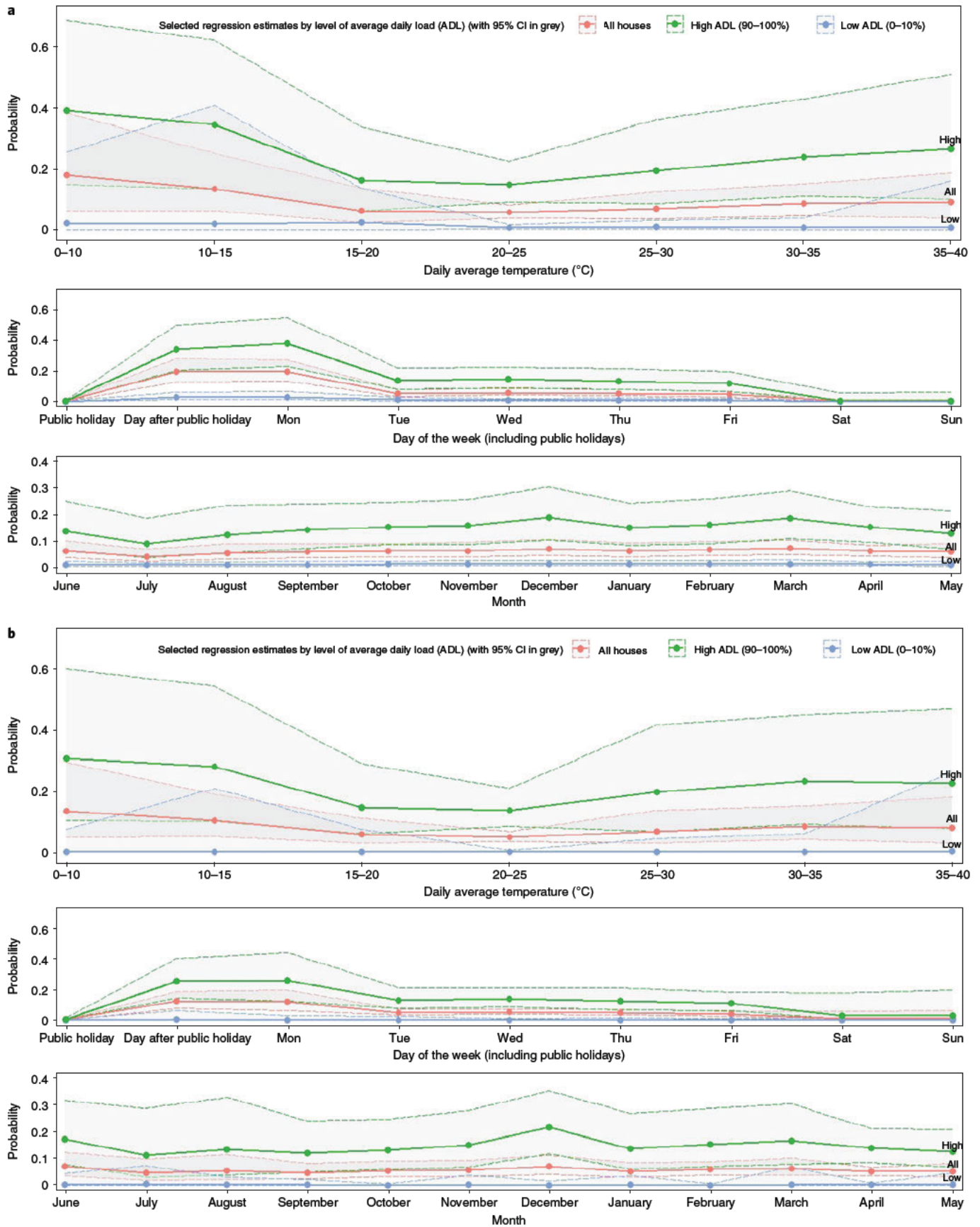
In considering such distributional injustices, procedural injustices first need to be addressed by supporting participatory community engagement in energy policy development (for example, increase local access to data/information and community consultations). Indigenous Australians have distinct societal values and perspectives of wellbeing, and for progress across all spheres of inequity

**Fig. 4 | Probability of a same-day disconnection by temperature, day and month. a**, All regions. **b**, Hot persistently dry grassland climate zone.

Coefficient estimates and 95% confidence intervals from multiple regressions for a sample with 1,674,786 daily observations across 3,300 houses are presented above. Regressions were grouped by percentile of electricity use (that is, average daily load) and by climate zone. Estimates for all houses, low-electricity-use households and high-electricity-use households are shown here (Supplementary Tables 7–11 have all same-day disconnection estimates). Temperature bins are specified using daily average temperatures (in °C). Temperature-based estimates are for a three-day period (that is, temperature on the day of disconnection and the two days before). Temperature estimates are interpreted using 20–25°C as the reference temperature range. Day of the week estimates are interpreted using Wednesday as the reference day. Monthly estimates are interpreted using April as the reference month.

and injustice faced by Indigenous communities there needs to be a recognition of these world views in the context of the realities that these communities face<sup>59</sup>.

The Partnership Agreement on Closing the Gap calls for the greater sharing of, and access to, data and information to support shared decision-making (Fig. 2)<sup>60</sup>. With respect to disconnections,



**Table 2 | Electricity use and disconnections by climate zones**

	Equatorial climate zone (most northern)	Coastal tropical climate zone	Savannah tropical climate zone	Hot persistently dry grassland climate zone (most southern)	All regions
<b>Percentage of disconnections above maximum temperature of 35 °C</b>					
Percentage of same-day disconnections	7	12	34	42	24
Percentage of multi-day disconnections	6	11	36	40	28
Percentage of all disconnections	7	12	34	42	25
<b>Percentage of disconnections above maximum temperature of 40 °C</b>					
Percentage of same-day disconnections	0	0	4	18	5
Percentage of multi-day disconnections	0	0	3	18	7
Percentage of all disconnections	0	0	4	18	5
<b>Percentage of disconnections below minimum temperature of 0 °C</b>					
Percentage of same-day disconnections	0	0	5	12	4
Percentage of multi-day disconnections	0	0	6	11	6
Percentage of all disconnections	0	0	5	12	4
<b>Number of disconnections</b>					
Number of same-day disconnections	32,133	39,212	54,309	30,281	155,935
Number of multi-day disconnections	1,971	2,787	4,841	4,692	14,291
Number of all disconnections	34,104	41,999	59,150	34,973	170,226

a key aim will be reducing the frequency, duration and effects of disconnection. This might include: improving the accessibility and affordability of energy through changes to tariffs or direct access to the benefits of renewable energy such as residential rooftop solar on community housing; improving energy efficiency of infrastructure, buildings and appliances; and improving energy provision for particular critical needs, for example, disconnection prohibitions or tariff reductions during temperature extremes, protections for critical care customers and the use of protected circuits for refrigeration, lighting and essential medical equipment.

In addition to better policy, the language around disconnection events needs to recognize and reflect community experience. The term ‘self-disconnection’, while in common use, is a misrepresentation as it incorrectly implies that households were making a voluntary choice to disconnect themselves<sup>21,50,61</sup>. The term ‘involuntary self-disconnection’ emphasizes ‘that the household has not chosen to cease their electricity supply’<sup>62</sup>.

### Limitations

On considering these results there are limitations that need to be considered. First, we were unable to identify the reasons for multi-day disconnections. Once a disconnection occurs, whether it becomes a multi-day disconnection will depend on a number of factors including whether residents can ‘top up’ credit, pay off ‘friendly credit’ debt, or make other arrangements. Inter- and intraregional mobility in remote and rural Australia is common (refs. <sup>63–65</sup> and E. Ings, personal communication), which could influence the onset and length of multi-day disconnections. Residents may choose to temporarily relocate to the residence of kin for socio-cultural reasons or because of a disconnection, and disconnection-associated relocations may themselves exacerbate overcrowding and increase electricity demand on households that are not yet disconnected. Future studies should focus on the experiences of energy poverty in these communities and further investigate these issues.

Second, we did not have information on the socio-economic and demographic composition of households. To address this, we used statistical approaches to control for differences across households and estimated the effect of temperature on the basis of the usual

level of electricity use and disconnections (during moderate temperatures between 20°C and 25°C). As a result, when discussing the estimates, we provide the likelihood of disconnections during moderate temperatures. Electricity consumption data were used to estimate relationships for different groups of households. There will be additional determinants for the differences in electricity use and disconnection, which should be investigated further.

Third, this study uses data from 3,300 smart prepayment meters and finds that over 170,000 disconnections occurred across 28 communities over a period spanning 18 months. Note that our dataset is unbalanced due to the timing of the roll out of smart meters in the NT. Thus, we underestimate the total number of disconnections in the NT as there are many more households currently using prepayment metering than just those represented in this study<sup>63</sup>. The vulnerability of prepayment customers is often overlooked by government reporting. Further research on prepayment and disconnection in other jurisdictions is needed, as is greater understanding of the direct health effects of these disconnections.

### Conclusions

Australia could do much better at providing protections from disconnection. Policymakers are beginning to consider the importance of electricity to wellbeing in approaches that seek to limit the frequency and duration of disconnection events, particularly in relation to temperature extremes and wellbeing. In the USA, for example, despite not having a formalized definition of energy poverty or federal level protections, many states have utility regulation policies that protect customers from disconnection of service in certain cases, including extreme temperatures<sup>4,26</sup>. Some state consumer protections target vulnerable groups, such as in the state of Texas where prepayment-meter enrolment is prohibited for those diagnosed with severe medical conditions that require electricity services to maintain temperatures or run devices<sup>26,66</sup>. Many European Union states have also introduced protection from disconnection<sup>7</sup>, many with particular focus on extreme temperatures and vulnerable groups.

In Australia, the Essential Service Commission (for Victoria) observes that “customers who are disconnected from electricity or gas can face significant risks to their welfare... disconnection for

non-payment reasons should only ever be a last resort<sup>67</sup>. Australia's National Energy Retail Rules require that the retailer not arrange for the de-energization of premises having life support equipment or during an extreme weather event<sup>68</sup>, but this is not comprehensively applied in remote NT communities<sup>47,48</sup>.

Energy insecurity in remote Indigenous Australia remains a pressing issue. Access to energy has been identified as a key part of the 'critical healthy living priorities' for remote living Indigenous Australians<sup>3</sup>. Ensuring access to essential services is an important prerequisite to improving health and wellbeing outcomes<sup>69</sup>. The focus should not be solely on electricity provision itself, but on maximizing the benefit that households receive from their electricity use and this includes a range of essential services, including heating and cooling.

## Methods

**Ethics statement.** This research was conducted with ethics approval from the Central Australian Health Research Ethics Committee Centre for Remote Health (CA-20-3809).

**Autoethnographic quotes.** While this is predominantly a quantitative study, our research methodology is based on principles of social justice where Aboriginal people participate in setting the research agenda<sup>70</sup> and we supplement our analysis with insights through autoethnography<sup>71</sup>. These quotes are included by authors, N.E.J. who is a community elder and V.N.D. who is a senior Aboriginal researcher. This paper has more than a single authorial voice, coming as it does from multiple perspectives. These perspectives are from researchers who work at an academic institution (T.L., B.R. and L.V.W.), a regional hospital (S.Q.) and community-based organizations (S.Q., M.K. and V.N.D.).

**Dataset.** The data used in this paper were sourced from the NT Government owned utility Power and Water Corporation, the Australian Bureau of Meteorology (BOM) and the Australian Bureau of Statistics. Daily electricity use data for 3,300 households with a smart prepayment meter were matched to temperature data from the closest weather station. For cases where there were no temperature data for that day, the next closest weather station was used (6.1% of all observations). If that still resulted in a missing value, then the average for that climate zone was used (0.3% of observations). Data on disconnections were provided along with the time and date that the electricity service was discontinued and subsequently restored. These cases of disconnection were aggregated into daily data and separated into two variables on the basis of whether an electricity service was restored to the household on the same day or not. Selected summary statistics for these data by climate zones are shown in the paper in Tables 1 and 2.

The climate zones we used were sourced from the Australian BOM<sup>31</sup>. We made some modifications to the zones mapped by BOM, which was to reclassify all of the mainland communities that were within 20 km of the coast as a 'coastal tropical climate zone' and combine the Central Australian climate zones into one region that we called the 'hot persistently dry grassland climate zone'. The second modification was due to sample size and a similarity in temperatures. The other climate zones are those prescribed by BOM, shown in Fig. 1c.

**Extreme temperatures in remote communities.** Those communities that we focus on are typically exposed to extremely hot days and cold nights. Supplementary Table 13 shows the breakdown of key temperature statistics by climate zone for these communities. Figure 1 presents maps produced by the Australian BOM showing how temperature differs across both Australia and the NT<sup>72</sup>. Differences in temperature indicators vary across climate zones (shown in Fig. 1a–c). Central Australia experiences prolonged hot daytime temperatures in summer and cold (below zero) nights in winter. For example, the hottest day (46 °C) and coldest night (−4 °C) in our dataset both occurred in the southern-most 'hot persistently dry grassland climate zone'. Northern regions of the NT experience the southern extent of the tropical monsoon, which brings seasonal cyclonic activity and afternoon storms. Average temperatures decrease north to south. The highest maximum temperature (lowest minimum temperature) increases (decreases) as you move from the north to south (Fig. 1b,c and Supplementary Table 13). The regressions were run using daily average temperatures.

**Grouping by average daily electricity use.** Energy insecurity and disconnection rates are likely to be determined by a range of factors, including the usual level of electricity use and the inability to pay. While we do not have household data on occupancy or income, we are able to categorize the meters into groups using average daily electricity use. The average daily load will be a function of the types of appliance, intensity of use and the number of residents. The percentile groupings used are shown in Supplementary Table 14 along with the aggregate expenditure on electricity. Note that the data are not a balanced panel due to the incremental roll out of smart meters across communities and we excluded those meters with less than 100 observations.

**Regression analysis.** To estimate the relationship between electricity use and temperature we used linear regression with panel-corrected standard errors that accounted for heteroscedasticity and autocorrelation. The 28 communities were the level for the panel correction. The software that was used to estimate these relationships was Stata MP 16.1. The 'xtpcse' command was used to estimate the results shown in Fig. 3 and Supplementary Tables 2–6. We also tested for normality in linear panel-data models using the 'xtsktest' command, which did not reject the null hypothesis of normality (Chi-square statistic of 3.28–3.42 ( $P$  value of 0.18–0.19)). The 'xtserial' command was used to perform the Wooldridge test for autocorrelation in panel data, which rejected the null hypothesis of no first-order autocorrelation ( $F$ -statistic of 6,694.17 ( $P$  of 0.00)). We used random-effects probit regressions to estimate the relationship between the probability of same-day/multi-day disconnection and temperature. These estimates were estimated using the 'xtpb' command in Stata and we clustered the standard errors by community to control for regional differences. The results of the same-day disconnection estimations are shown in Fig. 4 and Supplementary Tables 7–11. When discussing these estimates in the paper we compare them to the likelihood of disconnection during moderate temperatures. The probabilities of disconnection events were converted into an odds ratio (for example, 1:2) and then reported as the chance of a disconnection (for example, one in three). Multi-day disconnection estimates are included in Supplementary Table 12, but are not discussed in the paper as there was no clear relationship between multi-day disconnections and daily average temperature. Note that the regression estimates were graphed using the 'ggplot' command in R.

**Reporting Summary.** Further information on research design is available in the Nature Research Reporting Summary linked to this article.

## Data availability

The data used in this paper are not freely available and were sourced from the data custodians. The electricity data were sourced from Power and Water Corporation (<https://www.powerwater.com.au/>) and the Australian BOM (<http://www.bom.gov.au/>). We note that access to data will be a key part of local communities helping to develop appropriate policy responses to the challenges outlined in this paper. The Partnership Agreement on Closing the Gap calls for the greater sharing of, and access to, data and information at a regional level noting that "disaggregated data and information is most useful to Aboriginal and Torres Strait Islander organizations and communities to obtain a comprehensive picture of what is happening in their communities and to support decision-making"<sup>60</sup>.

## Code availability

The code used to estimate the regressions (in Stata MP 16.1) and create the graphics (in R v.4.1.1) is available on request. The 'xtpcse' and 'xtpb' commands in Stata MP 16.1 were used for the regressions. The regression estimates were graphed using the 'ggplot' command in R. Statistical tests for normality and autocorrelation were performed in Stata MP 16.1 using the 'xtsktest' and 'xtserial'.

Received: 16 April 2021; Accepted: 20 October 2021;



## References

- Bouzarovski, S. & Petrova, S. A global perspective on domestic energy deprivation: overcoming the energy poverty-fuel poverty binary. *Energy Res. Soc. Sci.* **10**, 31–40 (2015).
- Day, R., Walker, G. & Simcock, N. Conceptualising energy use and energy poverty using a capabilities framework. *Energy Policy* **93**, 255–264 (2016).
- Standen, J. C. et al. Prioritising housing maintenance to improve health in indigenous communities in NSW over 20 years. *Int. J. Environ. Res. Public Health* **17**, 5946 (2020).
- Bednar, D. J. & Reames, T. G. Recognition of and response to energy poverty in the United States. *Nat. Energy* **5**, 432–439 (2020).
- Hernández, D. Understanding 'energy insecurity' and why it matters to health. *Soc. Sci. Med.* **167**, 1–10 (2016).
- Walker, G. & Day, R. Fuel poverty as injustice: Integrating distribution, recognition and procedure in the struggle for affordable warmth. *Energy Policy* **49**, 69–75 (2012).
- Dobbins, A., Fuso Nerini, F., Deane, P. & Pye, S. Strengthening the EU response to energy poverty. *Nat. Energy* **4**, 2–5 (2019).
- Carley, S. & Konisky, D. M. The justice and equity implications of the clean energy transition. *Nat. Energy* **5**, 569–577 (2020).
- Sovacool, B. K. & Dworkin, M. H. Energy justice: conceptual insights and practical applications. *Appl. Energy* **142**, 435–444 (2015).
- Memmott, T., Carley, S., Graff, M. & Konisky, D. M. Sociodemographic disparities in energy insecurity among low-income households before and during the COVID-19 pandemic. *Nat. Energy* <https://doi.org/10.1038/s41560-020-00763-9> (2021).
- Anderson, W., White, V. & Finney, A. Coping with low incomes and cold homes. *Energy Policy* **49**, 40–52 (2012).

12. Bouzarovski, S., Petrova, S. & Sarlamanov, R. Energy poverty policies in the EU: a critical perspective. *Energy Policy* **49**, 76–82 (2012).
13. Snell, C., Bevan, M. & Thomson, H. Justice, fuel poverty and disabled people in England. *Energy Res. Soc. Sci.* **10**, 123–132 (2015).
14. Frank, D. A. et al. Heat or eat: the low income home energy assistance program and nutritional and health risks among children less than 3 years of age. *Pediatrics* **118**, e1293–e1302 (2006).
15. Cook, J. T. et al. A brief indicator of household energy security: associations with food security, child health, and child development in US infants and toddlers. *Pediatrics* **122**, e867–75 (2008).
16. Nord, M. & Kantor, L. S. Seasonal variation in food insecurity is associated with heating and cooling costs among low-income elderly Americans. *J. Nutr.* **136**, 2939–2944 (2006).
17. Reames, T. G. Targeting energy justice: exploring spatial, racial/ethnic and socioeconomic disparities in urban residential heating energy efficiency. *Energy Policy* **97**, 549–558 (2016).
18. Alola, A. A. et al. Cooling and heating degree days in the US: the role of macroeconomic variables and its impact on environmental sustainability. *Sci. Total Environ.* **695**, 133832 (2019).
19. Shin, M. & Do, S. L. Prediction of cooling energy use in buildings using an enthalpy-based cooling degree days method in a hot and humid climate. *Energy Build.* **110**, 57–70 (2016).
20. De Rosa, M., Bianco, V., Scarpa, F. & Tagliafico, L. A. Heating and cooling building energy demand evaluation; a simplified model and a modified degree days approach. *Appl. Energy* **128**, 217–229 (2014).
21. O'Sullivan, K. C., Howden-Chapman, P. L. & Fougere, G. Making the connection: the relationship between fuel poverty, electricity disconnection, and prepayment metering. *Energy Policy* **39**, 733–741 (2011).
22. Healy, J. D. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. *J. Epidemiol. Commun. Health* **57**, 784–789 (2003).
23. Robinson, C., Lindley, S. & Bouzarovski, S. The spatially varying components of vulnerability to energy poverty. *Ann. Am. Assoc. Geogr.* **109**, 1188–1207 (2019).
24. O'Sullivan, K. C., Stanley, J., Fougere, G. & Howden-Chapman, P. Heating practices and self-disconnection among electricity prepayment meter consumers in New Zealand: a follow-up survey. *Util. Policy* **41**, 139–147 (2016).
25. Jessel, S., Sawyer, S. & Hernández, D. Energy, poverty, and health in climate change: a comprehensive review of an emerging literature. *Front. Public Health* <https://doi.org/10.3389/fpubh.2019.00357> (2019).
26. Flaherty, M., Carley, S. & Konisky, D. M. Electric utility disconnection policy and vulnerable populations. *Electr. J.* **33**, 106859 (2020).
27. Dobbins, A., Pye, S., De Miglio, R. & Brajkovic, J. *Measures to Protect Vulnerable Consumers in the Energy Sector: An Assessment of Disconnection Safeguards, Social Tariffs and Financial Transfers* Vol. 8 (Insight-E, 2016).
28. Regulation—unregulated networks. *Power and Water Corporation* <https://www.powerwater.com.au/about/regulation> (2021).
29. *Climate Change in the Northern Territory – State of the Science and Climate Change Impacts* (NESP ESCC Hub, 2020).
30. Kovats, R. S. & Hajat, S. Heat stress and public health: a critical review. *Annu. Rev. Public Health* **29**, 41–55 (2008).
31. Longden, T. The impact of temperature on mortality across different climate zones. *Climatic Change* **157**, 221–242 (2019).
32. Patz, J. A., Campbell-Lendrum, D., Holloway, T. & Foley, J. A. Impact of regional climate change on human health. *Nature* **438**, 310–317 (2005).
33. Mora, C. et al. Global risk of deadly heat. *Nat. Clim. Change* **7**, 501–506 (2017).
34. Nussbaum, M. C. & Sen, A. *The Quality of Life* (Oxford Univ. Press, 2004).
35. Sen, A. *Inequality Reexamined* (Oxford Univ. Press, 1992).
36. Nussbaum, M. C. *Creating Capabilities: The Human Development Approach* (Harvard Univ. Press, 2011).
37. Zahurul, S. et al. Future strategic plan analysis for integrating distributed renewable generation to smart grid through wireless sensor network: Malaysia prospect. *Renew. Sustain. Energy Rev.* **53**, 978–992 (2016).
38. Fraser, N. *Justice Interruptus: Critical Reflections on the 'Postsocialist' Condition* (Routledge, 1997).
39. Schlosberg, D. *Defining Environmental Justice: Theories, Movements and Nature* (Oxford Univ. Press, 2007).
40. Council of Australian Governments *National Indigenous Reform Agreement (Closing the Gap)* (CAG, 2009).
41. Department of Families Community Services and Indigenous Affairs *National Indigenous Housing Guide: Improving the Living Environment for Safety, Health and Sustainability* 3rd edn (DSS, Australian Government, 2012).
42. *National Energy Retail Law (South Australia) Act 2011* (Government of South Australia, 2011); [https://www.legislation.sa.gov.au/LZ/C/A/NATIONAL%20ENERGY%20RETAIL%20LAW%20\(SOUTH%20AUSTRALIA\)%20ACT%202011/CURRENT/2011.6.AUTH.PDF](https://www.legislation.sa.gov.au/LZ/C/A/NATIONAL%20ENERGY%20RETAIL%20LAW%20(SOUTH%20AUSTRALIA)%20ACT%202011/CURRENT/2011.6.AUTH.PDF)
43. Australian Energy Market Commission *National Energy Retail Rules Version 27* (AEMC, 2021).
44. *Prepayment Meter System Code: Draft Final Decision* (Essential Services Commission of South Australia, 2005); [https://www.escosa.sa.gov.au/ArticleDocuments/805/050308-PrePaymentMeter\\_CombDraftFinalDec\\_Code.pdf.aspx?Embed=Y](https://www.escosa.sa.gov.au/ArticleDocuments/805/050308-PrePaymentMeter_CombDraftFinalDec_Code.pdf.aspx?Embed=Y)
45. *Prepayment Meters: Discussion Paper* (Energy and Water Ombudsman NSW, 2014).
46. McKenzie, M. *Pre-Payment Meters and Energy Efficiency in Indigenous Households* (Centre for Appropriate Technology, 2013); <https://cfat.org.au/pre-payment-meters-and-energy-efficiency-in-indigenous-households>
47. *Electricity Retail Supply Code Review Issues Paper* (Utilities Commission of the Northern Territory, 2021); [https://utilicom.nt.gov.au/\\_data/assets/pdf\\_file/0019/1011655/Issues-Paper-Electricity-Retail-Supply-Code-Review.pdf](https://utilicom.nt.gov.au/_data/assets/pdf_file/0019/1011655/Issues-Paper-Electricity-Retail-Supply-Code-Review.pdf)
48. Thomson, M. Review of the Retail Supply Code—further information. *Utilities Commission of the Northern Territory* [https://utilicom.nt.gov.au/\\_data/assets/pdf\\_file/0010/747568/Power-and-Water-Corporation-Submission-additional.pdf](https://utilicom.nt.gov.au/_data/assets/pdf_file/0010/747568/Power-and-Water-Corporation-Submission-additional.pdf) (2019).
49. Vyas, D. *Topping-up or Dropping-Out: Self-Disconnection Among Prepayment Meter Users* (Citizens Advice Bureau, 2014); [https://www.citizensadvice.org.uk/global/migrated\\_documents/corporate/topping-up-or-dropping-out.pdf](https://www.citizensadvice.org.uk/global/migrated_documents/corporate/topping-up-or-dropping-out.pdf)
50. O'Sullivan, K. C., Howden-Chapman, P. L., Fougere, G. M., Hales, S. & Stanley, J. Empowered? Examining self-disconnection in a postal survey of electricity prepayment meter consumers in New Zealand. *Energy Policy* **52**, 277–287 (2013).
51. Wagner, O. & Wiegand, J. Prepayment metering: household experiences in Germany. *Renew. Sustain. Energy Rev.* **98**, 407–414 (2018).
52. Brutscher, P.-B. *Self-Disconnection Among Pre-Payment Customers—A Behavioural Analysis* (Univ. Cambridge, 2012); <https://aspace.repository.cam.ac.uk/handle/1810/257126>
53. *Submission 165.2 to the Inquiry into Homelessness in Australia* (Tangentyere Council, 2021); [https://www.aph.gov.au/Parliamentary\\_Business/Committees/House/Social\\_Policy\\_and\\_Legal\\_Affairs/HomelessnessinAustralia/Submissions](https://www.aph.gov.au/Parliamentary_Business/Committees/House/Social_Policy_and_Legal_Affairs/HomelessnessinAustralia/Submissions)
54. *Households in the Dark II: Mapping Electricity Disconnections in South Australia, Victoria, New South Wales and South East Queensland* (St Vincent de Paul Society & Alviss Consulting, 2019); [https://www.vinnies.org.au/icms\\_docs/310289\\_Households\\_in\\_the\\_Dark\\_II\\_2019.pdf](https://www.vinnies.org.au/icms_docs/310289_Households_in_the_Dark_II_2019.pdf)
55. *Retail Performance Data Snapshot 2018–19* (AER, 2019); <https://www.aer.gov.au/system/files/AER%20Payment%20difficulties%20and%20hardship%20data%20by%20jurisdiction%202018-19.pdf>
56. *Empowering Remote Communities* (Queensland Council of Social Service, 2014).
57. *Prepayment Power Meters* (Power and Water Corporation, 2021); <https://www.powerwater.com.au/customers/power/power-meters/prepayment-power-meter-s#Remote>
58. Walker, G., Simcock, N. & Day, R. Necessary energy uses and a minimum standard of living in the United Kingdom: energy justice or escalating expectations? *Energy Res. Soc. Sci.* **18**, 129–138 (2016).
59. Kingsley, J., Townsend, M., Henderson-Wilson, C. & Bolam, B. Developing an exploratory framework linking Australian aboriginal peoples' connection to country and concepts of wellbeing. *Int. J. Environ. Res. Public Health* **10**, 678–698 (2013).
60. *Priority Reforms. Closing the Gap* (Australian Government, 2021); <https://www.closingthegap.gov.au/priority-reforms>
61. Rocha, M., Baddeley, M., Pollitt, M. & Weeks, M. Addressing self-disconnection among prepayment energy consumers: a behavioural approach. *Energy Econ.* **81**, 273–286 (2019).
62. *NTCOSS Cost of Living Report—Issue 26* (NTCOSS, 2019).
63. Memmott, P. et al. *NATSISS Crowding Data: What Does it Assume and How Can We Challenge the Orthodoxy?* (Australian National Univ., 2019); <https://press-files.anu.edu.au/downloads/press/p206931/html/ch12.html?referer=&page=19>
64. Memmott, P., Long, S. & Thomson, L. *Mobility of Aboriginal People in Rural and Remote Australia* Research and Policy Bulletin (AHURI, 2006); <https://www.ahuri.edu.au/research/research-and-policy-bulletins/69>
65. Memmott, P., Long, S., Bell, M., Taylor, J. & Brown, D. *Between Places: Indigenous Mobility in Remote and Rural Australia* (The Australian Housing and Urban Research Institute, 2004).
66. *Public Utility Commission (PUC) Rules Ch. 25* (Public Utility Commission of Texas, 2021); <https://www.puc.texas.gov/agency/rulesnlaws/subrules/electric/ch25complete.pdf?v=20200511>
67. *Victorian Energy Market Report 2019–20* (Essential Services Commission, 2020).
68. *National Energy Retail Rules—Current* (AEMC, 2021).
69. Hunt, J., Riley, B., O'Neill, L. & Maynard, G. Transition to renewable energy and indigenous people in Northern Australia: enhancing or inhibiting capabilities? *J. Hum. Dev. Capab.* <https://doi.org/10.1080/19452829.2021.1901670> (2021).
70. Coghlan, D. & Brydon-Miller, M. *The SAGE Encyclopedia of Action Research* (Sage, 2014).
71. Adams, T. E., Ellis, C. & Jones, S. H. in *The International Encyclopedia of Communication Research Methods* (ed. Matthes, J.) <https://doi.org/10.1002/9781118901731.iecrm0011> (2017).
72. Climate maps: temperature archive—twelve-monthly highest maximum temperature for Australia. *Australian Government Bureau of Meteorology* <http://www.bom.gov.au/jsp/awap/temp/archive.jsp?colour=colour&map=maxxtrm%2Fhi&year=2019&month=6&period=12month&area=nat> (2019).

73. Australian climate zones. *Australian Government Bureau of Meteorology* [http://www.bom.gov.au/jsp/ncc/climate\\_averages/climate-classifications/index.jsp?maptype=kpn#maps](http://www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp?maptype=kpn#maps) (2005).
74. Climate maps: temperature archive—twelve-monthly lowest minimum temperature for Australia. *Australian Government Bureau of Meteorology* <http://www.bom.gov.au/jsp/awap/temp/archive.jsp?colour=colour&map=minextrm%2Flow&year=2019&month=6&period=12month&area=na> (2019).
75. Climate maps: temperature archive—maximum temperature anomaly. *Australian Government Bureau of Meteorology* <http://www.bom.gov.au/jsp/awap/temp/archive.jsp?colour=colour&map=maxanom&year=2019&month=6&period=12month&area=na> (2021).

## Acknowledgements

We acknowledge and thank the Power and Water Corporation for providing the electricity data. We acknowledge the Australian BOM and thank them for providing temperature data and maps. A range of people provided useful advice that helped to shape this paper and they include E. Ings and J. Hulcombe. We thank the Board and staff of Tangentyere Council Aboriginal Corporation in Mparntwe (Alice Springs) and the Board and staff of Julalikari Council Aboriginal Corporation in Tennant Creek. Our research methodology was informed by the principles underpinning ethical Australian Indigenous research outlined in the AIATSIS Code of Ethics for Aboriginal and Torres Strait Islander Research (AIATSIS 2020): Indigenous self-determination, Indigenous leadership, impact and value, sustainability and accountability. We acknowledge and thank colleagues at the Australian National University. T.L., B.R. and L.V.W. thank their colleagues from the ANU Grand Challenge Zero-Carbon Energy for the Asia-Pacific and the Institute for Climate, Energy and Disaster Solutions.

## Author contributions

All authors contributed to the conceptualization of the research. We especially note the contributions of N.F.J. and V.N.D. in shaping our understanding of the key issues faced by Indigenous communities in the NT. S.Q. acquired the key data, and T.L. performed the analysis. T.L., S.Q., B.R., L.V.W. and M.K. wrote the initial draft of the manuscript, and all authors contributed to the review and revision. N.F.J. and V.N.D. were engaged in discussions on key issues with the other members of the authorship team and their selected quotes are provided to highlight those themes and the issues that they raised as being the most important (refer to autoethnographic data section for more information).

## Competing interests

The authors declare no competing interests.

## Additional information

**Extended data** are available for this paper at <https://doi.org/10.1038/s41560-021-00942-2>.

**Supplementary information** The online version contains supplementary material available at <https://doi.org/10.1038/s41560-021-00942-2>.

**Correspondence and requests for materials** should be addressed to Michael Klerck.

**Peer review information** *Nature Energy* thanks Kimberley O'Sullivan, Sangeetha Chandrashekeran and Stefan Bouzarovski for their contribution to the peer review of this work

**Reprints and permissions information** is available at [www.nature.com/reprints](http://www.nature.com/reprints).

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

© The Author(s), under exclusive licence to Springer Nature Limited 2021

## Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our [Editorial Policies](#) and the [Editorial Policy Checklist](#).

### Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a Confirmed

- The exact sample size ( $n$ ) for each experimental group/condition, given as a discrete number and unit of measurement
- A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
- The statistical test(s) used AND whether they are one- or two-sided  
*Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
- A description of all covariates tested
- A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
- A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
- For null hypothesis testing, the test statistic (e.g.  $F$ ,  $t$ ,  $r$ ) with confidence intervals, effect sizes, degrees of freedom and  $P$  value noted  
*Give  $P$  values as exact values whenever suitable.*
- For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
- For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
- Estimates of effect sizes (e.g. Cohen's  $d$ , Pearson's  $r$ ), indicating how they were calculated

*Our web collection on [statistics for biologists](#) contains articles on many of the points above.*

### Software and code

Policy information about [availability of computer code](#)

Data collection No software was used for data collection.

Data analysis The software that was used was Stata MP 16.1 and the 'xtpcse' and 'xtprobit' commands were used for the regressions. The regression estimates were graphed using the 'ggplot' command in R 4.1.1. Statistical tests for normality and autocorrelation were performed in Stata MP 16.1 using the 'xtsktest' and 'xtserial'.

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio [guidelines for submitting code & software](#) for further information.

### Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our [policy](#)

The data used in this paper is not freely available and was sourced from the following data custodians. The electricity data was sourced from Power and Water Corporation (<https://www.powerwater.com.au/>) and the Australian Bureau of Meteorology (<http://www.bom.gov.au/>).

## Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

Life sciences  Behavioural & social sciences  Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see [nature.com/documents/nr-reporting-summary-flat.pdf](https://www.nature.com/documents/nr-reporting-summary-flat.pdf)

## Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	This is a quantitative study that assesses the relationship between temperature and electricity use (including disconnection) using daily smart meter data for 28 remote Indigenous communities.
Research sample	The data set includes the electricity use of 3,300 households across 28 remote Indigenous communities. The data set is unbalanced due to the timing of the roll out of smart meters in the Northern Territory. But the data is representative of the communities where the roll out occurred as we had access to all smart meter data. The electricity data was sourced from Power and Water Corporation ( <a href="https://www.powerwater.com.au/">https://www.powerwater.com.au/</a> ) and the Australian Bureau of Meteorology ( <a href="http://www.bom.gov.au/">http://www.bom.gov.au/</a> ).
Sampling strategy	Most of the tables were created and all of the regressions were performed using all available data. Table 1 is limited to the observations for a balanced panel for 2018/19 financial year (i.e. only the observations with data for every day of the year). This was done to compare to other studies with annual disconnection rates.
Data collection	Data was received from two data custodians and matched at the community level. Daily smart meter data was sourced from Power and Water Corporation. Daily temperature data was sourced from the Australian Bureau of Meteorology. Data was matched based on the location of communities and weather stations. Dr Longden was the only researcher with full access to all of the matched data.
Timing	Unbalanced panel data between January 2018 to July 2019.
Data exclusions	We excluded those meters with less than 100 observations as we required temperature and seasonal variation to estimate the regressions.
Non-participation	No individual participants were involved in the study.
Randomization	No randomization occurred. We had access to all smart meters in those communities that had them installed at that point in time. We grouped households based on daily electricity use and climate zones. The key explanatory variables were exogenous (such as temperature and month) so randomization was not necessary.

## Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

### Materials & experimental systems

n/a	Involved in the study
<input checked="" type="checkbox"/>	<input type="checkbox"/> Antibodies
<input checked="" type="checkbox"/>	<input type="checkbox"/> Eukaryotic cell lines
<input checked="" type="checkbox"/>	<input type="checkbox"/> Palaeontology and archaeology
<input checked="" type="checkbox"/>	<input type="checkbox"/> Animals and other organisms
<input type="checkbox"/>	<input checked="" type="checkbox"/> Human research participants
<input checked="" type="checkbox"/>	<input type="checkbox"/> Clinical data
<input checked="" type="checkbox"/>	<input type="checkbox"/> Dual use research of concern

### Methods

n/a	Involved in the study
<input checked="" type="checkbox"/>	<input type="checkbox"/> ChIP-seq
<input checked="" type="checkbox"/>	<input type="checkbox"/> Flow cytometry
<input checked="" type="checkbox"/>	<input type="checkbox"/> MRI-based neuroimaging

## Human research participants

Policy information about [studies involving human research participants](#)

Population characteristics	The data set includes the electricity use of 3,300 households across 28 remote Indigenous communities. No individual characteristics were collected.
Recruitment	The data set is unbalanced due to the timing of the roll out of smart meters in the Northern Territory. But the data is representative of the communities where the roll out occurred as we had access to all smart meter data.

Ethics oversight

This research was conducted with ethics approval from the Central Australian Health Research Ethics Committee Centre for Remote Health (CA-20-3809).

Note that full information on the approval of the study protocol must also be provided in the manuscript.



## Is climate change exacerbating health-care workforce shortages for underserved populations?

Like many countries, Australia is faced with substantial maldistribution of the health-care workforce and inequity in access to health-care services. This inequity is especially acute in rural and remote areas, where health-care professionals are continuously in short supply, and where recruitment and retention are major policy challenges.<sup>1,2</sup> It is well established that, in these areas of Australia, increasing ambient temperatures caused by global climate change are heightening the risk of heat-related illnesses.<sup>3,4</sup> Heat might also be affecting health and access to health-care by making work in these locations less appealing to medical practitioners, but little is known about the specific effects of heat on the health-care workforce. We aimed to assess these effects in the Northern Territory of Australia, a geographically remote and sparsely populated region spanning 1.42 million km<sup>2</sup>. First Nations people make up 30.9% of the Northern Territory population, compared with 3.3% of the population of the entire country. They have much poorer health outcomes and a life expectancy of 66.6 years for men and 69.9 years for women, compared with the average of 78.1 years for men and 82.7 years for women in the non-Indigenous population of the Northern Territory.<sup>5</sup>

The Northern Territory is being increasingly exposed to extreme heat, water insecurity, and violent storms.<sup>3,6</sup> In December, 2019, and January, 2020, the temperature in the Northern Territory was almost 4.0°C higher than the long-term average, and in 2019, Katherine, the

third largest town in the Northern Territory, recorded 54 days of temperatures above 40°C;<sup>6</sup> extreme heat that is associated with considerably increased morbidity and mortality.<sup>3,4</sup> Poorly maintained and overcrowded housing, energy insecurity, lack of air conditioning, and substantial socioeconomic disadvantages aggravate the health risks of the population in these areas, particularly among Indigenous communities with high rates of chronic disease.<sup>3</sup>

We surveyed registered practicing medical professionals working in the Northern Territory during November, 2020, to assess their perceptions of climate-related health effects and investigate whether climate change is affecting their intentions to stay in the Northern Territory. Our survey was adapted from pre-existing surveys for the evaluation of medical workforce retention and community attitudes to climate change.<sup>7,8</sup> The online survey was distributed electronically through local professional networks. Ethics approval was granted by the Human Research Ethics Committees of the Australian National University, Canberra, Australia and of the Northern Territory Department of Health and Menzies School of Health Research, Darwin, Australia.

Overall, 362 doctors (25.7% of 1407 registered)<sup>10</sup> took the survey. Of the 359 respondents who completed demographic questions, 198 (55.2%) were women (compared with 50.8% of all Northern Territory medical professionals), and 215 (59.9%) were aged 30–49 years. In 352 respondents indicating their

	Climate change is already causing	Climate change is likely to cause	Climate change is unlikely to cause	Climate change will not cause	Do not know
Me to consider leaving the Northern Territory (n=342)	50 (15%)	65 (19%)	114 (33%)	89 (26%)	24 (7%)
Negative effects on the health of my patients (n=339)	180 (53%)	108 (32%)	12 (4%)	12 (4%)	27 (8%)
Parts of the Northern Territory to become uninhabitable (n=340)	104 (31%)	148 (44%)	22 (7%)	12 (4%)	54 (16%)
Water shortages in our communities (n=340)	208 (61%)	79 (23%)	17 (5%)	11 (3%)	25 (7%)
More heatwaves and extremely hot days (n=342)	266 (78%)	47 (14%)	6 (2%)	6 (2%)	17 (5%)
Rising sea levels threatening our coastal communities (n=340)	223 (66%)	84 (25%)	7 (2%)	8 (2%)	18 (5%)
More bushfires (n=341)	258 (76%)	49 (14%)	9 (3%)	8 (2%)	17 (5%)
More extreme weather events, such as floods and cyclones (n=341)	243 (71%)	64 (19%)	6 (2%)	8 (2%)	20 (6%)

Total survey respondents: 362.

**Table: Medical professionals' perception of climate-related health effects in the Northern Territory, Australia**

professional category, 122 (34.7%) were doctors in training, 92 (26.1%) were general practitioners or rural generalists, 137 (38.9%) were other specialists, and one (0.3%) was a non-specialist medical officer. Of 359 eligible responses, only 24 (6.7%) reported having completed their medical training in the Northern Territory, whereas 256 (71.3%) completed it elsewhere in Australia and 79 (22.0%) were overseas graduates.

Over a third (34%) of the respondents indicated that climate change is already causing, or likely to cause, them to consider leaving the Northern Territory (table). 85% of respondents reported that climate change is already causing, or likely to cause, negative effects on the health of their patients, and nearly three-quarters (74%) responded that climate change is already causing, or likely to cause, parts of the Northern Territory to become uninhabitable. Responses to the survey also indicate that climate change is already causing, or is likely to cause, an intensification of environmental health stressors through more extreme heat events (92% of respondents), more extreme weather events such as floods and cyclones (90%), rising sea levels threatening coastal communities (90%), more severe bushfires (90%), and water shortages (84%).

Our findings indicate that the vast majority of doctors in the Northern Territory perceive that the effects of climate change are already having serious adverse effects on local health, and causing a large proportion of them to consider moving elsewhere to work. Out-migration to cooler climates is a response to worsening heat stress that is available to doctors, who generally have the financial means and ability to relocate.<sup>9</sup> However, if even modest numbers of medical practitioners in the Northern Territory did so, health-care workforce shortages, staff turnover, and reliance on short-term staff would be greatly exacerbated, leading to less effective care, higher hospitalisation rates, and higher costs of health care.<sup>1,2</sup>

Climate change has multiple effects on the health of populations, and is a driver of migration within and between countries.<sup>9</sup> Our survey suggests that the disproportionate mobility of the professional medical workforce compared with the local populations in increasingly hot zones will eventually lead to severe

health-care workforce shortages, especially for disadvantaged populations.<sup>2,9</sup> Health-care workforce supply should be considered in climate-related health risk assessments and adaptation strategies, and climate-related concerns should feature in the national health workforce strategy. A comprehensive National Plan for Health and Climate Change would address the challenges faced by remote and Indigenous communities, who are at particular risk, and by the workforce that supports their health needs.<sup>2,4</sup>

We declare no competing interests.

Copyright © 2021 The Authors. Published by Elsevier Ltd. This is an Open Access article under the CC BY-NC-ND 4.0 license.

\*Catherine G Pendrey, Simon Quilty, Russell L Gruen, Tarun Weeramanthri, Robyn M Lucas  
catherine.pendrey@anu.edu.au

Research School of Population Health (CGP, SQ, RML), Australian National University College of Health and Medicine (RLG), Australian National University, Canberra, ACT, Australia; School of Population and Global Health, University of Western Australia, Nedlands, WA, Australia (TW)

- 1 Wakerman J, Humphreys J, Russell D, et al. Remote health workforce turnover and retention: what are the policy and practice priorities? *Hum Resour Health* 2019; 17: 99.
- 2 WHO. Global strategy on human resources for health: workforce 2030. July 7, 2020. Geneva: World Health Organisation. <https://www.who.int/publications/i/item/9789241511131> (accessed Dec 20, 2020).
- 3 Hall NL, Crosby L. Climate change impacts on health in remote Indigenous communities in Australia. *Int J Environ Health Res* 2020; published online June 16. <https://doi.org/10.1080/09603123.2020.1777948>.
- 4 Talley NJ, Stanley FJ, Lucas T, Horton RC. Health and climate change MJA-Lancet Countdown report: Australia gets another failing grade in 2020 but shows signs of progress. *Lancet* 2020; published online Dec 18. [https://doi.org/10.1016/s0140-6736\(20\)32632-5](https://doi.org/10.1016/s0140-6736(20)32632-5).
- 5 Australian Bureau of Statistics. Aboriginal and Torres Strait Islander Peoples. 2018. Canberra: Australian Bureau of Statistics. <https://www.abs.gov.au/statistics/people/aboriginal-and-torres-strait-islander-peoples> (accessed Dec 31, 2020).
- 6 Bureau of Meteorology. Annual Climate Summary for Northern Territory—Northern Territory in 2019: a very warm and dry year. 2020. Canberra: Bureau of Meteorology, Australian Government. <http://www.bom.gov.au/climate/current/annual/nt/archive/2019.summary.shtml> (accessed Dec 20, 2020).
- 7 Campbell N, Smedts A, Lowe S, Keane S, Smith T. The Northern Territory Allied Health Workforce study final report. 2010. Darwin: Flinders University. [https://www.academia.edu/7824137/The\\_Northern\\_Territory\\_Allied\\_Health\\_Workforce\\_Study\\_The\\_Northern\\_Territory\\_Clinical\\_School\\_and\\_the\\_University\\_Departments\\_of\\_Rural\\_Health\\_at?pls=RHCr9pbNOZ](https://www.academia.edu/7824137/The_Northern_Territory_Allied_Health_Workforce_Study_The_Northern_Territory_Clinical_School_and_the_University_Departments_of_Rural_Health_at?pls=RHCr9pbNOZ) (accessed Dec 10, 2020).
- 8 Merzian R, Quicke A, Bennett E, Campbell R, Swann T. Climate of the Nation 2019: tracking Australia's attitudes towards climate change and energy. September 2019. Canberra: The Australia Institute. <https://australiainstitute.org.au/report/climate-of-the-nation-2019> (accessed Dec 30, 2020).
- 9 Black R, Bennett SR, Thomas SM, Beddington JR. Migration as adaptation. *Nature* 2011; 478: 447–49.
- 10 Australian Health Practitioner Regulation Agency. Registrant Data: reporting period 01 July 2020 to 30 September 2020. November 2020. Melbourne: Medical Board of Australia. <https://www.medicalboard.gov.au/News/Statistics.aspx> (accessed Nov 30, 2020).



## COMMENTARY

## Climate change: A Wumpurrarni-kari and Papulanyi-kari shared problem

Simon Quilty<sup>1,2</sup> and Norman Frank Jupurrula<sup>3</sup><sup>1</sup>Alice Springs Hospital, Alice Springs, <sup>3</sup>Warumungu Elder, Tennant Creek, Northern Territory and <sup>2</sup>Research School of Population Health, Australian National University, Canberra, Australian Capital Territory, Australia

SQ & NFJ: We are two men around the same age, not yet 50 years old, both born in Australia. One of us is Wumpurrarni, a First Nations man of the Warumungu people of Tennant Creek and the Barkly region of the Northern Territory, Australia. The other one of us is Papulanyi, a non Indigenous man from Sydney, Australia, descended from Irish and English ancestors.

We share a deep friendship and a shared concern about climate change – the way it is already impacting the lives of our children and our grandchildren. We are worried about climate justice and the ways climate change will grow the already big inequity between Wumpurrarni and Papulanyi even more than it is now, with our children and future generations, who have contributed least to the problem, being hurt hardest.

NFJ: We Warumungu people all go right back thousands of years living on this *Manu* [country]. Our connection goes all the way back in time – stretching right back to where we are all from. There is a deep thing called *Ngurlu*, our marker. My *Ngurlu* is from my great great great grandmother. Nobody can argue with *Ngurlu*, because it tells us where we are from, who we are, how we are related to each other, and it goes all the way back.

SQ: Today, we all share this country, and in Northern Australia, the profound new heat of climate change is reshaping everything.

NFJ: Climate change is like a fire that Papulanyi [started and we need to put it out]. If not, we will face the consequences, whole families, the whole world. It'll sing [kill] us all. Wumpurrarni [First Nations] do not like what Papulanyi have done to the land, and to our health.

SQ: For First Nations people in the north of Australia, living with heat over thousands of generations has shaped cultural and knowledge structures in ways that are so old they tangle with genetics.<sup>1</sup> But recent years have brought new extreme heat, which is destroying ecosystems that have long been the foundations of life, and wellness of this land (Fig. 1).

Communities in the north of Australia already have significantly higher heat associated mortality than their southern counterparts,<sup>2</sup> and we are only at the beginning of a long journey into this new climatic age.

Without factoring the impact of future climate change, remote living Aboriginal children born today have a life expectancy that is already 14.3 years lower than the national average.<sup>3</sup> To understand how climate change will affect the wellbeing of these children as they grow older, current circumstances in their communities need to be acknowledged for the threat they represent.

**Correspondence:** Dr Simon Quilty, Alice Springs Hospital, Alice Springs, NT, Australia. email: simon.quilty@anu.edu.au

Accepted for publication 1 September 2021.

NFJ: We've got to talk about the past, about the present and about how it affects our future. We've got to talk about truth telling, including how racism and colonisation affect our lives today.

When Papulanyi talks to Papalinyi [a non indigenous person with a grievance negotiates with another non indigenous person, using western legal frameworks to resolve the circumstances], he locks it in. That man who is listening puts it in his head, and he makes sure he does something about it.

But like the old Blackfellas say, when Wumpurrarni talk to Papulanyi it goes in one ear and out the other. When it comes to climate change and our children, this is not good enough. Papulanyi must hear us and act.

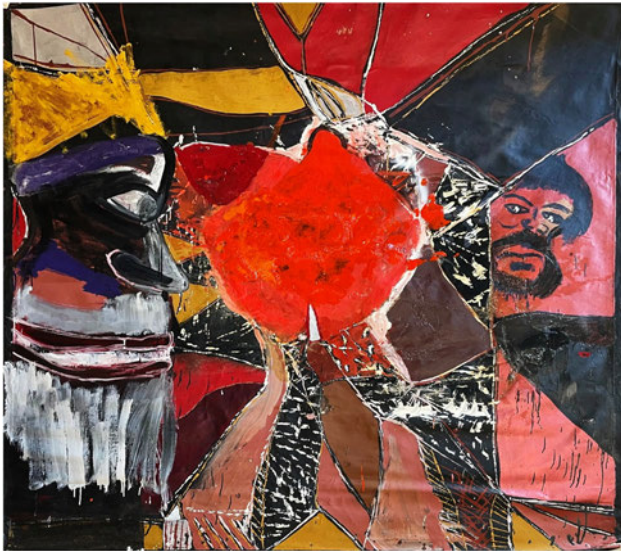
SQ: In contrast to Papulanyi/Western people, who have developed an almost complete multi generational divorce from the outside world as if it has no relevance in day to day existence, Wumpurrarni/First Nations people of northern Australia live in socio cultural harmony with the environment. This is not some kind of romanticisation of more wholesome times of the past. It is real today and it is lived. Warming of the climate was recognised by Wumpurrarni people, independent of Western scientific reports (Fig. 2), decades ago. It was recognised as a unidirectional phenomenon that was changing many aspects of an interdependent ecosystem upon which thousands of generations have relied upon for life.

NFJ: Papulanyi in cities do not see the country dying like we do. In the cities, they do not see Nature. They see walls every day, they see green parks, and they have running water all the time. They do not see creeks that only run once a year. In the city, they know that beach where the waves are flapping every day. They do not see it change. Not like us, we see our rivers and creeks rise up and down. It might look good this year, then next one it's no good. We see a change because of weather over different seasons and years, but now we can see big changes over the last 30 years.

On a really hot day, we would stay right near water. We would sit right on the side in the shade all day, do not worry about working during the day. We'd hunt or set traps in the evening when it's cool and get it early the next morning.

Now we are just watching these hot days that are getting hotter more often and for longer. Finding a cool time and place is getting harder. It's getting too hot for Ceremony. Ceremony is all about keeping things level, between people and country. Now it's getting hard to find a safe time and place for young fellas to go through Ceremony, a place and time when it's not too hot. That's not healthy for our people or our *Manu* [country].

In a mining town, like Tennant Creek, we have seen that the Papulanyi way is to rip the ground, dig up the ore, cart it away to another country. All that's in their heads, and in their eyes, and what they see in front of them, is dollar signs. But Wumpurrarni,



**Fig 1** ‘Peering’ by Rupert Betheras and Fabian Brown. ‘The artists looking into the future 10,000 years ago Indigenous people of Africa and Australia discussing the way of survival games and supporting younger generations about maintaining their abilities surviving in the arid desert where food is scarce’.

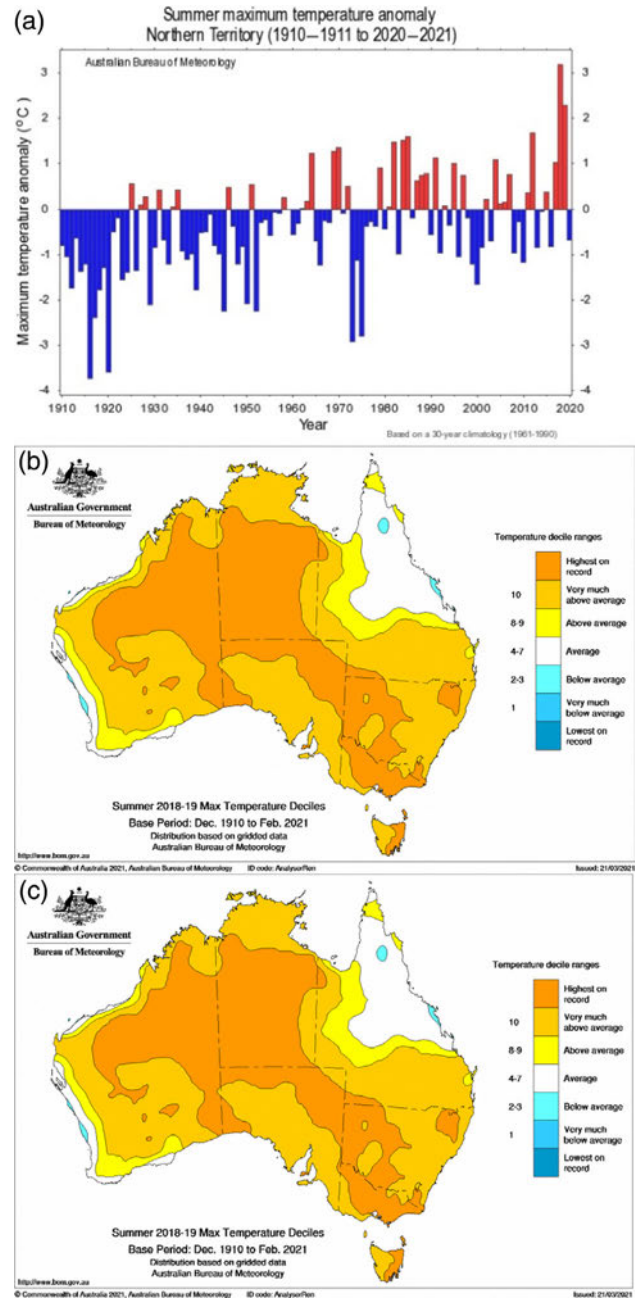
we do not see dollar signs. All we see is our country and what is happening to it it’s getting destroyed but we want to make it get better.

And now the country is burning, getting destroyed, because of climate change. Already, I cannot see sand goannas any more. They’ve gone now. Even after that recent rain they did not come back. And the little lizards, we do not see them running around the desert ground any more. We have not seen them back. We have not seen many kangaroos lately. We are worried that they are going. Bush turkeys too. They are really poor now, and not really healthy, not fat. Now, [after the years of extreme heat] what can we teach our children when the *Manu* [country] is poor and animals are missing?

*SQ: Remote First Nations people will not thrive in a warming future world when the simplest of problems have remained profoundly neglected, when their circumstances of Western poverty have even been weaponized against them.<sup>4</sup> For remote living people, existing as second class citizens, poverty and poor health are a daily reality.*

*We do not need sophisticated Western research to understand how, in the tropical north of Australia, diseases of poverty linger in a household of 20 people who live in a poorly constructed two bedroom dwelling that has no air conditioner or fridge. Truth telling that recognises the baseline of injustice that causes sickness and disease is required, as existing inequities are the foundations upon which new extreme heat will fall.*

NFJ: If the Papulanyi does not move on the issue raised by another Papulanyi, then he’ll write him a letter or send him an email to remind him. Then the person responsible has to move, and if he does not move he knows he’ll get in trouble because that’s going to go higher, going to go further. Second time it’s a warning, third one it’s a strike. Because that’s Papulanyi law.



**Fig 2** (a) Northern Territory annual average daily summertime maximum anomaly compared to long term average daily summertime maximum, 1910 1911 to 2020 2021; (b) Temperature extremes of summer of 2018 2019; (c) Temperature extremes of summer of 2019 2020. [Courtesy of Dr. Pandora Hope, Bureau of Meteorology.]

But for my people it’s different. Wumpurrarni can talk as much as he likes. But the Papulanyi responsible never listens to him. It’s in one ear and out the other. That is racism and it’s killing our people.

*SQ: There are always two sides to the stories of this colonial inequity at the heart of the foundations of contemporary Australian society. For*

instance, in Central Australia, John McDouall Stuart is celebrated in Western history as having been a courageous gentleman and 'explorer' who crossed Australia from south to north in the 1860s. He is not celebrated by First Nations people of this land he once crossed Pitjantjatjara, Luritja, Arrernte, Alyawarre, Anmatyerre, Kaytetye, Warumungu who have heard their grandparents' stories of his gun dealt violence.

When he arrived on Warumungu land, despite his guns he was turned back by a strength of force by Warumungu people at Attack Creek, 100 km north of Tennant Creek in the Northern Territory. The Western story recounts how he bravely fended off violent savages who did not want him on their land. But for Warumungu people, the story told is dramatically different. A distant train of camels was seen coming like string over the barren sandy horizon and misinterpreted as a huge serpent approaching from a very long way off. When it invariably arrived at the waterhole that attracted its thirst, where the attack occurred, it can only be presumed that the white skinned men, shrouded in leather hats and shiny black boots, draped in strange cloth, riding on the back of huge humped beasts, were even more threatening than a serpent.

NFJ: My old fella told me a story his old fella told him. When McDouall Stuart was coming, they thought he was a big rainbow serpent coming down from the hills. When those camels were coming all in a line, they thought it was a big snake, and they thought it was going to attack. They did not want it to attack or come to the water. He helped himself to our precious water with out asking permission.

SQ: The structure of First Nations knowledge is verbal and ancient. In parts of Australia, volcanoes exploding 15 000 years ago still exist in human minds, stories have been accurately passed from person to person through thousands of generations. There are people who can still describe the hunting habits of *Thylacines* [Marsupial tigers, now extinct] in Arnhem Land 3000 years after it disappeared from that ecosystem. First Nations hold knowledge that reaches back into lived experience of other massive shifts in the global climate the only such knowledge still in existence.

NFJ: My father said to me: 'You will not stop learning. You will learn every day for the rest of your life'. Wumpurrarni people can teach Papulanyi how to look after this country better than anyone else. We have looked after it for thousands of years. People used to know do not go there, do not do that because you are on someone else's country and you might hurt it.

If you do the wrong thing you are in big trouble, you will face the consequences, you will be a dead man walking. And it is still the same today. If I accidentally light a fire and I cannot put that fire out and it burns someone else's country and their sacred objects, then you are in trouble. Climate change is like a fire.

SQ: White invasion, colonisation, consumerism and a growth addicted economy has effectively lit a fire on someone else's land that we cannot put out. We are all in trouble. The first step for Western people is to listen and to believe what they hear, to recognise that as a society with foundations in Western science we have great weakness in listening to, accepting, or learning from other cultural paradigms.

NFJ: In my home town and in my town camp, the first thing I would like to see is a healthy place for children and families to live. I want to see proper houses and shade where we live. I'd put in housing, playgrounds and streets with shade over them, and plenty of water fountains with solar power to make cold water on a hot day. Around our town and living areas, we need little shady rest stops everywhere, and parks with big shady trees,

so people have somewhere to go to sit down and play when it's hot.

SQ: There's a park in Alice Springs just like this vision, opposite the Hospital, that offers lawn and shade. In this park there is a 20 ft statue of McDouall Stuart, erected 7 years ago by the Freemasons to commemorate 150 years since his arrival. He stands proud and stern at the western edge of the park, holding a huge bronze rifle as tall as an Wumpurrarni.

NFJ: There are always Wumpurrarni people in that park, waiting for their families whilst they are in Hospital. McDouall Stuart's standing in that park today, and that is racism right there. That man, and other Papulanyi who followed him, shot our people. You cannot see a statue of an Arrernte man standing in that park holding a spear or woomera [spear thrower], do you? But Arrernte have been in this country for thousands of years before McDouall Stuart turned up. People need to see the true story of this country. We need truth telling. That will help us heal our trauma.

SQ: The barriers of adaptive change to global warming that racism throws up are not imagined in towns like Alice Springs, Tennant Creek, or across the Northern Territory and Australia. The forces of colonisation continue and institutionalised racism leaves more destruction.

In towns like Tennant Creek, Alice Springs and Katherine in the Northern Territory, there are families with children living outdoors in corrugated iron tin sheds, behind windbreaks, in tents, and in poor quality housing year round, surviving through extreme heat, many homeless with no chance of getting a climate safe house. Some are even picked up from their camp and delivered to the air conditioned renal dialysis centre three times a week.<sup>5</sup> Doctors prescribe cholesterol lowering tablets to people who regularly go hungry. Young people suffering from diseases like bronchiectasis and rheumatic heart disease come to the end of their short lives without ever having lived in an environmentally safe home, a living space that most Australians take for granted.

The solutions for remote living First Nations people are not Western biomedical, they are much more obvious than this. Whilst western medicine has a place for remote living people, when it comes to climate change, it has no role and risks distraction from the blatantly obvious work that urgently needs to be done to prepare.

What needs to urgently happen can be found by asking First Nations residents of towns and community living areas on town camps on the fringes of many remote Australian towns what they need to prepare for longer, hotter summers.

Houses offer environmental shelter to extreme weather events, but implementation of effective housing policy and programmes since colonisation has been an appalling story. Rates of homelessness in the Northern Territory far out shadow all other states. Katherine [a town 800 km north of its neighbouring town Tennant Creek] has a homelessness rate 31 times the national average.<sup>6</sup> Housing stock is outrageously inadequate, poorly designed for the local environment, uninsulated, often profoundly overcrowded. People live in extreme energy insecurity, with the cost of electricity impacting available family income for food and other essentials. Not even reliable running water can be assumed. A Besser block structure with no eaves is as good as it gets in Tennant Creek town camps.

NFJ: Before, I used to live in a tin shed [A space literally made of uninsulated corrugated iron and nothing more, a structure that some residents still feel lucky to reside in]. But now, that iron, it is too hot, it is like an oven, you cannot even stand in one now on a hot day.

A safe house should fit in with our climate, where we are from. What I want on a hot day is a fan, a fridge, safe, clean, reliable water and shade. I'd have a house up on stilts, so the air could go through, a breeze catcher, I need solar power on the roof, so I do not have to pay for electricity. That's all we need. That's all you need when it's really hot – not a tin house.

*SQ: Other foundational institutions that are necessary for preparing future generations for a hotter world, such as education, require much more work balancing out cultural requirements that empower communities as they see fit.*

NFJ: My kids have connections from two First Nations – two sides – Alyawarra and Warumungu. I want my children to learn three worlds – from their mother's side, from their father's side, and Papulanyi side [a Western education]. It is really good to learn their mother's side, really good to learn their father's side [and Western education is important also].

*SQ: What is the role of doctors in this complex space that is not western biomedical?*

NFJ: Every doctor has got more power than anyone, they have got more power than me. A doctor has more say, and a stronger voice, than anyone in our community. We need a Wumpurrarni voice that is stronger and louder than doctors, and a seat at the decision making table, to make a healthy future for our children.

We also have our own First Nations science that teaches us how to live on this *Manu* [country]. It needs to be acknowledged, respected, and taught alongside Papulanyi science.

*SQ: When it comes to using our collective voice within our own professional domain, an undeniable truth, when it comes to climate change, is that we are all a part of the problem and the solution. Health care in Australia emits 7% of the nation's entire emissions.<sup>7</sup> Leadership in mitigating is a powerful statement to the communities from which we all belong. Green health services and hospitals, powered by clean renewable energy rather than fossil fuels, will help lead green industries. If we do this and loudly demonstrate our actions and successes, this is a voice that can potentially reach to the remotest corners of the planet.*

*But from a remote Indigenous perspective, it all comes down to fierce and fearless advocacy for climate justice, advocate for an equity that still does not exist for many people in this country let alone for future generations of children. And as doctors, we have an absolute obligation to use our privileged voice, because it works.*

NFJ: Doctors have to help Wumpurrarni shake the bush make a strong voice. It's same for getting food, like from the conker berry bush [bush plum], that grows a black berry. You

put a tarp up underneath, and if you want to eat conker berries you gotta shake that bush. When you shake the bush, the fruit hits the ground. That's how we get the government and Papulanyi to listen to us – shake the bush till the fruit hits the ground.

Wumpurrarni are here to protect our families. Every Wumpurrarni is the same everywhere, and so are Papulanyi. When it comes to climate change we should all be strong voices working together – for healthy country, healthy communities, healthy children.

## Acknowledgement

The authors would like to acknowledge Dr. Pandora Hope of the Bureau of Meteorology who provided us with climate data and maps (Fig. 2) to demonstrate the new extremes of summer heat in the north of Australia.

## References

- 1 Taylor NAS. Ethnic differences in thermoregulation: Genotypic versus phenotypic heat adaptation. *J. Thermal Biol.* 2006; **31**: 90–104.
- 2 Longden T. The impact of temperature on mortality across different climate zones. *Clim. Change* 2019; **157**: 221–42.
- 3 Australian Institute of Health and Welfare. Indigenous life expectancy and deaths. Available from: <https://www.aihw.gov.au/reports/australias-health/indigenous-life-expectancy-and-deaths>. [accessed 7 April 2021].
- 4 Perche D. Ten years on, it's time we learned the lessons from the failed Northern Territory intervention. *The Conversation*, June 21, 2017. Available from: <https://theconversation.com/ten-years-on-its-time-we-learned-the-lessons-from-the-failed-northern-territory-intervention-79198> [accessed 7 April 2021].
- 5 Quilty S, Wood L, Scrimgeour S *et al.* Addressing profound disadvantage to improve indigenous health and reduce hospitalization: A collaborative community program in remote Northern Territory. *Int. J. Environ. Res. Pub. Health* 2019; **16**: 4306.
- 6 Zillman S. Katherine's homeless rate is 31 times the national average, but one service is helping close the gap. *ABC News*, 13 July 2018. Available from: <https://www.abc.net.au/news/2018-07-13/homeless-shelter-helps-katherine-doorways-hub-housing/9987668> [accessed 7 April 2021].
- 7 Malik A, Lenzen M, McAlister S, McGain F. The carbon footprint of Australian health care. *Lancet Planet. Health* 2018; **2**: E27–35.

# Climate, housing, energy and Indigenous health: a call to action

The convergence of excessive heat, poor housing, energy insecurity and chronic disease has reached critical levels

Most Australians take safe housing and uninterrupted electricity for granted. Yet in remote Indigenous communities, low quality poorly insulated housing and energy instability are common.<sup>1</sup> Most houses require prepaid power cards, resources are meagre, financial literacy is low, and people often have to choose between power and food. New evidence reveals extreme rates of prepaid electricity meters' disconnection in these communities,<sup>2</sup> making people with chronic diseases who depend on cool storage and electrical equipment particularly vulnerable. The convergence of excessive heat, poor housing, energy insecurity and chronic disease has reached critical levels in many parts of northern Australia, and a multisectoral response is needed to avert catastrophe. Medical professionals have a key role to play.

The Northern Territory, for example, is experiencing extreme heat stress (Box 1). The summer of 2019–20 was 4°C above the long term average, and the town of Katherine, which previously averaged 6 days per year over 40°C, had 56 such days in 2019.<sup>3</sup> The year before, Tennant Creek recorded 28 days above 40°C in one month,<sup>4</sup> and Alice Springs recorded its hottest day since records began.<sup>5</sup>

Over recent summers it's been too hot. Particularly them hot days when the power do go off, we all get out of the house, we always sit outside. I normally just sit under the sprinkler or under the hose, over my head.

Everything's been dying out here around Tennant Creek. All the water in the rock holes went dry. The heat killed animals. Even the spinifex went black, it looked like it'd been burnt or poisoned. A lot of them trees around town, not them native trees but cedar trees and African mahogany, all them mango trees around Tennant Creek, all died, nothing left. That heat would just come too low, the heat wave killed the whole lot. (Norman Frank Jupurrurla, Warramungu Elder and dialysis patient from Tennant Creek)

Around the world it has been shown that chronic disease and heat stress combine to exacerbate morbidity and mortality.<sup>6,7</sup> The rate of chronic diseases in remote communities is high, and many people depend on heat-sensitive medications such as insulin. Most medications have recommended storage temperatures below 30°C, and yet for many this may be impossible to achieve.

Some people on the outskirts of Tennant Creek still live in old tin houses and there's no running

water, there's no power, there's not even a toilet, not even an old drop toilet. Kids go to school from there and people go to work ... "You'll end up getting cooked in that tin house today," that's what we say ... There's a renal patient out there, living in a camp, he got renal at the same time as me and the renal bus go out there, pick him up in the camp, near his tin shed, take him to dialysis with me.

The association between health and housing quality in remote communities is well documented, as is "health hardware", such as a functioning refrigerator, necessary for the practices of healthy living.<sup>8</sup> It has been two decades since the last major survey of Indigenous housing quality, when it was shown that more than half of remote households did not have a refrigerator.<sup>9</sup> It is not known whether this has changed. Even less well understood is the impact that energy poverty has on the function of such hardware. For people experiencing energy poverty, refrigeration for food and medication, air conditioning, power for oxygen concentrators, continuous positive airway pressure machines, home dialysis equipment and so on become critical concerns. Health care providers need to be alert to the implications for clinical practice.

Doctors should start asking the question, if you've got a fridge or not. I reckon that's what these doctors think, every Wumpurrarni [Indigenous person] lives the same as a whitefella and they've got everything the same. But not all of us got a fridge. When doctors put people on insulin and educate them, when dieticians talk to them and tell them, "You need to be on insulin", they don't ask that question "Do you have a fridge? Where do you stay? What kind of condition you live in?" When the power disconnects because we run out of money [on a prepaid meter], you have to hurry up. If you catch it in a few hours, you'll be lucky, but if I'm out somewhere on the weekend and it goes off, everything goes off in the fridge. When I come in late or at night and find that the power's been off, everything's off in the fridge, so I've had to throw everything out.

Current building codes provide little protection for residents against environmental harms. The NT building code legislation has two tiers, with more rigorous requirements in urban than rural areas. However, remote houses are outside of these two tiers and building contractors are not even required to be registered with the Building Practitioners Board.<sup>10</sup> As a result, many dwellings, particularly older ones, lack the basics — appropriate passive cooling design,

Simon Quilty<sup>1</sup>

Norman Frank Jupurrurla<sup>2</sup>

Ross S Bailie<sup>3</sup>

Russell L Gruen<sup>1</sup>

<sup>1</sup> Australian National University, Canberra, ACT.

<sup>2</sup> Julalikari Council Aboriginal Corporation, Tennant Creek, NT.

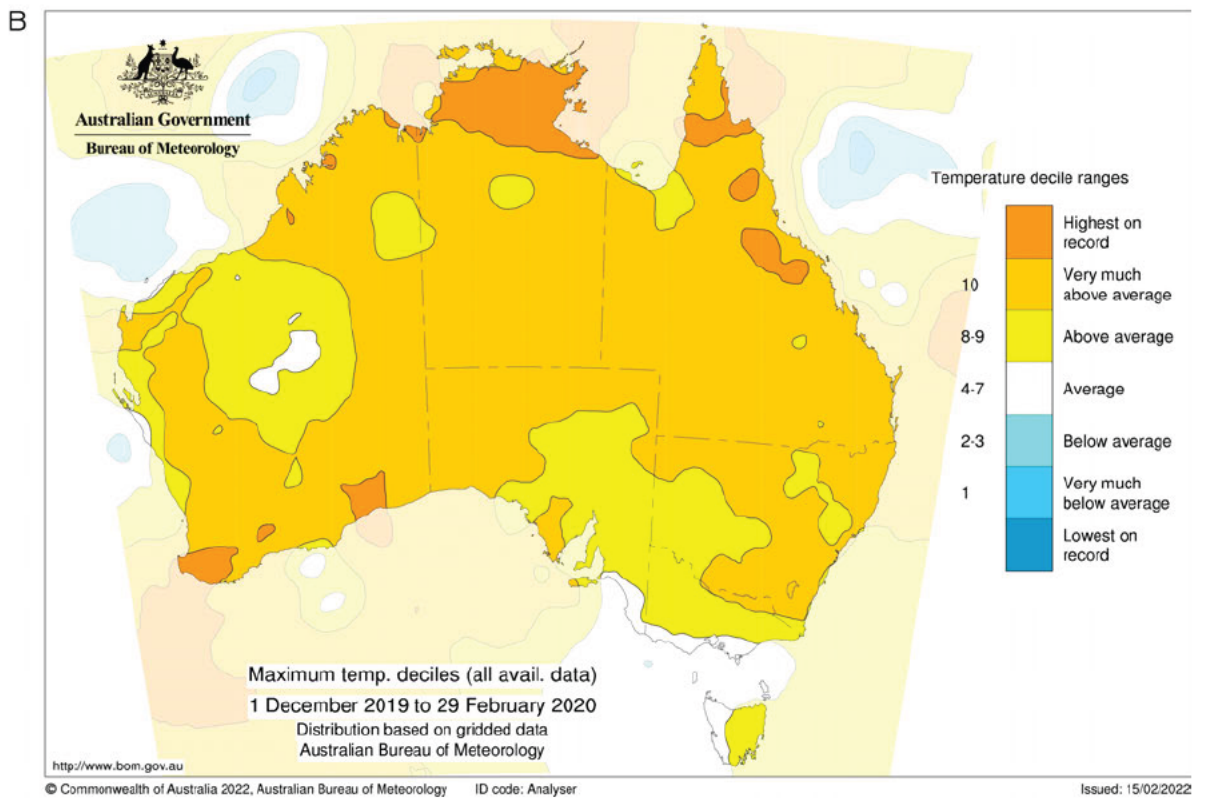
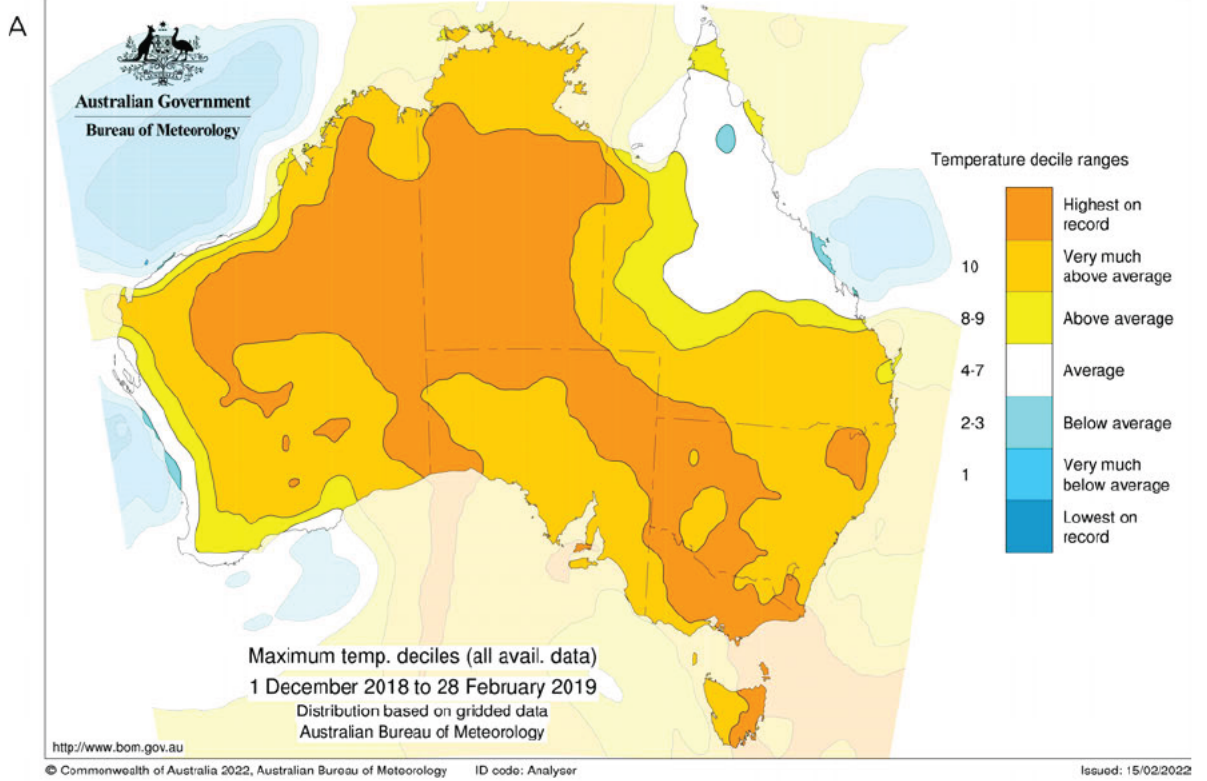
<sup>3</sup> University Centre for Rural Health, Lismore, NSW.

simon.quilty@anu.edu.au

doi: 10.5694/mja2.51610

Podcast with Simon Quilty and Norman Frank Jupurrurla available at [mja.com.au/podcasts](http://mja.com.au/podcasts)

1 Unprecedented summer extremes for (A) 2018–2019 and (B) 2019–2020



Source: Bureau of Meteorology; reproduced with authorisation from Pandora Hope.

structural integrity, insulation in ceiling cavities — and poor quality housing fiercely exacerbates energy poverty.<sup>1</sup> Particularly in areas of Australia where temperature extremes now extend for months,

houses turn into heat caves, much like a car parked in the hot sun. Even if air conditioning is available, cooling poorly designed and uninsulated houses is far more expensive than it is for better quality dwellings.



disadvantage.<sup>16</sup> This begins with health professions bearing witness to current housing disparities and their impact on health and safety of remote community residents. The profession can highlight the association of housing quality, heat stress and energy security in relation to demand on health services so it is given appropriate priority in government decision making.

In relationship to housing and health, our profession needs to advocate for strengthening of building codes and housing standards for remote Indigenous dwellings (Box 3). Identifying and rectifying deteriorating infrastructure, reviewing maintenance standards to ensure dwellings are fit for purpose into the future, and ensuring appropriate design and quality construction of new buildings is all of urgent priority in a warming climate. This includes enhanced responsiveness of public utilities in the interest of the health and safety of remote community residents.

You've got to stand strong. If you're going to give up on them and stop holding them accountable, they'll give up on you too and won't do what they are supposed to, that's how they are. If you stop making noise, they'll just sit there quietly and do nothing, they wouldn't worry and would leave things broken as they are. They don't give a damn about you. The way I see it I've been in my house for nearly 5 years, and I've been trying to get help with housing and providers coming round, trying to ask them for help or support or fix plumbing. I've had to report it over and over and over before they do anything about it. If I give up, they'll give up. But I am not ever going to give up.

And finally, Indigenous leadership at all levels, from community to state to federal, is fundamental to ensuring that housing solutions are designed and controlled by the people who will call these dwellings home. Health professionals are well positioned to advocate for Indigenous-led multisectoral approaches to comprehensively address the need for healthy and safe living conditions in a warming climate.

The community needs to be in charge of what they want done in their housing and how they want their lifestyle, and be allowed to make the solutions. Then they can bring that to the table, to the housing and to the providers. Then it's not coming from some government from Canberra, it's not coming from some politician. It's coming from us, it's coming straight from the horse's mouth and straight from the ground, from the grassroots, that's where you've got to listen, from their home.

**Acknowledgements:** We thank Pandora Hope (Bureau of Meteorology) for her work on the climate maps.

**Open access:** Open access publishing facilitated by Australian National University, as part of the Wiley - Australian National University agreement via the Council of Australian University Librarians.

**Competing interests:** No relevant disclosures.

**Provenance:** Not commissioned; externally peer reviewed. ■

© 2022 The Authors. *Medical Journal of Australia* published by John Wiley & Sons Australia, Ltd on behalf of AMPCo Pty Ltd.

This is an open access article under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

- 1 Lea T, Grealy L, Moskos M, et al. Sustainable Indigenous housing in regional and remote Australia — final report No. 368. Melbourne: Australian Housing and Urban Research Institute, 2021. <https://www.ahuri.edu.au/research/final-reports/368> (viewed Oct 2021).
- 2 Longden T, Quilty S, Riley B, et al. Energy insecurity during temperature extremes in remote Australia. *Nature Energy* 2022; 7: 43-54.
- 3 Bureau of Meteorology. Annual Climate Summary for Northern Territory — Northern Territory in 2019: a very warm and dry year [9 Jan 2020]. <http://www.bom.gov.au/climate/current/annual/nt/archive/2019.summary.shtml> (viewed Oct 2021).
- 4 Abram M, Garrick M. Outback town smashes temperature records with 28 days above 40°C in one month. *ABC News* 2018; 27 Dec. <https://www.abc.net.au/news/2018-12-27/bureau-of-meteorology-says-heat-records-broken-in-outback/10670438> (viewed Oct 2021).
- 5 Alice has hottest day on record. *Alice Springs News* 2018; 31 Dec. <https://alicespringsnews.com.au/2018/12/31/alice-has-hottest-day-on-record/> (viewed Oct 2021).
- 6 Layton JB, Li W, Yuan J, et al. Heatwaves, medications, and heat-related hospitalization in older Medicare beneficiaries with chronic conditions. *PLoS One* 2020; 15: e0243665.
- 7 Gasparrini A, Armstrong B, Kovats S, Wilkinson P. The effect of high temperatures on cause-specific mortality in England and Wales. *Occup Environ Med* 2012; 69: 56-61.
- 8 Foster T, Hall NL. Housing conditions and health in Indigenous Australian communities: current status and recent trends. *Int J Environ Health Res* 2019; 31: 325-343.
- 9 Bailie N, Main N. Environmental health survey year 2 evaluation. Indigenous housing authority of the Northern Territory. Casuarina: Cooperative Research Centre for Aboriginal and Tropical Health, 2002.
- 10 Northern Territory Government. Building outside of building control areas [website]. <https://nt.gov.au/property/building/build-in-a-controlled-area/building-control-areas/building-outside-of-building-control-areas> (viewed Oct 2021).
- 11 Northern Territory Government, Department of Housing and Community Development. Property management — policy [reference No. 059; file HSG2016/01872-5-001]; 28 Sept 2018.
- 12 Australian Energy Regulator. Our role [website]. <https://www.aer.gov.au/about-us/our-role> (viewed Oct 2021).
- 13 Romero Rodríguez L, Sánchez Ramos J, Guerrero Delgado M, et al. Mitigating energy poverty: potential contributions of combining PV and building thermal mass storage in low-income households. *Energy Convers Manag* 2018; 173: 65-80.
- 14 World Health Organization. Accelerated stability studies of widely used pharmaceutical substances under simulated tropical conditions. *WHO*, 1986. <https://apps.who.int/iris/handle/10665/61480> (viewed Oct 2021).
- 15 Yu J, Ouyang Q, Zhu Y, Shen H, Cao G, Cui W. A comparison of the thermal adaptability of people accustomed to air-conditioned environments and naturally ventilated environments. *Indoor Air* 2012; 22: 110-118.
- 16 Gruen RL. Evidence-based advocacy: the public roles of health care professionals. *Med J Aust* 2008; 188: 684-685. <https://www.mja.com.au/journal/2008/188/12/evidence-based-advocacy-public-roles-health-care-professionals>
- 17 Evans EJ. The no-wrong-door approach: antidote to boundaries within the American welfare state. *Health Soc Work* 2019; 44: 8-12. ■