Climate and environmental crisis: effects on ear and hearing health in Australia and for Aboriginal and Torres Strait Islander peoples

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Positionality statement

As a collaborative research team, we acknowledge the diverse perspectives, lived experiences, and cultural knowledges that shape our work. We are united in our commitment to examining health and climate through the lens of Aboriginal and Torres Strait Islander peoples, recognising the profound and disproportionate impacts these intersecting issues have on Indigenous communities globally.

Our team includes Aboriginal and Torres Strait Islander researchers, clinicians and allies who bring deep cultural, professional and personal insights to this work. Professor Kelvin Kong AM, a Worimi man and Australia's first Indigenous ear, nose and throat surgeon, has dedicated his career to addressing health inequities, particularly in ear health, guided by cultural values and respect for community leadership. Dr Georgia Tongs, a Wiradjuri woman and emerging researcher, contributes her passion for Indigenous-led health research, strengthened by mentorship and collaboration within the team.

Non-Indigenous team members — Associate Professor Robert Eisenberg, Professor Jennifer Martin, and Dr Isabella Ludbrook — bring their expertise in surgery, public health, climate advocacy, and infectious diseases, while actively engaging in culturally safe, Indigenous-led research practices. Their work is informed by long-standing partnerships with Aboriginal and Torres Strait Islander communities, guided by principles of self-determination, reciprocity and respect.

This research is grounded with Aboriginal and Torres Strait Islander community priorities driving its direction. The project emerged from discussions at the Otitis Media Australia (OMOZ) conference (www.omoz.com.au), where Indigenous health leaders highlighted the urgent need to address otitis media — a condition disproportionately affecting Aboriginal and Torres Strait Islander children — alongside the growing threats of climate change.

We recognise that climate change is not just an environmental issue but a critical health justice issue for First Nations peoples, who face systemic inequities compounded by ecological disruption. Our collective approach centres Indigenous knowledge, resilience, and leadership in developing solutions that promote health equity and climate resilience.

Through this work, we strive to amplify Indigenous voices, uphold cultural authority, and contribute to a future where health and climate policies are shaped by the wisdom and needs of Aboriginal and Torres Strait Islander communities.

Adherence to the CONSIDER statement

We acknowledge the Consolidated criteria for strengthening the reporting of health research involving Indigenous Peoples (CONSIDER) statement[1] and have outlined how each principle was addressed during the research process (Supporting Information).

Introduction

Otitis media, which is a bacterial infection of the middle ear, is at risk of becoming more prevalent with the progression of climate change. The condition already occurs more frequently in Aboriginal and Torres Strait Islander (henceforth First Nations) populations who are disproportionately affected by climate change.[2] Pathogenesis is thought to be influenced by changes in air and water quality and exacerbated by flourishing new organisms and worsening antimicrobial resistance. Prevention and early detection of disease can be disrupted by social instability resulting from environmental changes.[3]

Otitis media globally affects over 80% of children under the age of three years.[4] It has the potential to cause life-threatening complications if infection spreads to the bone or brain, but it is more commonly associated with temporary or long term hearing loss. Untreated, paediatric hearing loss is associated with delays in speech and language development, poorer educational outcomes, higher adulthood unemployment, and increased contact with the criminal justice system.[3] Given its profound and enduring impacts, paediatric hearing loss is a developmental emergency.

Hearing and language are particularly important in First Nations communities, as knowledge sharing is often done through oral storytelling. The rate of Australian First Nations children diagnosed with otitis media varies greatly with age group and geographical location, but it is generally accepted to be among the highest globally — well over the 4% disease prevalence classifying a major public health concern.[3,5-7] In remote areas, the cohort prevalence for children under five years of age has been recorded up to 90%, and even in urban areas, First Nations children experience a burden of disease three times that of non-First Nations children.[3] Disease may manifest within weeks of birth and is often insidious. Structural barriers to health care access and systemic racism and stigma result in delayed diagnosis and more late-stage or chronic complications for First Nations populations compared with non-Indigenous Australians.[3]

Climate change, which is defined as the long term change in average weather patterns, has been identified by the World Health Organization as the

single biggest health threat facing humanity.[8] This is due to its many impacts on the physical, environmental and social systems in which individuals are born, live, grow, eat, and work. Although there are unique regional hazards and differing levels of vulnerability to such hazards, expected trends as the climate changes include increased temperature extremes, changes in precipitation patterns, poorer air quality, and more frequent extreme weather events.[8]

The health effects of climate change can be direct, such as heat-related illness and traumatic injury from extreme weather events, or indirect, including through food and water insecurity, overwhelmed health resources, and increased opportunities for spread of vector- and water-borne diseases.[8,9] Strategies to combat these issues involve mitigation, aiming to slow the process of climate change, and adaptation of health systems to a new climate.[10]

Prevention and early detection of otitis media are closely linked with addressing modifiable risk factors such as nutrition and housing density.[3] These social determinants of health reflect broader societal inequities and are inherently tied to our environment, including climate.[8] This perspective article addresses how direct and indirect risk factors for otitis media are likely to be affected by climate change and outlines the importance of climate change mitigation and adaption to reduce the burden of ear disease on First Nations children.

Australian First Nations peoples and climate change

Populations at greater risk of climate change-related health issues, as identified by the Australian Government, include children, people of low socio-economic status, geographically isolated communities, and First Nations peoples.[11] Rural and remote communities with a high proportion of First Nations residents are therefore likely to be facing substantially disproportionate effects of climate change.[2,12,13]

There is an intrinsic relationship between the wellbeing of the land, the community and the individual in First Nations culture.[13] First Nations peoples have already adapted to tens of thousands of years of changing climate in Australia.[14] Conversely, colonial perspectives of land ownership (rather than custodianship) have resulted in significant physical, emotional and spiritual harm relating to climate change. Extreme weather events such as bushfires and floods may result in damage to important sacred sites, homes and livelihoods.[13] Eco-migration of First Nations communities from Country can be expected as land is exposed to climate extremes of heatwaves, rising sea levels, and drought. Existing social inequities driven by systemic racism may hinder capacity for communities to adapt to these changes.[8]

A 2024 systematic mapping review of 48 Australian studies on climate change health interventions identified studies involving priority populations, including First Nations people.[15] Surprisingly, no studies were conducted in Aboriginal Community Controlled Health Organisations (ACCHOs). The literature addressed general health outcome consequences, rather than specific mitigation or adaptation solutions.[15]

The effects of fossil fuel emissions and climate change on ear health

Emerging evidence suggests that climate change may directly affect the prevalence of otitis media through pathological susceptibility to changes in temperature, humidity, and air and water quality. The indirect effects of climate change exacerbate existing societal inequities such as food and water insecurity, barriers to health care access, and housing instability. It is theorised that the impact of otitis media may be compounded by decreased access to services from extreme weather events, poor nutrition following reduction in local food yields and increased cost of living, oversaturation of health services, domestic overcrowding, aggravation of comorbid chronic disease, and geographical isolation.[9]

Air pollutant exposure

Air pollution mostly arises from industrial and road traffic-related use of fossil fuels. There is a new body of research developing around a possible association between higher ambient air pollution exposure and prevalence of otitis media in children. Current literature suggests an increase in otitis media by 3–6% following spikes in measured air pollutants.[16-22] A 2018 Australian systematic review of over 143 000 cases found increasing evidence for this relationship, particularly in relation to nitrous oxide.[4] There is growing concern regarding the health effects of natural gas fracking, although Australian research is currently limited to respiratory diseases such as asthma.[23]

There is significant crossover between air pollutants such as particulate matter, ozone, and nitrous oxide and the contents of bushfire smoke.[20,24] Lower rainfall and higher temperatures in Australia have resulted in the bushfire season starting up to three months earlier than 75 years ago, and an increase in days with extreme fire danger warnings of up to 65%.[25] This is compounded by increased dry lightning and pyro-convective events (ie, fire-generated thunderstorms).[26,27] While there is a paucity of Australian research into the effects of bushfire smoke on otitis media, a prospective Canadian study of 45 513 children identified a relative risk of otitis media of 1.32 (95% confidence interval, 1.27–1.36) after days following woodsmoke exposure, raising the possibility of transferrable risk.[21]

Allergen exposure and respiratory disease

Climate change has been linked to increased incidence of atopic diseases, such as allergic rhinitis and asthma, partially due to the enhanced effects of pollen and moulds following changes in temperature, rainfall and humidity.[28] Irritation to respiratory mucosa during allergic changes is theorised to be associated with

Suggested adaptive strategies to mitigate the effects of climate change on ear health

Adaptation type	Climate hazards and other exposure pathways: Extreme weather events (eg, heatwaves, bushfires, cyclones, floods)	Air quality	Food and water security and safety	Vector distribution and ecology	Cultural safeguarding and protection of community
Technical interventions	▪ Green spaces ▪ Heat refuges ▪ Air conditioning ▪ Bushfire smoke filters ▪ Medical research	▪ Air filtration systems ▪ Clean energy use ▪ Medical research	▪ Water filtration systems ▪ Agricultural technology	▪ Vaccines ▪ Antibiotics ▪ Antimicrobial stewardship	
Information sharing and awareness	▪ Community preparedness ▪ Controlled burning		▪ Nutrition education ▪ Food handling policy	▪ Habitat preservation ▪ Urban planning	▪ Culturally appropriate/safe sharing of public information
Emergency service capacity	▪ Public cool rooms ▪ Firefighting services ▪ Safe working hours telehealth	▪ Air filters ▪ Urgent care centres ▪ Local workforce training ▪ Telehealth	▪ Cost of living subsidies	▪ Pandemic preparedness ▪ Telehealth	▪ Relationships and pathways with rural and remote communities
Surveillance and early warning systems	▪ Meteorological monitoring ▪ Fire danger rating system	▪ Air quality monitoring		▪ Public health unit tracking	
Resilient health care infrastructure	▪ Building codes ▪ Reliable continuous power and water ▪ Air filtration systems			▪ Air filtration systems	
Informed health care workforce	▪ Workplace sustainability officers ▪ Local workforce training			▪ Pandemic response training	▪ Training of First Nations health care workers

Blue cells indicate a high impact area. ◆

increased risk of otitis media, but more research in this area is required.[29,30] In non-tropical Australia, allergy season is commencing up to two weeks earlier and lasting an average of 41 days longer than 50 years ago.[31] This may be because warmer temperatures and higher carbon dioxide levels cause grasses and other allergenic species to grow faster, flower earlier and produce more pollen.[31]

Antimicrobial resistance

Although not specific to Australia, antimicrobial resistance (AMR) is one of the largest public health threats globally. A 2019 international systematic review estimated AMR was directly responsible for 1.27 million deaths globally in the preceding year, including from pathogens causing otitis media.[32] Extreme weather events and resulting food and water insecurity drive agricultural antibiotic misuse and drive AMR. Such events also bring humans and animals into contact and lead to outbreaks of bacterial zoonotic and vector-borne diseases, which are rapidly adapting to warmer temperatures.[32]

Climate change-exacerbated extreme weather events

Large-scale population studies have shown a relationship between the prevalence of otitis media and short term extreme weather events, but there is less evidence for long term meteorological trends such as average temperature and relative humidity.[16,33,34]

More indirectly, extreme weather events and rising sea levels lead to food insecurity due to reduced agricultural and aquacultural crop yield.[8] Malnutrition, vitamin deficiencies, and high housing density are all risk factors for otitis media in children.[3,8,18] Extreme weather events cause population displacement and isolation, further marginalising populations in Australia with existing geographical barriers to health care.[12]

Recommendations

Mitigation strategies

The ecological crises we face today are rooted in the shift away from First Nations ways and kinship-based relationships with the Earth, to viewing it as a commodity to be exploited. It is critical to address the role of custodianship and relationship to the land and sea through First Nations leadership in climate mitigation. A reduction in greenhouse gases from all fossil fuels must be considered in all policies at all government levels.

Adaptation strategies

At a primary prevention level, community consultation is essential for developing culturally safe response plans to address further pressure on already strained health and social services, including food and water insecurity and housing affordability. At a tertiary level, further research is needed on individual risk factors for illness exacerbation by extreme weather events in Australian populations to support the current literature. Further funding is urgently needed for vaccine and antibiotic development, as well as educational and interventional programs for adherence to antimicrobial stewardship to combat AMR (Box).

Conclusion

Climate change is not solely an environmental issue, but a health issue affecting highly specific body systems and with disproportional effects on priority populations. Otitis media is just one example of a

common and serious childhood illness with economic, social and environmental risk factors on track to escalate with the effects of climate change. First Nations leadership can help mitigate climate change by shifting the dominant culture to a view of land custodianship rather than ownership. The capacity of affected communities to adapt to eco-migration, food and water insecurity, and health service stress will depend on proactive investment in strong primary health systems and social stability.

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1 Huria T, Palmer SC, Pitama S, et al. Consolidated criteria for strengthening reporting of health research involving indigenous peoples: the CONSIDER statement. *BMC Med Res Methodol* 2019; 19: 173.

2 Standen JC, Spencer J, Lee GW, et al. Aboriginal population and climate change in Australia: implications for health and adaptation planning. *Int J Environ Res Public Health* 2022; 19: 7502.

3 The Closing the Gap Clearinghouse. Ear disease in Aboriginal and Torres Strait Islander children. Canberra: Australian Institute of Health and Welfare, 2014. https://www.aihw.gov.au/getmedia/c68e6d27-05ea-4039-9d0b-a11eb609bacc/ctgc-rs35.pdf?v=20230605181156&inline=true (viewed May 2025).

4 Bowatte G, Tham R, Perret JL, et al. Air pollution and otitis media in children: a systematic review of literature. *Int J Environ Res Public Health* 2018; 15: 257.

5 Australian Institute of Health and Welfare. Aboriginal and Torres Strait Islander Health Performance Framework: summary report, August 2024. Canberra: AIHW, 2024. https://www.indigenoushpf.gov.au/getattachment/79e5f9c5-f5b9-4a1f-8df6-187f267f6817/hpf_summary-report-aug-2024.pdf (viewed May 2025).

6 Morris PS, Leach AJ, Silberberg P, et al. Otitis media in young Aboriginal children from remote communities in Northern and Central Australia: a cross-sectional survey. *BMC Pediatr* 2005; 5: 27.

7 Watson DS, Clapin M. Ear health of aboriginal primary school children in the Eastern Goldfields Region of Western Australia. *Aust J Public Health* 1992; 16: 26-30.

8 Sherratt S. Hearing loss and disorders: the repercussions of climate change. *Am J Audiol* 2023; 32: 793-811.

9 Boylan S, Beyer K, Schlosberg D, et al. A conceptual framework for climate change, health and wellbeing in NSW, Australia. *Public Health Res Pract* 2018; 28: 2841826.

10 Al-Marwani S. Climate change impact on the healthcare provided to patients. *Bull Natl Res Cent* 2023; 47: 51.

11 Adapt NSW. Climate change impacts on our health and wellbeing. Sydney: NSW Government, 2024. https://www.climatechange.environment.nsw.gov.au/impacts-climate-change/climate-impacts-our-health-and-wellbeing (viewed Apr 2025).

12 Lansbury Hall N, Crosby L. Climate change impacts on health in remote Indigenous communities in Australia. *Int J Environ Health Res* 2022; 32: 487-502.

13 Department of Premier and Cabinet. Final report of the NSW Bushfire Inquiry. Sydney, 2020. https://www.nsw.gov.au/sites/default/files/noindex/2023-06/Final-Report-of-the-NSW-Bushfire-Inquiry.pdf (viewed May 2025).

14 Adapt NSW. How Aboriginal culture can help us understand climate change. Sydney: NSW Government, 2024. https://www.climatechange.environment.nsw.gov.au/stories-and-case-studies/how-aboriginal-culture-can-help-us-understand-climate-change (viewed Apr 2025).

15 Department of Health and Aged Care. Systematic mapping review of Australian research on climate change and health interventions. Canberra: Australian Centre for Disease Control, Australian Government; 2024. https://www.health.gov.au/sites/default/files/2024-10/systematic-mapping-review-of-australian-research-on-climate-change-and-health-interventions.pdf (viewed May 2025).

16 Gestro M, Condemi V, Bardi L, et al. Meteorological factors, air pollutants, and emergency department visits for otitis media: a time series study. *Int J Biometeorol* 2017; 61: 1749-1764.

17 Brauer M, Gehring U, Brunekreef B, et al. Traffic-related air pollution and otitis media. *Environ Health Perspect* 2006; 114: 1414-1418.

18 Heinrich J, Raghuyamshi VS. Air pollution and otitis media: a review of evidence from epidemiologic studies. *Curr Allergy Asthma Rep* 2004; 4: 302-309.

19 Kousha T, Castner J. The Air Quality Health Index and emergency department visits for otitis media. *J Nurs Scholarsh* 2016; 48: 163-171.

20 Lukina AO, Maquiling A, Burstein B, Szyszkowicz M. Exposure to urban air pollution and emergency department visits for diseases of the ear and mastoid processes. *Atmos Pollut Res* 2021; 12: 101198.

21 MacIntyre EA, Karr CJ, Koehoorn M, et al. Residential air pollution and otitis media during the first two years of life. *Epidemiology* 2011; 22: 81-89.

22 Zemek R, Szyszkowicz M, Rowe Brian H. Air pollution and emergency department visits for otitis media: a case–crossover study in Edmonton, Canada. *Environ Health Perspect* 2010; 118: 1631-1636.

23 Haswell MR, Bethmont A. Health concerns associated with unconventional gas mining in rural Australia. *Rural Remote Health* 2016; 16: 3825.

24 World Health Organization. Health topics: wildfires. Geneve: WHO, 2024. https://www.who.int/health-topics/wildfires#tab=tab_1 (viewed Apr 2025).

25 Royal Commissions. Royal Commission into National Natural Disaster Arrangements report. Canberra: Commonwealth of Australia, 2020. https://www.royalcommission.gov.au/natural-disasters/report (viewed May 2025).

26 Di Virgilio G, Evans JP, Blake SAP, et al. Climate change increases the potential for extreme wildfires. *Geophys Res Lett* 2019; 46: 8517-8526.

27 Duane A, Castellnou M, Brotons L. Towards a comprehensive look at global drivers of novel extreme wildfire events. *Climatic Change* 2021; 165: 43.

28 Paudel B, Chu T, Chen M, et al. Increased duration of pollen and mold exposure are linked to climate change. *Sci Rep* 2021; 11: 12816.

29 Byeon H. The association between allergic rhinitis and otitis media: A national representative sample of in South Korean children. *Sci Rep* 2019; 9: 1610.

30 Fireman P. Otitis media and nasal disease: a role for allergy. *J Allergy Clin Immunol* 1988; 82: 917-926.

31 Swann T, Ogge, M. Out of season: expanding summers and shrinking winters in subtropical and temperate Australia. Canberra: Australian Institute, 2020; p 49. https://www.preventionweb.net/quick/49841 (viewed Apr 2025).

32 Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Lancet* 2022; 399: 629-655.

33 Miller ME, Shapiro NL, Bhattacharyya N. Annual temperature and the prevalence of frequent ear infections in childhood. *Am J Otolaryngol* 2012; 33: 51-55.

34 Tian H, Xu B, Wang X, et al. Study on the correlation between ambient environment-meteorological factors and the number of visits of acute otitis media, Lanzhou, China. *J Otol* 2020; 15: 86-94. ■

Supporting Information

Additional Supporting Information is included with the online version of this article.