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Climate Change and Human Health: Building Australia's Adaptation Capacity

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The links between climate change and health have been reported by the Intergovernmental Panel on Climate Change, which states that climate change is already contributing to the global burden of disease and premature death and that these effects are likely to increase in all countries.[1] The extent and nature of future health impacts will depend on the nature and magnitude of climate change.[2] Climate change is a global issue, but it will not be experienced uniformly across the globe, and a significant proportion of adaptation measures will need to be developed and implemented at a local or regional level.

Understanding the pathway from climate change to predicted health impacts can provide us with critical information for planning effective adaptation strategies. Health impact pathways can occur through a range of direct or indirect exposures. Direct exposures refer to immediate health impacts that occur as a direct result of a climate variable. This type of exposure usually refers to impacts caused by extreme events such as flooding, fires, and heat waves. Indirect exposures occur when climate affects a range of environmental parameters such as air, water, or food quality; food production and disease vectors; or social parameters such as changes to population distribution and economic variables. The pathway between climate and health impact for indirect exposures typically includes multiple steps, many of which occur in nonhealth sectors.

Australia adopted a novel approach to build national adaptive capacity to respond to the threats posed by climate change. The Australian government called for tenders for collaborations to host a National Climate Change Adaptation Research Facility (NCCARF), which would generate the knowledge required for Australia to adapt to the physical impacts of climate change and oversee the roll out of Adaptation Research Networks (ARNs) across Australia. A nine member consortium led by Griffith University's Gold Coast Campus was successful, and NCCARF was established in November 2007 (http://www.nccarf.edu.au/about-facility). Soon afterwards, the Federal Department of Climate Change (now Department of Climate Change and Energy Efficiency) was established in December 2007.

NCCARF then repeated the tender process, calling for proposals from nationwide collaborations of researchers to host ARNs across eight key research domains: terrestrial biodiversity; human health; marine biodiversity and resources; water resources and freshwater biodiversity;

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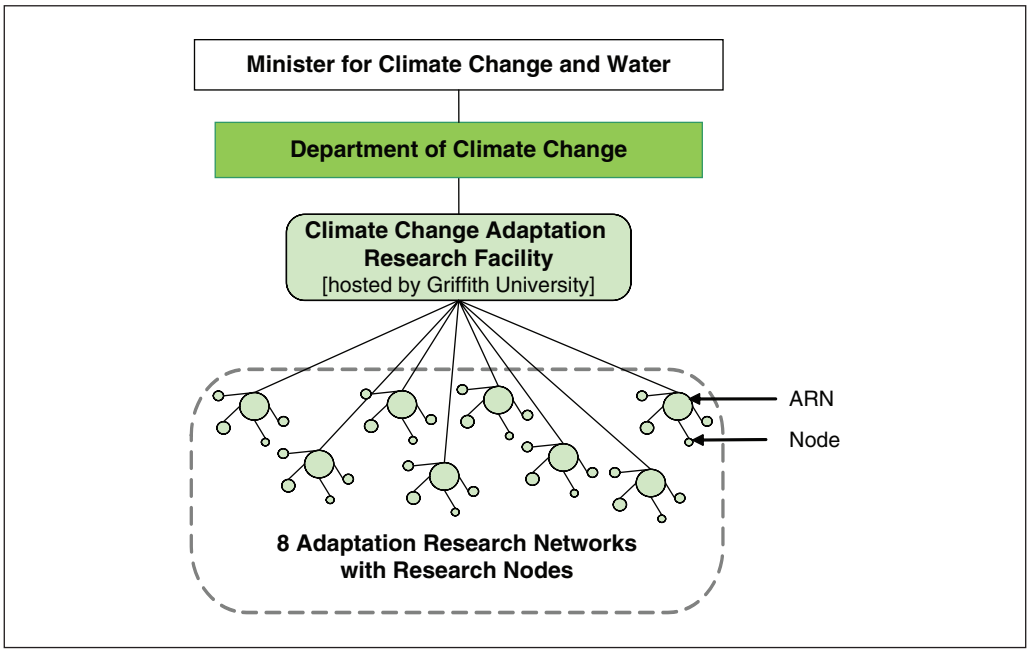

Figure 1. Organizational structure for Australia's National Climate Change Adaptation Research Network, depicting thematic research nodes

settlements and infrastructure; emergency management; social, economic, and institutional dimensions; and primary industries.

The Australian National University, National Centre for Epidemiology and Population Health hosts the *Climate Change and Human Health Adaptation Research Network*. Professor Tony McMichael led the bid with support from Professor Tony Capon and Dr Liz Hanna. In 2008, Tony McMichael led the team to prepare the National Adaptation Research Plan (NARP) for Human Health.[3] The NARP broadly synthesized existing and emerging national and international research on climate change impacts and adaptation. It also specifically set out the key understandings of health impacts of climate change threats facing Australia, identified critical gaps in the information currently available to decision makers, and proposed a strategy for building local research capacity and supporting the advancement of Australia's adaptive response to climate change (http://www.nccarf.edu.au/humanhealth/).

The NARP was approved by the Minster for Climate Change, and in November 2008 the Human Health ARN was established and through 2009 was co-convened by Tony Capon and Liz Hanna. The role of each of the eight ARNs is to undertake a program of integrative research to address national priorities, establish and maintain adaptation research nodes that link together key researchers investigating thematic areas of specific climate change concerns, and assist these nodes in focusing on national research priorities.

Advancing adaptation to climate change requires a foundational understanding of the starting point of this journey and a characterization of the current and projected key concerns, from which to eventually compare progress toward minimizing health harm from a warming climate.

Since the establishment of the Human Health ARN in 2008, climate change impacts have accelerated in Australia, and elsewhere, notably in China, Russia, Vietnam, and Pakistan. Against

a background of gradual warming, and drying across the southern and eastern agricultural regions, Victoria, South Australia, Tasmania, New South Wales, and Queensland experienced extreme weather events in early 2009. This highlighted the devastating effects that climate change can bring to bear on human health and welfare in developed nations. In the aftermath of these events, Australia became acutely aware of the need for prompt action by governments and communities to activate climate change adaptation plans. For example, bushfires are a frequent event across Southern Australia, and it was assumed that existing response systems would cater adequately to future fire events. The unprecedented climatic conditions that resulted in the 2009 Victorian bushfires demonstrated that a new climatic era has emerged and highlighted the urgent need for existing response systems to be reevaluated and upgraded in order to ensure ongoing protection of population health and community well-being.

It is known that climate change will bring a range of effects that act directly and indirectly on human health and well-being.[4] However, much of the research focus to date has been on environmental impacts. In this series we argue that impacts on human livelihoods and physical and mental health consequences can be profound and that the public health community needs to engage in climate change adaptation.

This supplementary issue of *APJPH* presents a series of articles from the major research nodes established during the first year of the Human Health ARN. These articles outline the state of the science on research and adaptive policy responses to climate change in Australia and provide a set of succinct authoritative documents that summarize what is currently known about health risks facing Australia from climate change. Each article explores a specific health risk. This series of articles also contributes to the broader understanding of potential impacts of climate change on human health in countries throughout the Pacific region. The insights provided here to key health considerations of climate change can assist other countries as they prioritize and assess likely health risks in their own country and devise appropriate policy responses.

Topic Areas

Health impacts need to be contextualized into the underlying burdens of disease and mix of health infrastructure, health sector skills, plus the geophysical and emerging climatic environment. The complexity of issues embedded within each domain points to the need for in-depth analyses and exploration of policy implications. The 11 articles presented in this series explore climate change and human health research domains identified as key for Australia.

Thermal Impacts

Extreme heat and the impact on worker health and productivity. Climate change scenarios predict increases in the frequency and intensity of extreme heat events in the future, and population health may be significantly compromised for people who cannot reduce their heat exposure. An individual's capacity to withstand heat varies relative to background temperature, physiology, comorbidities and general fitness level, activity, capacity to rehydrate, and ability to cool the core temperature. Hanna et al review the physical effects of heat exposure, outlining the hazardous nature to all who are physically active, particularly outdoor workers and indoor workers with minimal access to cooling systems while working.[5] Ramifications this can bring to long-term health, productivity, and personal income are also highlighted. In view of the intensifying threat posed by heat on workers, the article calls for rectifying the policy vacuum that exists in Australia, and many other countries, where occupational health and safety legislation to protect workers from hazardous heat exposures is still lacking.

Extreme heat, temperature, health, morbidity, mortality. The second article by Bi et al reviews the evidence for heat-related mortality and morbidity in Australia and the projected impacts from a warming climate.[6] Extreme environmental heat can trigger the onset of acute conditions, including heat stroke and dehydration, as well as exacerbate a range of underlying illnesses. Consequently, in the absence of adaptation, the associated mortality and morbidity are expected to increase in a warming climate, particularly within the vulnerable populations of the community such as the elderly, children, those with chronic diseases, and people engaged in physical labor in noncooled environments. Bi et al argue that there is a need for further research to address the evidence needs of public health agencies in Australia. Building resilience to extreme heat events, especially for the most vulnerable groups, should be a priority, and public health professionals and executives need to be aware of the very real and urgent need to act now.

Air Quality

Climate change and air quality: the potential impact on health. Spickett et al consider the potential health impacts in Australia and in the region arising from possible changes in air quality occurring as a result of climate change[7] and identify vulnerable groups and adaptation measures to address these potential impacts, and consider the implications for policy. Climate change is likely to impact on levels of ozone, and possibly particulates, both of which are associated with increased mortality and a range of respiratory and cardiovascular health effects. Implications for policy include the need for improved modeling and forecasting of air pollutant levels, increased efforts to reduce emissions of air pollutants, continued monitoring of air pollutant levels, and monitoring of the incidence of health effects associated with air pollutants in all countries in the region.

Aeroallergens. Another related issue for human health is the predicted increase in pollen as a result of climate change. In the article by Beggs et al, what is known from Australian and international studies about the impacts of climate change on aeroallergens and other naturally derived particulates are reviewed and assessed.[8] The article summarizes the associated human health impacts and examines responses to these in Australia, focusing on adaptation. The review concludes that these impacts may be adverse and of considerable magnitude and that more research is required to assess the impacts of climate change on aeroallergens and other naturally derived particulates in Australia. Important policy implications arise from this review. There is a need for enhanced monitoring of the atmospheric environment and associated health conditions. Education about climate change and human health in general, and air quality and related diseases specifically, is required for the community, health professionals, and others. Improvements are needed in the preparedness of infrastructure, such as health care facilities and early warning systems, particularly for aeroallergens.

Infectious Diseases

The range, seasonality, and intensity of infectious disease incidence are predicted to alter under differing climate scenarios. Against this background, successful public health actions have mitigated against the spread of malaria, yet some disease spread is complicated by international travel patterns. Therefore, a degree of uncertainty is associated with climate modeling, and greater uncertainty is associated in predictions of infectious disease incidence with climate change. However, a very real potential remains for infectious diseases to extend their range into populations not previously exposed, and nations, including Australia, must be prepared for this. Dave Harley leads the article that presents current knowledge of climate impacts for respiratory, diarrheal, and vector-borne diseases and the challenges they bring challenges to Australia.[9] Recommendations

suggest that all parts of the health system, including surveillance, environmental health, and medical services, will need sufficient flexibility to assess and respond to these changes.

Urban Settings

Urban populations are growing rapidly throughout the Asia-Pacific region. Cities are vulnerable to the health impacts of climate change due to their concentration of people and infrastructure, the physical (geographical, material and structural) attributes of the built environment, and also the ecological interdependence with the urban ecosystem. Climate change is expected to increase morbidity and mortality from thermal stress, bacterial gastroenteritis, vector-borne disease, air pollution, flooding, and bushfires, and these impacts will not be evenly distributed. Adaptation strategies need to address this underlying burden of disease and inequity as well as implement broad structural changes to building codes and urban design and infrastructure capacity. In doing so, cities provide opportunities to realize "cobenefits" for health (eg, from increased levels of physical activity and improved air quality). With evidence that climate change is underway, Bambrick et al argue the need for cities to be a focus for the development of climate adaptation strategies is becoming more urgent.[10]

Water

Under current climate change projections the capacity to provide safe drinking water to Australian communities will be a major problem. The challenges facing public health in Australia will be to develop flexible and robust governance strategies that strengthen public health input to existing water policy, regulation, and surveillance infrastructure through (*a*) proactive risk planning, (*b*) adopting new technologies, and (*c*) intersectoral collaborations. Goater et al propose an approach that could assist policy makers avert or minimize risk to communities arising from changes in climate and water provisions both in Australia and in the wider Asia Pacific region.[11]

Food Safety and Security

Agricultural production both in Australia and globally is expected to be heavily affected by climate change. Edwards et al review the potential for sustained interruptions in food systems, food transport and spoiling, and food prices and availability, which can lead to food insecurity, equity issues, and nutritional deficits. Local gardening systems have been suggested.[12]

Rural Health

Australia is regarded more vulnerable than most OECD countries to climate change, largely due its fragile environment and highly variable climate that, under "natural conditions," are classed as extreme. Agricultural systems are intrinsically linked with environmental conditions that are already under threat in much of southern Australia due to rising heat and protracted drying. Rural Australia, is characterized as being socioeconomically disadvantaged and having significantly worse health status than metropolitan counterparts, this intensifies their vulnerability to the impacts of a changing climate. Current indications suggest that rural populations may be forced to confront major economic and environmental upheavals simultaneously. Health consequences will undoubtedly unfold. Hanna et al present an argument to boost public health preparedness in order to protect rural communities, and they conclude by suggesting that adaptation to climate change

requires planning for worst-case scenario outcomes to avert catastrophic impacts on rural communities.[13] This will involve national policy planning as much as regional-level leadership for rapid development of adaptive strategies in agriculture and other key areas of rural communities.

Farmers' Mental Health

Most of what is known about the possible effects of climate change on rural mental health relates to prolonged drought. But though drought is known to be a disproportionate and general stressor, evidence is mixed and inconclusive. Over time, like drought other weather-related disasters may erode the social and economic bases on which farming communities depend. Rural vulnerability to mental health problems is greatly increased by socioeconomic disadvantage and related factors, such as reduced access to health services. The aim of the review by Berry et al is to consider how climate change may affect farmers' mental health in Australia and other countries.[14]

Health System

Increases in extreme weather-related events superimposed on health effects arising from a gradually changing climate will place additional burdens on health systems and challenge existing capacity. Australia still requires much work to guide the development of a comprehensive strategy to underpin the adaptation of its health system. Adaptation will be an evolving process as impacts emerge. Blashki et al focus on how the Australian health system can best prepare health services for predicted health risks from heatwaves, bushfires, infectious diseases, diminished air quality, and the mental health impacts of climate change.[15] In addition, this article provides some general principles for adapting health systems to climate change that may be applicable beyond the Australian setting. Key recommendations are that a well-adapted system should be flexible and robust, with resources strategically allocated. Long-term planning will also require close collaboration with the nonhealth sectors as part of a nationwide adaptive response.

Australia is a wealthy nation and considered to be "at the vanguard" facing climate change impacts, and therefore, other countries are looking to Australia to observe public health responses. This Australia-focused special issue, which examines the public health implications of climate change and explores policy responses, is presented to provide public health practitioners and policy makers in Australia and across the Pacific region with an improved understanding of the potential health impacts of climate change in the Asia Pacific region.

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