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Perspective

Reflections on a highly unusual summer: bushfires, COVID-19 and mosquito-borne disease in NSW, Australia

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Key points

- Extreme weather and other disruptive events may directly and indirectly increase the community's exposure to mosquito-borne disease
- Natural disasters, such as bushfires or floods, will directly influence mosquito abundance. Natural disasters may also influence the spatiotemporal distribution of wildlife that represent reservoir hosts of arboviruses (e.g. Ross River virus) and concomitant mosquito-borne disease risk
- During public health emergencies such as COVID-19, the capacity of public health authorities to maintain mosquito surveillance and communications programs may be restricted
- Strategic adaptive responses are required to reduce the public health risks associated with mosquitoes during natural disasters and/or public health emergencies

Abstract

Mosquitoes and mosquito-borne disease are a normal part of the Australian summer but the 2019–2020 summer was anything but normal. Above average temperatures and below average rainfall resulted in drought across many parts of New South Wales (NSW), Australia, which then contributed to catastrophic bushfires. However, by late summer, above average rainfall resulted in a dramatic increase in mosquito abundance.

While the coronavirus disease 2019 (COVID-19) pandemic unfolded, NSW experienced increased activity of mosquito-borne Ross River virus. All these extreme events created many challenges for managing the pest and the public health risks associated with mosquitoes, from maintenance of mosquito monitoring and control programs through to unique challenges of communicating mosquito bite prevention advice to local communities.

There are important lessons to be learned in situations where extreme weather events may influence the risk of mosquito-borne disease through driving changes in the abundance and diversity of mosquito populations, while also influencing the abundance and distribution of native wildlife that represents important local reservoirs of arboviruses. Similarly, supporting the maintenance of mosquito monitoring and management programs while local authorities face competing priorities due to extreme natural disasters and/or public health events is critical.

Background

There are dozens of mosquitoes of pest and public health significance in Australia, and these are highly specific in their habitat associations, including estuarine, brackish water and freshwater habitats.[1] Many of these mosquitoes are found within the Sydney metropolitan region with their abundance and diversity driven by prevailing climatic and environmental conditions, especially temperature, rainfall and tides.

The most commonly reported mosquito-borne disease in Australia is caused by Ross River virus (RRV). RRV disease is typified by symptoms of

fever, rash, headache, joint pain and fatigue and, while symptoms are generally mild, the illness can be severely debilitating.[2] There are more than 5000 cases of disease reported across the country each year and, over the past 20 years, an average of about 700 cases have been reported from NSW each year.[3] There are also other arboviruses active around Sydney, most notably Barmah Forest virus, which is responsible for a disease sharing similar symptoms to RRV disease but less commonly reported. There is also a suite of other arboviruses routinely detected from mosquitoes in the region, such as Stratford virus and Edge Hill virus, but little is known of their public health significance.[4]

Climate change, extreme weather and bushfires

Predictions of a changing climate are often accompanied by expectations of increased mosquito-borne disease due to global warming and increasingly frequent and intense extreme weather events. In reality, predicting future mosquito-borne disease risk is made difficult due to the complex relationships between a wide range of mosquito species and their associations with environmental and climatic factors (e.g. vegetation, tides, temperature, rainfall, humidity and sea level rise).[5] Exotic mosquito and mosquito-borne disease threats are real but may be determined by human activity just as much, or more so, than a changing climate.[5,6]

A key prediction associated with the increased temperatures that are predicted to accompany climate change has been that the mosquito season will be extended, with the potential for mosquitoes to be more active during early spring and extending into late autumn[5], with concomitant risk of mosquito-borne disease. Beyond increased temperatures and changes in seasonal rainfall, increasingly frequent and intense extreme weather events are among a suite of impacts associated with a changing climate.[7] These events may include storms, drought, flood and bushfires, and – notwithstanding the direct impacts of these events on the health and wellbeing of the human population[8] – there may be direct and indirect impacts that may drive change in risks of mosquito-borne disease.

During the spring and early phases of summer 2019, mosquito populations, as monitored by the NSW Arbovirus Surveillance and Mosquito Monitoring Program[9], were less abundant than usually expected across many areas of NSW. This was due to unfavourable conditions for mosquitoes, including recorded temperatures in many regions being well above average – in some cases the highest spring mean daily maximum temperature on record – and many regions experiencing their lowest total spring rainfall for at least 20 years.[10] These conditions also contributed to some of the worst bushfires on record in NSW. Although there is little evidence of how bushfires may directly or indirectly influence mosquito-borne disease risk, there is likely to be an impact on mosquitoes and the wildlife reservoirs of pathogens such as RRV.

It was estimated that by the start of January 2020, more than 1 billion animals were likely to have been killed during the bushfires across Australia, with the majority of those in NSW.[11] This has the potential to significantly reduce the abundance of wildlife that represent important reservoirs of arboviruses such as RRV.[2] However, the bushfires may also change the distribution of surviving wildlife. Evidence suggests wildlife will seek refuge in unburnt areas of the landscape[12] and, in peri-urban areas, which may be in closer proximity to residential areas. The concentration of wildlife close to human habitation may inadvertently increase the risk of arbovirus transmission to humans as has been observed for other zoonotic pathogens.[13] There is already a clear gap in our understanding of how the spatiotemporal distribution of wildlife impacts the risk of mosquito-borne disease; the response of wildlife to extreme weather events, including bushfire, requires further research.

Although it may seem reasonable to assume bushfires adversely impact local mosquito populations, populations associated with wetland habitats will be less likely to be directly impacted by fire. Recent evidence suggests some mosquitoes associated with coastal swamp forests and estuarine wetlands, such as *Aedes vigilax*, are highly resilient to fire disturbance and recover quickly.[14] Mosquito populations are also not only determined by rainfall. Given that coastal mosquito abundance will be driven by tidal events[1], even during periods of hot and dry conditions, mosquitoes may remain abundant due to tidal water inundating wetlands and, potentially, increase risk of mosquito-borne disease. The need for proactive mosquito management may be a critical component of the response strategies of local authorities to extreme weather events.

COVID-19 and mosquito-borne disease

In early February 2020, exceptional rainfall was reported across Sydney, resulting in the wettest four-day period since 1990[15] and the extensive inundation of wetland and bushland habitats provided ideal conditions for mosquitoes. Subsequently, mosquitoes dramatically increased in number from hundreds to tens of thousands at local surveillance locations during the weeks following this exceptional rainfall.[9]

While mosquito populations and mosquito-borne disease risk were increasing, the COVID-19 pandemic was drawing the attention of local health authorities. This placed additional pressure on staff associated with various local authorities to continue mosquito surveillance and control activities. With increasing threat of community transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), health authorities

in Australia initiated strategies to reduce exposure risk including physical distancing regulations.[16] Starting in late March 2020, these 'lockdowns' were designed to limit movement of people, minimising the transmission risk of SARS-CoV-2. However, these restrictions provided many residents with an opportunity to spend more time around their homes and exercising locally outdoors. As a result, there was a substantial increase in activity around parklands within the Sydney metropolitan area, as highlighted by media coverage of crowds at Sydney beaches and popular recreation areas.[17] Did the increased outdoor activity increase the risk of mosquito-borne disease?

Many of the areas reporting increased recreational activity were those close to wetlands and bushland areas where mosquitoes are known to be active. Increases in reported cases of RRV infections from regions of metropolitan Sydney correlated to this period of lockdown.[9] Further investigation is required to determine whether any increased cases of mosquito-borne disease may have resulted from increased mosquito abundance and diversity resulting from favourable environmental conditions, or was perhaps due to changes in human behaviour and resulting exposure to mosquitoes. There is much to learn about the role of human behaviour in determining exposure risk to mosquito-borne pathogens, and it may be the case that increased time spent indoors during the COVID-19 pandemic actually resulted in decreased exposure to mosquitoes for some individuals.

Considerations for the future

Notwithstanding predicted long-term changes in climate, weather extremes experienced during the 2019–2020 summer have highlighted the need to be adaptive in our mosquito control and management strategies across Australia. The issues faced in NSW during 2019–2020 provide valuable lessons for other jurisdictions that may face regionally specific extreme weather events (e.g. cyclones, floods, bushfire) and/or other public health emergencies. Predictions of the conditions ahead for seasonal mosquito abundance and mosquito-borne disease risk will remain critical, but the operational response needs to be flexible enough to adapt to short-term changing conditions. Local authorities need to consider operational issues where mosquito control or enhanced mosquito surveillance is required due to the identification of increased early season or late season pest and public health risks associated with mosquitoes.

The COVID-19 pandemic has created many challenges for local authorities, but the experiences last summer highlighted that mosquito-borne disease risk must also be considered amid other public health priorities. Maintaining mosquito control during the COVID-19 pandemic in North America has already been identified as a key public health service.[18] Similarly, it is important that operational capacity be maintained for mosquito control and surveillance programs in Australia during these challenging periods. This may include consideration of adaptive public health communication strategies where specific personal protection measures against mosquito-borne disease[19] are required alongside other important public health messages.

Peer review and provenance

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Competing interests

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Author contributions

CW was responsible for the concept, drafting, analysis of data, and editing of the manuscript.

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