

Ecological suitability of Japanese encephalitis virus in Australia: a modelling analysis of vector-host transmission dynamics to potential spillover in humans

Skinner EB ^{1 ‡}, Sartorius B ^{1 ‡}, Furuya-Kanamori L ¹, Craig AT ¹, Kiani B ¹, Johnson BJ ², Moore K ³, Hickson RI ⁴⁻⁵, Mordecai EA ⁶, Devine G ², Lau CL ¹

¹ Centre for Clinical Research (UQCCR), Faculty of Health, Medicine and Behavioural Sciences, University of Queensland, Brisbane, Australia

² QIMR Berghofer Medical Research Institute, Mosquito Control Laboratory, Royal Brisbane and Women's Hospital, Brisbane, Qld, Australia

³ Centre for Planetary Health and Food Security, Griffith University, Gold Coast, QLD 4222, Australia

⁴ Commonwealth Scientific and Industrial Research Organisation (CSIRO), Townsville, Australia

⁵ Australian Institute of Tropical Health and Medicine, James Cook University, Townsville, Australia

⁶ Department of Biology, Stanford University, Stanford, California, USA

[‡]Joint first authors; *Corresponding authors email: eloise.skinner@uq.edu.au; b.sartorius@uq.edu.au

Abstract: Japanese encephalitis virus (JEV) is a multi-vector, multi-host pathogen maintained in circulation between *Culex* mosquitoes and waterbirds, with occasional spillover to humans. In Australia, sporadic local transmission of JEV was historically confined to northern Australia until 2021 after which outbreaks occurred for the first time in temperate southern regions in 2022 and 2023, respectively. Following this outbreak, there have been concerns that JEV has potentially become endemic in Australia, posing an ongoing public health risk exacerbated by shifting climatic and environmental factors. We developed and applied a spatially explicit spillover modelling framework which focuses on estimating i) an ecological suitability index for JEV in Australia and, ii) the spillover potential to human populations if endemic transmission is established. To calculate ecological suitability and the potential number of humans that could be exposed, we integrated the ecological and epidemiological conditions that would allow JEV to circulate in Australia and spillover to human populations. An ecological suitability index was calculated by combining the presence of hosts (Ardeidae birds, domestic piggeries, feral pigs) and vectors (*Culex annulirostris* and *Culex quinquefasciatus*), host-vector contact rates, and vector infection and transmission potential for JEV at a 1km resolution. JEV spillover potential was estimated by multiplying the ecological suitability index with human population density. We used this estimate to calculate the total population that could be exposed to JEV at the Local Government Area (LGA) level and State/Territory level. We validated our estimates by calculating a population-weighted mean value for each LGA and compared the values between LGAs with confirmed JEV clinical cases to those without. We found an elevated ecological suitability along the east coast and south-western coast of Australia, inland from the northern centre of the country, and surrounding the Murray River Basin (along the border of New South Wales and Victoria). If JEV becomes established in ecologically suitable areas, high spillover potential to humans would exist along Australia's eastern coast. This exposure potential extends inland to areas like the Murray River Basin, which provide ample habitat for enzootic hosts and vector species. High spillover potential also exists in the Northern Territory, along the southwestern coast of Western Australia, and in South Australia. LGAs with historically confirmed clinical cases in humans had a statistically higher population-weighted mean value compared to those without confirmed cases, supporting the model's capability to differentiate highly suitable areas. By integrating vector-host dynamics and human population density into a spatially explicit framework, we identified areas with high JEV ecological suitability and the potential for spillover into human populations if transmission of JEV were to become established. The results were driven by interactions between vectors, hosts and vector competence. These findings provide insights for targeted surveillance and vector control strategies in Australia. Proactive and sustained interventions are essential to mitigate JEV's growing threat and to protect vulnerable populations in the face of ongoing environmental changes.

Keywords: Japanese encephalitis virus (JEV); mosquito-borne zoonoses; climate and environmental suitability; vector-host dynamics; spillover risk; spatial modelling.