

# A spatio-stochastic SEIR model of the 1789 smallpox epidemic in Dharawal Country

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**Abstract:** The arrival of the First Fleet in 1788 marked the introduction of infectious disease to Dharawal Country, in what is now the Sydney region. Smallpox was the greatest threat, spreading rapidly through Aboriginal communities, resulting in widespread mortality and demographic collapse. Historically biased perspectives and contemporary misinformation of the disease's introduction and spread impede modern-day truth-telling and subsequent reconciliation and national healing. Understanding how it impacted communities, disrupted their ability to care for Country, and the pathways through which it spread is critical for reassessing colonial narratives and providing a clear account of the epidemic's consequences.

We present a spatio-stochastic SEIR-type binomial chain model to explore how this epidemic may have moved across southeastern Australia and the immediate impacts on the Dharawal people. The model partitions the infectious period into multiple stages of differing transmissibility and allows for age and sex structure. It also incorporates movement across land and waterways, seasonal mobility linked to resource availability, and a nonlinear behavioural response in which infected patches are increasingly avoided before residents eventually return.

To inform parameters, we consulted texts describing the spatial landscape of pre-colonial Australia, including names of language groups, estimated homelands, observed movements, regional boundaries, and estimated populations. We also drew on journal reports of smallpox from 1789–1795 and 1828–1870, which often provided vague references to disease or oral histories of perceived outbreaks many years earlier. These fragmentary accounts limit precision, but allow us to explore possible epidemic trajectories. Importantly, this work was developed in close partnership with the Gujaga Foundation from Dharawal Country and supported by the Centre of Excellence for Indigenous and Environmental Histories and Futures (CIEHF), ensuring that the modelling approach respected Indigenous perspective, histories, and knowledge systems.

Preliminary simulations highlight how age-dependent mortality, structured contact, seasonal mobility, and behavioural responses could be important factors to consider when exploring the possible spread of smallpox in southeastern Australia. In addition to the human toll, widespread sickness and mortality would have greatly diminished the ability of communities to care for Country, disrupting cultural responsibilities and management of landscapes. While records of the epidemic are incomplete, this modelling highlights the role of mechanistic approaches in reconstructing historical epidemics allowing us to understand the impact of past disease.

**Keywords:** *epidemics, smallpox, multi-patch model, demographic collapse, spatio-stochastic*