

## **The Underlying Causes of Nipah Virus Emergence, Malaysia, 1998-9**

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Nipah virus emerged in 1998-9 in Malaysia causing the death of over 100 people, mainly those associated with the pig industry. Virological studies, epidemiological studies and wildlife surveillance work rapidly demonstrated that this virus is closely related to Hendra virus, and emerged via domestic pig amplifier hosts from its wildlife reservoirs, two species of flying foxes of the genus *Pteropus*. In a unique international collaboration, members of the NIH-funded Henipavirus Ecology Research Group have used a combination of laboratory-based, field-based and modeling studies to test hypotheses on the underlying cause of Nipah virus emergence. We present data that suggest Nipah virus (NiV) is continuously present in bat colonies across Peninsular Malaysia and that these bats move freely across national borders and over the straits of Molucca. We have identified significant numbers of seropositive bats in three colonies within 50 Km of the index case for NiV, including one temporary colony within 3 Km of the index farm. We use these data, and epidemiological data from the outbreak investigation, to refute a hypothesis that anthropogenic fires during the large El Nino-driven drought in Sumatra during the mid-1990s caused NiV-infected bats to appear in Malaysia for the first time, leading to spill-over into the pig populations. We have developed an age-structured matrix model for Nipah virus dynamics within the index farm, parameterized with population data from this and other farms. Computer simulations suggest that 1) the intensive livestock production methods used at these farms provide conditions suitable for NiV emergence; and 2) the scenario that best explains the difference between the series of cases in 1997 and the 1998-1999 outbreak is that the virus was reintroduced into the pig population while a large proportion of the sows retained antibodies from previous exposure. Our work demonstrates the value of detailed, multidisciplinary studies designed to examine the underlying causes of disease emergence. Ultimately, it provides data that may help manage the risk of future emergence of Nipah and related viruses.