Japanese encephalitis virus

Fact Sheet

July 2024

Key points

- Japanese encephalitis (JE) is an acute mosquito-borne viral disease of horses, pigs and, occasionally, humans. It can cause reproductive losses (pigs) and encephalitis (pigs, horses, humans).
- Wild birds - particularly of the family *Ardeidae* (wading birds; herons and egrets) - are considered to be reservoir hosts[a] for Japanese encephalitis virus (JEV) in Asia and the virus is maintained in nature by transmission cycles involving *Culex* sp. mosquitoes, birds and pigs.
- The epidemiology and wildlife reservoirs of JEV are not fully understood, particularly in the Australian context, where it is a newly emerged disease.
- It is possible that other wildlife species or domestic species (in addition to pigs) may play a role in the epidemiology of the disease in Australia.
- Japanese encephalitis virus is a nationally notifiable disease (in both humans and animals) in Australia (see *Surveillance and management* below).

Aetiology

Japanese encephalitis virus (JEV); genus: *Flavivirus;* family: *Flaviviridae*. There are five genotypes (I-V). Other notable viruses in this genus include Murray Valley encephalitis, Kunjin, West Nile, Dengue, and St Louis encephalitis viruses.

Japanese encephalitis virus is also known as an arbovirus (a non-taxonomic grouping of **ar**thropod **bo**rne **viruses**, see WHA Fact Sheet *Arboviruses associated with Australian wildlife* for more details).

One Health implications

Wildlife and the environment: there is no evidence of JEV causing disease in Australian wildlife. It is highly likely that wading birds, and possibly other wildlife species, are involved as reservoirs hosts for JEV in the Australian context, but more research is required.

Domestic animals: pigs act as both amplifying hosts for the virus (once infected by mosquitoes) and also suffer from disease. Horses and donkeys can also be affected.

Humans: although less than 5% of human infections develop signs of disease [1], there are more than 60,000 human cases of clinical JE globally each year, with a fatality rate of around 25% of

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[a] A reservoir host is a host that harbours the virus and acts as a sustained source of transmission to other hosts.

clinical cases [2]. Most infections occur in clusters at the end of the mosquito breeding season or summer [3, 4].

The Australian Department of Health and Aged Care has information on Japanese encephalitis and human health, see www.health.gov.au/diseases/japanese-encephalitis.

Natural hosts

The primary (reservoir) host of JEV is believed to be wild birds, especially those in the family *Ardeidae* (herons and egrets) [5]. Flying-foxes have been suggested as a possible reservoir host (see *Epidemiology*) [6].

Domestic pigs are the main amplifying hosts of JEV, especially in epidemic areas of the world, and may act as maintenance hosts[b] in endemic areas [7]. Birds may also play a role as amplifying hosts in areas where pigs are not present [5].

Japanese encephalitis virus can infect a wide range of species, although few species develop signs of disease. A range of Australian marsupials, bats and birds have been experimentally infected with JEV [6, 8, 9].

Clinically affected hosts include pigs**,** horses, donkeys and humans. Other than pigs, these are all considered dead-end hosts, meaning the level of viraemia is too low to allow infection to be transmitted onwards.

Clinically unaffected hosts include cattle, sheep, goats, dogs, cats, rodents, bats, reptiles and amphibians, as well as birds. These species can become infected with JEV but rarely, or never, show clinical signs of disease. It is not known if other Australian wildlife species can develop clinical disease or act as reservoirs for JEV in a natural setting.

World distribution

Japanese encephalitis virus occurs in temperate and tropical regions of eastern and southern Asia, in south-east Russia, and sporadically in Papua New Guinea (PNG) and the Torres Strait islands. The geographic range of JEV has expanded considerably in the last four decades. Major epidemics have occurred when the virus spread into new areas, e.g. India in the late 70s.

Occurrences in Australia

Japanese encephalitis virus was exotic to mainland Australia until 2022. Prior to this, the virus had been detected occasionally in the Torres Strait, bordering northern Australia [4 humans cases in 1995 and 1998] [10, 11] and it was considered a significant threat to Australia because of the presence of host species and competent vectors. The first known JE human case acquired on the Australian mainland was in western Cape York in 1998 [3, 12]. Seroconversion had been documented in sentinel pigs in the area [11] and in 2004, JEV was isolated from a mosquito on the Cape York Peninsula [13].

[b] A maintenance host is a host species within which the virus continues to circulate without any restoration from another host species; in this case, pigs may maintain the transmission cycle without ongoing transmission from birds.

One fatal human case was reported from the Tiwi Is, NT in 2021 [14]. Strong winds, such as those associated with cyclones, are suspected to be capable of blowing infected mosquitoes from PNG into northern Australia [3].

In February-March 2022, an outbreak of JEV occurred in Australia, with detections in over 80 piggeries in southern Qld, NSW, Vic and SA. Over 40 human cases were reported with 7 fatalities [15]. Japanese encephalitis virus is now considered to be established on the Australian mainland, although the risks in a given area are likely to vary with seasonal and across years, depending on weather and other factors [16].

This was the first time JEV had established transmission on mainland Australia and it was declared a Communicable Disease Incident of National Significance [11]. Weather conditions (above average rainfall and warmer minimum temperatures) may have been contributing factors in this outbreak [17, 18]. It is not known how the virus entered southern Australia but the movement of infected mosquitoes or migratory waterbirds may have played a part in spreading the virus [19] as the movements of wild birds and local human populations (with possible associated introduction of vectors or pigs) were risks for introduction of JEV into northern Australia.

Epidemiology

Japanese encephalitis virus is maintained in nature by transmission cycles involving *Culex* sp. mosquitoes and certain species of wild and domestic birds and pigs, as the vertebrate hosts. Wild birds (particularly of the family *Ardeidae* (wading birds; herons and egrets) are believed to act as reservoir hosts and pigs act as amplifying hosts for JEV [10].

Japanese encephalitis virus has been isolated from more than 30 mosquito species. *Culex tritaeniorhynchus* is the primary vector of JEV in Asia and thrives in the rice paddies of south-east Asia where wading birds also flourish [20]. Within Australia, *Cx. annulirostris* (which has a wide geographical distribution and is abundant across the country) is considered the likely primary vector, although *Cx. gelidus* and *Cx. palpalis* are also competent vectors [20]. Research on mosquito feeding patterns in northern Australia indicates that marsupials, particularly the agile wallaby (*Macropus agilis*), are preferred to feral pigs and birds by these mosquito species [5]. The previous lack of establishment of the virus in Australia may have been due in part to these mosquito species preferring to feed on macropods (thought to be inefficient hosts for transmission of JEV), rather than pigs or birds [3, 20].

Transmission of the virus via semen from infected boars is possible [3]. Certain insectivorous animals (e.g. lizards and bats) may contract the virus after ingesting infected mosquitoes. It is not certain if transmission via infected milk is possible [3, 10]. The virus cannot be transmitted from human to human, directly from an animal to a human, or by eating infected meat [11].

Horses, humans and ruminants are considered to be dead-end hosts. It is not known whether other Australian wildlife such as dingos, marsupials, bats, amphibians and reptiles are susceptible, are potential reservoir hosts, or may play a role in impeding the establishment of JE [3, 21], although marsupials are thought to be inefficient hosts for the transmission of JEV [3]. A study showed experimental transmission of JEV from the black flying-fox, *Pteropus alecto*, to *Cx. annulirostris*

mosquitoes, despite the absence of detectable viraemia in the host. Although infection rates in recipient mosquitoes were low, it was suggested that the black flying-fox might play a role in the dispersal of JEV, because of the high population densities of flying-foxes in roosting camps, coupled with their migratory behaviour [5, 22].

A study following the 2022 Australian outbreak found that the geographic distributions of six species of ardeid birds (*Ardea alba* [great egret], *A. pacifica* [white-necked heron], *Botaurus poiciloptilus* [Australasian bittern], *Egretta novaehollandiae* [white-faced heron], *Ixobrychus minutus* [little bittern] and *Nycticorax caledonicus* [nankeen night heron]) were strongly associated with the distribution of JEV cases in piggeries and humans, suggesting that these species of birds might be involved in the epidemiology of JEV in the Australian context [23]. An assessment found ardeid birds, feral pigs and flying-foxes as having the potential to act as maintenance hosts for JEV in the Australian context [24]. In addition, feral pigs are considered an abundant and widespread potential wildlife amplifying or reservoir host. Japanese encephalitis virus has been detected in samples collected from feral pigs in the NT, SA, north Qld and northern WA [16].

Overseas, transmission generally occurs in agricultural zones, particularly in the vicinity of pig farms and irrigated areas such as rice paddies. The main overwintering mechanisms of JEV in Japan might be reintroduction by wild birds and extended incubations in amphibians, reptiles and bats [6].

Incubation period

- Humans: 5-15 days
- Pigs: 1 day
- Horses: 8-10 days
- Herons: 1-2 days [6]
- Bats, reptiles and amphibians: extended incubation possible [25]; experimental studies demonstrated viraemia in bats after 107 days of artificial incubation [26, 27].

Clinical signs

Humans: acute signs include sudden onset of fever, gastrointestinal signs and headache Up to 20-50% of clinical cases may develop encephalitis with associated neurological signs. Approximately 30% of survivors are left with ongoing and normally severe sequelae [1].

Pigs: transplacental transmission can cause foetal encephalitis, abortion and stillbirth, with mummified foetuses. Japanese encephalitis virus can cause poor fertility in boars. Non-pregnant animals may show no signs. Surviving piglets commonly exhibit tremors, convulsions and death. Encephalitis may occur in piglets up to six months of age [see 20].

Horses: there are three clinical syndromes - see Animal Health Australia 2020 [20]:

1. Transient syndrome: fever for 2-3 days with anorexia, sluggish movement and congested or jaundiced mucous membranes; followed by an uneventful recovery
2. Lethargic syndrome: as above, fevers reaching 41°C for up to a week, difficulty in swallowing, neck rigidity, radial paralysis, pronounced lethargy, falling or staggering
3. Hyperexcitable syndrome: high fever, aimless wandering or violent demented behaviour, blindness, profuse sweating, trembling, collapse and death.

Diagnosis

In humans and animals, JE is confirmed either by isolation of the virus or by a rising antibody titre (in the absence of recent vaccination). In animals, a serum neutralisation test or immunohistochemistry may also confirm the diagnosis [5]. In humans, if the infection is believed to be acquired in Australia, confirmation from a second reference laboratory is required.

Laboratory diagnostic specimens and procedures

Diagnostic specimens are serum, brain and other tissues collected aseptically, and less than 12 hours post-mortem from animals in the acute stage of the disease. A range of fixed tissue samples should also be collected. Fresh samples should be transported chilled to the local government diagnostic laboratory, if expected to arrive within 48 hours after collection. Otherwise samples should be frozen and transported on dry ice [1].

Serological tests include complement fixation, haemagglutination inhibition, serum neutralisation and/or enzyme-linked immunosorbent assay. Additional tests used in humans include immunoglobulin detection in serum or CSF, and detection of JEV RNA in clinical material [20]. The Australian Centre for Disease Preparedness has a Factsheet for JEV testing in animals https://acdp.csiro.au/resources/documents/CSIRO_JE_Diagnostic_Testing_Factsheet_V3.pdf.

Pathology

In humans, clinical laboratory findings of JE include moderate leucocytosis, mild anaemia, hyponatraemia, and cerebrospinal fluid (CSF) pleocytosis with a lymphocytic predominance [1, 20].

There are no characteristic gross lesions in humans, animals or aborted foetuses. Oedema of the brain may be present in piglets. Histologically, there may be pronounced necrosis of Purkinje cells in the cerebellum with no inclusion bodies. A diffuse non-suppurative encephalomyelitis with neuronal necrosis, neuronophagia, gliosis, perivascular cuffing, spinal hypomyelinogenesis and engorged blood vessels with many mononuclear cells may be seen.

Differential diagnoses

In pigs, diseases which cause abortions in sows and neurological diseases in piglets should be considered as differentials [20]. In horses, diseases which cause fevers and neurological symptoms or ataxia should be considered as differentials.

Treatment, prevention and control

There is no specific treatment for JEV infection. For horses and humans, symptomatic and supportive treatment will depend on clinical signs.

In humans, pigs and horses, avoiding mosquito bites and vaccination are the main prevention and control methods. Guidelines are available for pig producers and horse owners to help them protect their animals from mosquito bites and reduce the risk of infection. Ongoing or targeted mosquito control should be performed, as appropriate. See www.health.gov.au/diseases/japanese-encephalitis for more information. There may be considerations and limitations with deployment

and supply of vaccination [20]. It has been recommended that piggeries should be located a minimum of 3 km from human dwellings.

Details of domestic animal control during a JE outbreak can be found in the AUSVETPLAN Japanese Encephalitis Response Strategy [20]. No special precautions are recommended for handling of animal carcasses or pathological specimens as they are not considered a source of infection [20].

Research

AUSVETPLAN recommends that the National Arbovirus Monitoring Program and flavivirus sentinel programs should monitor the spread of JEV through the use of appropriate sentinel hosts and vector testing and monitoring [20].

To better understand the role of Australian wildlife in JEV epidemiology, and to better understand the potential impact of JE in Australia, areas of research include:

- evaluation of Australian wildlife as potential reservoirs or clinically affected species
- epidemiological modelling of the possible spread of JEV in Australia, based on vector competence, abundance and movement and potential host dynamics (including wild birds and feral pigs)
- assessment of current biosecurity measures
- assess the timeliness of likely detection, reporting and control measures
- analyses of the financial impact of a JE incursion or establishment.

Surveillance and management

In Australia, JE is nationally notifiable disease in both humans and animals (see www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/animal/notifiable). By law you must notify animal health authorities in your jurisdiction if you know or suspect that an animal has a notifiable pest or disease. Refer to advice in your jurisdiction (www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/animal/state-notifiable) and on outbreak.gov.au on how to report.

The AUSVETPLAN for JE is available at www.animalhealthaustralia.com.au/our-publications/ausvetplan-manuals-and-documents. Trace-back activities may be instigated on infected humans and animals, and pigs may be monitored for further viral activity. Serum banking of potential wild animal hosts for later testing may be helpful [20]. Arbovirus surveillance is conducted in Australia via monitoring of mosquitoes and sentinel chicken flocks.

Wildlife Health Australia administers Australia's general wildlife health surveillance system, in partnership with government and non-government agencies. Wildlife health data is collected into a national database, the electronic Wildlife Health Information System (eWHIS). Information is reported by a variety of sources including government agencies, zoo based wildlife hospitals, sentinel veterinary clinics, universities, wildlife rehabilitators, and a range of other organisations and individuals. Targeted surveillance data is also collected by WHA. See the WHA website for more information https://wildlifehealthaustralia.com.au/Our-Work/Surveillance and https://wildlifehealthaustralia.com.au/Our-Work/Surveillance/eWHIS-Wildlife-Health-Information-

System. There are no reports of JE in Australian wildlife in the National Wildlife Health Surveillance Database.

Acknowledgements

We are grateful to the people who had input into this Fact Sheet.

Wildlife Health Australia recognises the Traditional Custodians of Country throughout Australia. We respectfully acknowledge Aboriginal and Torres Strait Islander peoples' continuing connection to land, sea, wildlife and community. We pay our respects to them and their cultures, and to their Elders past and present.

Please cite this Fact Sheet as: Wildlife Health Australia (2024) "Japanese encephalitis virus – Fact Sheet", published by Wildlife Health Australia, Canberra, available at https://wildlifehealthaustralia.com.au/Resource-Centre/Fact-Sheets

Updated: July 2024.

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