Japanese Encephalitis

Japanese B Encephalitis,
Arbovirus B,
Mosquito–borne Encephalitis Virus

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Importance

Japanese encephalitis virus (JEV) is a mosquito–borne agent best known as a cause of encephalitis in humans and equids, though rare cases have been reported in other species, and reproductive losses may be seen sometimes in pigs. While most infections in people and horses are asymptomatic or mild, with < 1% developing neurological signs, human encephalitis is often severe and many survivors are left with neurological sequelae. Japanese encephalitis tends to be a childhood disease in endemic areas, where people are usually exposed to the virus by adulthood, though clinical cases are also seen occasionally in adults with waning immunity. At times, epidemics have resulted in hundreds or thousands of cases in people and/or horses when virus circulation was particularly high or population immunity low.

Although routine childhood vaccination has reduced the incidence of Japanese encephalitis in some countries, it continues to be an important cause of illness in others. It can also be a concern for travelers of all ages to endemic areas. The virus is widely distributed in Australasia and the western Pacific, with some introductions to new areas during the last 50 years. It could become established in additional regions where suitable mosquito vectors exist, potentially resulting in significant morbidity and mortality in a naive population. Eradication is unlikely once JEV has become established in mosquitoes in a suitable climate, as it is maintained and amplified in cycles between these vectors and both wild and domesticated vertebrate hosts.

Etiology

Japanese encephalitis virus (JEV) is a member of the Japanese encephalitis serogroup in the genus *Flavivirus*, family Flaviviridae. There is only one serotype of JEV, but at least five genotypes, G-I to G-V. Some genotypes are more common than others, and the dominant genotypes in an area can change over time. Information on the genotypes circulating in some areas is still limited.

Species Affected

JEV can infect a wide variety of vertebrates, though only those species that consistently develop viremia sufficient to infect mosquitoes can act as maintenance or amplifying hosts. Certain birds in the family Ardeidae (herons and egrets) appear to be important maintenance hosts, but antibodies to this virus have also been found in many other avian species. Laboratory experiments suggest that some non-ardeid birds, such as some ducks, passerines, gulls and pigeons, can develop significant viremia, while others (e.g., crows, American white pelicans, double-crested cormorants) have little or no virus in the blood. Among mammals, evidence for JEV infections has been demonstrated in pigs, wild boar, cattle, water buffalo, sheep, goats, alpacas, equids, rabbits, dogs, cats, raccoon dogs (*Nyctereutes procyonoides*), raccoons (*Procyon lotor*), seals, meerkats (*Suricata suricatta*), various nonhuman primates, bats, some captive cervids and other species. Most mammals seem to be dead-end hosts, and pigs are the only domestic animal thought to be important in virus amplification. While horse-to-horse transmission via mosquitoes appears possible in the laboratory, viremia in this species is low and there are usually too few susceptible horses nearby to maintain and propagate the virus. Research in wildlife is limited, but feral swine and wild boar could be amplifying hosts, there are reports that bats might participate in some cycles, and brush-tailed possums (*Trichosurus vulpecula*) can develop significant viremia after experimental inoculation. The virus also appears to infect some reptiles and amphibians.

Illnesses caused by JEV are mainly seen in equids and pigs, but a few clinical cases have been confirmed in other animals including cattle, an alpaca, captive meerkats and captive speckled seals (*Phoca hispida*). The diversity of these species suggests some other mammals might also be susceptible and clinical cases may be missed due to their rarity and lack of awareness. The authors of one research paper noted that clinical cases are not seen in dogs and cats in Japan during human and equine epidemics; however, a suspected natural case in a dog was described in the Japanese scientific literature during a large epidemic in 1949. Blood taken from the sick dog resulted in typical Japanese encephalitis lesions when tested by animal

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inoculation in mice. The dog also had serological evidence of exposure, with stronger reactivity to JEV than St. Louis encephalitis virus. Some experimentally infected dogs had neurological signs after intracerebral inoculation, confirming that clinical cases might be possible in this species if the virus reaches the brain. Studies that inoculated dogs or livestock by routes closer to natural transmission, such as subcutaneous inoculation, found that the animals only developed asymptomatic infections. However, these studies used very few animals, which may not be sufficient to detect clinical cases if the disease is uncommon.

Experimental infections resulting in illnesses have also been reported in nonhuman primates (primarily members of the genus *Macaca*), mice and hamsters, including some primates and hamsters infected by intranasal inoculation. Some goats developed neurological signs after intracerebral inoculation. Guinea pigs and rabbits remained asymptomatic after inoculation by all routes, including intracerebral.

Zoonotic potential

Humans are susceptible to infection with JEV and sometimes develop clinical signs.

Geographic Distribution

Japanese encephalitis is widespread in temperate and tropical regions of eastern and southern Asia, with reports of the virus as far north as southern Russia. It also occurs in parts of the western Pacific. The precise distribution of JEV in some countries is unclear, due to limited surveillance and/or cross-reactivity with other flaviviruses in some serological tests. JEV isolates have been found regularly in the Torres Straits islands of Australia since 1995, and a different virus was detected in pigs and humans on the Australian mainland in 2021 and 2022. Serological evidence of widespread exposure in feral pigs after these outbreaks suggests the virus may have become established in this location. Countries where human cases are not reported, such as Singapore, sometimes have evidence of continuing subclinical JEV circulation in animals.

Rare reports have described infections that were apparently acquired outside Asia, though there is currently no definitive evidence that the virus has become established in any of these locations. In one instance, part of the JEV genome was identified in seven birds in Italy during dead bird surveillance in 1997-2000, gene segments and viral antigens were found in a few bone marrow samples collected from healthy birds around that time, and some PCR-positive mosquitoes were detected in 2010. Similarly, nucleic acids of both JEV and yellow fever virus were found in a yellow fever patient in Angola in 2016, though the patient had not traveled to regions where JEV is endemic.

Transmission

JEV is usually transmitted in mosquito bites, but lizards and bats can also become infected by eating infected mosquitoes, and non-vector mediated routes seem to be possible in some instances. *Culex tritaeniorhynchus*, which breeds in rice paddies and connecting canals, is the most important mosquito vector across much of Asia. Other culicine species may be significant locally or transmit JEV where this vector is absent. Some examples include *C. gelidus* in Asia, *C. quinquefasciatus* in some urban locations, and *C. annulirostris* and other members of the *C. sitiens* subgroup in Australia. The virus has also been found in members of other mosquito genera, such as *Aedes* and *Mansonia*, and some species appear to be competent vectors in the laboratory. JEV was isolated from *Culicoides* midges in China, though the significance of this finding, if any, is unclear.

Laboratory experiments have demonstrated that pigs and some other mammals, including rhesus macaques, hamsters and mice, can also be infected by intranasal inoculation. Both pigs and mice could infect other members of their species during close contact, though transmission in pigs did not seem to be efficient, and contact pigs and mice had low levels of viremia. Mice could transmit the virus through double mesh barriers, indicating possible aerosol transmission. Pigs have been reported to shed live virus in oronasal secretions for up to 5-6 days, and it can sometimes be detected in the tonsils for about 3 weeks, with nucleic acids found longer. In other studies, it was found in the semen of boars. The occurrence of live virus in other secretions and excretions is uncertain, though some researchers have occasionally reported viral nucleic acids at low levels in feces, urine or vaginal secretions. Some experimentally infected passerine birds, egrets, gulls and mallards transiently shed low titers of JEV in oropharyngeal fluids, while cloacal shedding appeared to be absent or rare.

People mainly become infected from mosquito bites, but clinical cases have occasionally been reported after direct exposure to the virus in the laboratory or while collecting tissue samples. The routes implicated in these incidents include exposure of mucous membranes or broken skin, inhalation/ aerosols and needlestick injuries. JEV or PCR evidence of the virus has been found occasionally in human throat swabs or urine, but person-to-person transmission has never been reported. Two immunocompromised transplant recipients were infected via blood transfusions.

Japanese encephalitis virus does not survive well outside a living host. How the virus persists during the winter in temperate climates is uncertain.

Disinfection

JEV is reported to be susceptible to various disinfectants including 70% ethanol, 2% glutaraldehyde, 3-8% formaldehyde, 1% sodium hypochlorite, iodine, phenols, iodophors and organic solvents/detergents. This virus is also sensitive to heat, ultraviolet light and gamma irradiation.

Infections in Animals

Incubation Period

Reported incubation periods are about 4-14 days in experimentally infected horses and 5-10 days in experimentally infected nonhuman primates. Experimentally infected pigs developed clinical signs after 3 days, with rising temperature detected in some animals as soon as 24 hours.

Clinical Signs

While most infections in horses are subclinical, mild to severe clinical cases are seen occasionally. Some animals have only nonspecific signs such as a transient fever, inappetence, lethargy, and congested or jaundiced mucous membranes, with the animal usually recovering after a few days without complications. Others develop encephalitis of varying severity. Common signs in milder cases include difficulty swallowing, incoordination, transient neck rigidity, radial paralysis or impaired vision, often accompanied by a fluctuating fever, inappetence and lethargy, and in some cases, jaundice or petechiae on the mucous membranes. Mildly affected horses often recover within a week. A more severe but uncommon form, called the "hyperexcitable form," is characterized by high fever and neurological signs that may include aimless wandering, violent and demented behavior, profuse sweating, muscle tremors and occasionally blindness. While some severely affected horses recover, many collapse and die within a day or two. Neurological defects such as ataxia can sometimes persist after recovery.

Pigs that are first exposed to JEV during pregnancy may give birth to stillborn or mummified fetuses, usually at term. Abortions have also been reported, though this is less common, and congenital neurological defects including hydrocephalus, cerebellar hypoplasia and spinal hypomyelinogenesis may be seen in some litters. Infected piglets born alive occasionally have tremors and convulsions and die soon after birth. The sow does not appear ill, and subsequent pregnancies are expected to be normal. Nonpregnant pigs are usually infected subclinically or experience a transient febrile illness, though rare cases of encephalitis are apparently possible up to 6 months of age. Results from experimentally infected pigs suggest these cases are generally mild, with fever, lethargy, mild neurological signs such as hindleg tremors or ataxia, and full recovery, though field reports suggest that affected animals may occasionally die. A wasting syndrome was reported in one group of piglets with post-mortem evidence of nonsuppurative meningoencephalitis. Decreased sperm motility and concentration has been seen in some boars and is usually transient, though permanent infertility is possible if the boar is severely affected.

Rare clinical cases reported in calves and adult cattle, two young meerkats and two adolescent seals were characterized by neurological signs (e.g., seizures, circling, head tilt, ataxia, muscle tremors, changes in consciousness), sometimes preceded or accompanied by fever, depression, decreased appetite and other nonspecific signs. Lung, liver, intestinal and kidney lesions were also found in the meerkats at necropsy, though clinical signs related to these body systems were not noted. All of these cases were fatal or resulted in euthanasia. Another death, in a 10 year old seal co-infected with JEV and heartworms (*Dirofilaria immitis)*, was attributed to the parasite, though meningoencephalitis caused by JEV was found in the brain. Its contribution, if any, to the clinical signs of diarrhea, appetite loss, reduced activity and terminal convulsions was unclear. A case in an alpaca, seen during recent outbreaks in Australia, has not been published.

In 1949, Japanese encephalitis was diagnosed in a dog that had bitten members of the family, based on serology and lesions consistent with Japanese encephalitis in mice inoculated with the dog's blood. The animal displayed clinical signs of mild excitement, conjunctival hyperemia of the left eye, and loss of light reflection in the right eye. It had recovered almost completely when re-examined a month later. Both subclinical infections and encephalitis have been reported in intracerebrally inoculated dogs. One of these studies reported a range of outcomes in 17 young dogs (< 6 months), including mild to severe neurological signs in the majority; and either general prostration without CNS signs or subclinical infections in a few individuals. A small number of dogs infected by subcutaneous and/or intraperitoneal injection or via mosquitoes did not develop any clinical signs.

Some experimental infections in intranasally or intracerebrally inoculated macaques and hamsters, subcutaneously inoculated mice and intracerebrally inoculated goats were also characterized by neurological signs from encephalitis, sometimes preceded or accompanied by various nonspecific signs of illness, including fever. In other experiments, including some where nonhuman primates and rodents were inoculated by other routes, with different doses or other isolates, the infections were subclinical. Abortions were documented in intraperitoneally inoculated pregnant mice.

There are currently no reports of illnesses definitively linked to JEV in naturally infected birds, and most experimentally infected birds were asymptomatic. However, a few studies reported nonspecific signs (reduced appetite and activity) and decreased growth rates in recently hatched, experimentally infected ducklings. Elevated mortality was also seen in some experiments, with terminal opisthotonos in one report. Some dead ducklings had encephalitis, but one study found the virus in the heart, lung and stomach of moribund ducklings, but not in the CNS. Ducklings older than 10 days of age remained asymptomatic.

Post Mortem Lesions

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Nonsuppurative encephalitis is the characteristic histopathological lesion in mammals with CNS signs. There may be no gross lesions in the brain, though hemorrhages

and/or congestion have sometimes been reported. Other organs are generally unaffected by JEV in equids. Reported lesions with uncertain relevance to Japanese encephalitis in other hosts include pulmonary emphysema in two cattle with encephalitis, and in the meerkats, diffuse lymphoplasmacytic interstitial pneumonia, multifocally necrotizing suppurative bronchitis, mild portal lymphoplasmacytic hepatitis, and reddened segments of the duodenum and jejunum with reddish-brown, mucoid content, and radiating white streaks in the medulla and along the corticomedullary junctions of the kidneys. One study found histopathological evidence for nonsuppurative encephalitis in recently hatched, experimentally infected ducklings, though another experiment did not detect any gross or microscopic CNS lesions and there was no evidence of virus in the brain. Some ducklings also had enlarged and darkened spleens.

Mummified or stillborn fetuses can be found in litters from affected sows. Congenital neurological defects including hydrocephalus, cerebellar hypoplasia and spinal hypomyelinogenesis may be also seen in some litters.

Diagnostic Tests

JEV, its nucleic acids and antigens may be found in the brain and/or spinal cord of animals with neurological signs. Recovery of live virus from horses with clinical signs is difficult, and tissue samples should be very fresh, i.e., taken from animals that have been dead for less than 12 hours or were killed during the acute illness. Recommended samples from the brain include the corpus striatum, cortex and thalamus. It may be possible to detect JEV in the blood, serum or CSF of live horses, but viremia is usually short-lived and virus isolation is rarely successful in animals with clinical signs. In swine, the virus may be found in the brains of affected fetuses or piglets with encephalitis, as well as the tonsils, spleen, liver or placenta. The sow has usually cleared the virus by the time an affected litter is born.

Reverse transcription polymerase chain reaction assays (RT-PCR) are generally used to detect JEV nucleic acids, while immunohistochemistry can identify viral antigens in the CNS. Live virus can be isolated in some mammalian cell lines such as Vero, BHK-21 and MDBK cells, certain mosquito cell lines (e.g. C3/36) and some primary cell cultures, including chicken embryo cells. The recovered virus can be recognized as a flavivirus by hemagglutination inhibition or ELISAs, and its identity can be confirmed by RT-PCR, virus neutralization, or immunofluorescence. JEV can also be isolated in mice, though animal inoculation is generally discouraged if there are alternatives. Histopathology is also helpful in diagnosis.

Japanese encephalitis is often diagnosed by serology in endemic regions. ELISAs for IgM or IgG are a commonly used test, but virus neutralization (e.g., the plaque neutralization test), hemagglutination inhibition, indirect immunofluorescence and some infrequently-used tests (e.g., complement fixation) may also be employed. Antibodies specific for JEV may be detected in the cerebrospinal fluid (CSF) of animals with encephalitis. A definitive diagnosis can also be made by a significant rise in titer in paired acute and convalescent samples, and a presumptive diagnosis if a high titer is found in a single serum sample and supportive evidence suggests Japanese encephalitis. Sows usually seroconvert before the onset of reproductive signs, and rising titers may not be observed in these animals. Test interpretation can be complicated by significant cross-reactivity to other flaviviruses, particularly those in the Japanese encephalitis serogroup (e.g., St. Louis encephalitis virus, Murray Valley encephalitis virus, West Nile virus) in serological tests other than virus neutralization

Treatment

Affected animals are treated symptomatically.

Control

Disease reporting

Veterinarians who encounter or suspect a Japanese virus infection should follow their national and/or local guidelines for disease reporting. In the U.S., state or federal authorities must be notified immediately.

Prevention

Japanese encephalitis vaccines have been licensed for horses and pigs in some areas. Sows are widely vaccinated in a few countries (e.g., South Korea, Taiwan), but not in others, due to the cost of vaccination, rapid turnover of pigs, interference of maternal antibodies with vaccination during the first 2-3 months of life, and consequently, the short period when vaccination would be expected to have a benefit. While vaccines also seem to protect animals against genotypes other than the vaccine strain, some reports suggest they may be less effective, particularly for G-V, the most divergent genotype.

Various measures to reduce contact with mosquitoes, such as stabling animals in screened barns during peak mosquito biting activity or the use of insecticide-treated mosquito nets for pigs, may also be of some help, particularly during outbreaks. Environmental control of mosquitoes may temporarily help control these vectors during an outbreak, but large-scale use of insecticides is costly, difficult to implement well long-term, may have adverse effects on the environment, can result in insecticide resistance, and is impractical in many areas.

Morbidity and Mortality

Japanese encephalitis may occur year round or seasonally, depending on the area. Clinical cases in horses peak in late summer and autumn in some temperate regions. While the virus circulates year-round in the tropics, these areas may also have seasonal peaks associated with irrigation, rainfall or other factors that affect the local abundance of mosquitoes and/or amplifying hosts. Maternal antibodies can persist up to 3 months in pigs, and immunity has been reported to last at least 3 years after infection. However, the continuous generation of susceptible young pigs and slaughter of older animals in swine farming provides a large pool of susceptible animals

to amplify the virus. Seasonal changes in the abundance of young birds might also influence virus circulation, as it does in some other diseases, but this does not seem to have been examined.

While JEV infections seem to be common in many mammals, most are subclinical or mild. Cases of encephalitis in horses, the most frequently affected species, usually occur sporadically or in small clusters, though epidemics have also been seen occasionally. The morbidity rate in horses was estimated to be approximately 0.045% (45 cases per 100,000 population) in Asia between 1948 and 1967; however, it was reported to be 0.3% during a severe outbreak in Japan in 1948. Estimated fatality rates in equine clinical cases range from ≤ 5% to 15%, with occasional reports of higher mortality, such as an incident where a group of susceptible broodmares was introduced to an endemic area and a third of the mares died.

Cases of encephalitis in other species appear to be very rare, though some cases may be overlooked due to lack of awareness. Reported cases in cattle affected animals from 3 months of age to 9 years; however, some evidence from experimentally infected rodents, dogs and ducklings suggests that immature animals might be more likely to develop encephalitis. Similarly, two cases of encephalitis occurred in adolescent spotted seals, while 12 older animals at this facility were unaffected. Although encephalitis was reported in a 10-year-old spotted seal in a separate incident, debilitation from a fatal *D. immitis* infection may have played a role. In experimentally infected ducklings, one study reported no deaths in the birds that became ill; another found mortality rates of 13% and 37% in ducklings inoculated with two strains of JEV, but not other isolates; and a third study reported 30% morbidity with 100% case fatality.

Pigs that become infected before they reach breeding age do not usually become ill, and few or no disease issues may be seen in this species, particularly in tropical regions where the virus circulates year round. In other areas, losses probably vary with the proportion of previously unexposed sows that become infected during pregnancy. In one instance, reproductive losses were reported to affect 50-70% of pigs during a severe epidemic in Japan.

Infections in Humans

Incubation Period

The incubation period in humans is estimated to be 5 to 15 days.

Clinical Signs

The initial signs of Japanese encephalitis are usually nonspecific and flu-like, and may include fever, chills, malaise, muscle aches and, in some cases, severe headache with vomiting. Children may appear to have a gastrointestinal illness, with nausea, vomiting and abdominal pain. Some patients also have thrombocytopenia, and coryza and diarrhea have been reported.

Most people recover after this initial stage, but a minority develops neurological signs that may include encephalitis, signs suggestive of benign aseptic meningitis, or atypical presentations such as flaccid paralysis with or without encephalitis. Encephalitis, the most common form, can appear either insidiously or as the sudden onset of fever and convulsions. Common symptoms include a reduced level of consciousness; focal neurological signs; quadriplegia, hemiplegia or cerebellar disorders; behavioral changes; painful stiffness of the neck; and mild to severe convulsions that range from subtle focal signs to generalized seizures. Movement disorders also occur frequently, and some people develop transient Parkinson's like signs (e.g., masking of the face, reduced blinking, rigidity with or without tremor, akinesia). Various atypical presentations have been reported, and include isolated acute onset behavioral abnormalities that may be misdiagnosed as psychiatric illnesses. Apparent effects on other organs, such as pulmonary edema and upper gastrointestinal hemorrhage, have been described occasionally. Miscarriages can occur in pregnant women who are infected for the first time during pregnancy; however, this is reported to be uncommon in endemic areas.

Convalescence from CNS signs can be prolonged, though some patients make a rapid, spontaneous recovery ("abortive encephalitis"). An estimated 30-50% of survivors have neurological sequelae such as epileptic seizures, deafness, cognitive, behavioral or language impairment, or a Parkinsonian syndrome with tremors and rigidity. Some survivors gradually improve, although this may take months or years.

Diagnostic Tests

Serology is often used to diagnose Japanese encephalitis in endemic areas. IgM can be found in the CSF of most patients with neurological signs, and IgM in acute phase serum is suggestive of recent infection (or vaccination). A fourfold rise in neutralizing antibody titers can provide a retrospective diagnosis. Cross-reactivity with other flaviviruses is an issue in some other serological assays, as in animals. Viremia is usually transient and low level, but JEV or its nucleic acids may occasionally be found in blood, CSF or other samples (e.g., throat swabs) of encephalitic patients. Viral antigens may be detected in the postmortem brain by immunohistochemistry. Neuroimaging and electroencephalographic analysis can also be helpful.

Treatment

Treatment is supportive and symptomatic. While some therapies specific for the virus (e.g., antiserum) have been investigated, information about them is still limited.

Control

Several different vaccines are in use for childhood vaccination in endemic areas. Vaccination may also be offered to some adults in these regions and, outside these

areas, to some laboratory workers and travelers. Recommendations for travelers vary, depending on factors such as the season, duration of travel, activities and type of lodging. Mosquito bites can be discouraged with insect repellents, insecticide-impregnated bed nets, long-sleeved shirts and pants, and similar measures. Other interventions, such as environmental modifications to decrease mosquito populations (e.g., intermittent irrigation of rice fields, larvivorous fish, insecticide spraying) or relocation of pigs away from human population centers have occasionally been investigated or implemented. Where Japanese encephalitis is seasonal, serological surveillance in pigs, and perhaps other species, can help predict epidemics in humans.

Morbidity and Mortality

Japanese encephalitis follows the same pattern in humans as horses, peaking in late summer and autumn in some temperate regions, but occurring year-round in the tropics, sometimes with seasonal peaks caused by local factors such as rainfall. Clinical cases are more common in rural areas, especially where stagnant bodies of water, such as rice paddies, support high mosquito populations. The presence of large numbers of pigs, which can act as amplifying hosts for the virus, is thought to increase human infections; however, there can also be significant numbers of cases where pigs are uncommon. More than 99% of human infections are thought to be asymptomatic or very mild, with encephalitis estimated to occur in 0.2-0.4% of all infections, and CNS signs thought to develop in about 20-30% of the clinical cases seen by a physician. All ages can be affected in a population without previous exposure, but most cases in endemic areas occur in children. However, occasional cases are also seen in adults with declining immunity, particularly those who are older or are not repeatedly exposed to the virus.

The annual incidence of encephalitis in endemic regions generally ranges from < 0.005 to about 1-4 cases per 100,000 population, depending on the country, though higher levels have been reported during some epidemics. Particularly severe epidemics in Thailand, where the usual incidence at the time was 2-3 cases/100,000, resulted in 14-20 cases per 100,000 in 1969 and 1970. Climatic conditions that favored high mosquito populations, together with antibodies in only 50% of children, were thought to have been contributing factors. Childhood vaccination, improved standards of living and other factors have greatly reduced the incidence of disease in some countries, though encephalitis continues to be a significant issue in others. The effects of routine vaccination have been estimated in Japan, where the annual incidence of encephalitis was 0.001 cases per 100,000 population in 1995-2004, at a time when childhood vaccination was recommended, and 0.004 cases per 100,000 in 2005-15, when vaccination was halted due to concerns about side effects from a mouse brain-derived inactivated vaccine.

In clinical cases, reported fatality rates mostly range from < 5% to about 25-30%, though higher rates have been seen in some case series. Severe cases and deaths are most common in young children and the elderly. Some countries note that both morbidity and case fatality rates have decreased significantly in recent years, possibly due to partial immunity from an incomplete vaccination series, better care and/or other factors. Up to 30-50% of survivors of encephalitis are estimated to have mild to severe neurological sequelae. Some gradually improve, although this may take months or years.

Internet Resources

Government of Australia. Department of Agriculture, Fisheries and Forestry. Japanese Encephalitis.

Public Health Agency of Canada. Pathogen Safety Data Sheets

The Merck Veterinary Manual

World Organization for Animal Health (WOAH)

WOAH Manual of Diagnostic Tests and Vaccines for Terrestrial Animals

WOAH Terrestrial Animal Health Code

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