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REVIEW ARTICLE

Japanese encephalitis with special reference to prevention and control

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INTRODUCTION

Japanese Encephalitis (JE), formerly called Japanese B Encephalitis. It is caused by a Flavivirus and transmitted by mosquitoes. It is a viral zoonotic disease, infecting mainly animals and accidentally man. In endemic countries, JE is primarily a disease of children. However, travel-associated JE can occur among persons of any age. It occurs in Korea and Japan between May and October. In the more tropical countries of south-east Asia, for example Thailand, Cambodia and Vietnam, it occurs between April and October. In Nepal and Northern India, it occurs between April and December. JE is the main cause of viral encephalitis in many countries of Asia with nearly 68,000 clinical cases every year (WHO, 2014). Up to 60 per cent of them develop serious inflammation of the brain, which can lead to permanent brain damage or death.

The disease is caused by *Flavivirus* (group B Arbovirus), which is closely related to the agents of Dengue fever virus, St. Louis Encephalitis Virus, West Nile Fever and Murray Valley Encephalitis. JE virus belongs to the family Flaviviridae, genus Flavivirus, serogroup B and serotype JBE. The disease is transmitted by culicine mosquitoes such as *Culex tritaeniorhynchus, Culex vishnui* and *Culex gelidus* along with some anophelines. These mosquitoes generally breed in irrigated rice fields, shallow ditches and pools. Among these, *Culex tritaeniorhynchus* has been implicated as the most important vector in south India (National Institute of Virology, Pune, 1980). Immunologically JE virus is of 2 distinct types *i.e.* Nakayama prototype strain isolated from human brain and JaGAr01 strain from C*ulex tritaeniorhynchus*.

Epidemiological features of JE :

Japanese encephalitis virus is the leading cause of viral encephalitis in Asia and occurs in almost all Asian countries. 24 countries in the WHO south-east Asia and western Pacific regions have endemic JE transmission, exposing more than 3 billion people to risks of infection (WHO, 2014). According to the prevalence of different genotypes of JE virus, countries of the world have been grouped into six regions. The prevalence of different genotypes

of JE virus in different regions of the world has been given in Table 1.

JE has emerged as a major public health problem. About thirty years ago JE was known as an endemic disease in east Asia especially Japan, China and Korea but in recent years the disease has spread widely in south-east Asia. The outbreaks of considerable magnitude have occurred in India, Sri Lanka, Thailand, Indonesia, Viet Nam, and Myanmar (Okuno, 1978). The outbreaks between 1986 and 1990, the registered cases of JE in China, India, Thailand and Japan were 126000, 26000, 836 and 122, respectively (WHO, 1994).

The global incidence of JE is unknown because the intensity and quality of JE surveillance and the availability of diagnostic laboratory testing vary throughout the world. Countries that have implemented high-quality childhood JE vaccination programmes have seen a dramatic decline in JE incidence (Campbell *et al.*, 2011). JE has also been reported from other than Asian countries. In Spain the first outbreak of JE occurred in 1990. Between 1989 and 1993 three tourists became infected in Bali and developed JE, and one tourist died. The spread of JE in Australia is limited due to the fact that 80 per cent of wild boars have antibodies against Murray Valley Encephalitis and against Kunjin virus. These antibodies protects against infection with JE virus. JE occurs frequently in Malaysia but not in Indonesia. The reduced pig farming in the Islamic country may be one of the reasons.

The disease is rare in other parts of the world and when seen, is generally associated with travelers running form endemic areas. Up to 70 per cent of adults in tropical region of Asia have antibodies. The virus has been isolated from the mosquitoes in India (Carey *et al*., 1968 and Shehgal *et al*., 1994). In endemic areas the virus can be isolated from the mosquitoes (Kedarnath *et al.*, 1984 and George *et al.*, 1987). The occurrence of JE is higher in rainy season due to propagation of mosquitoes.

Japanese Encephalitis was first reported in 1935 in Japan and 1955 in Tamil Nadu, India (Work *et al*., 1956). Subsequent surveys carried out by the National Institute of Virology, Pune, indicated about that about half of the population of south India had neutralizing antibodies to this virus (ICMR, 1975). JE has been reported time to time from India but in the last two decades, there has been a major upsurge of JE in most of the states of India such as U.P., M.P., A.P., Karnataka, Tamil Nadu, Bihar, West Bengal, Assam, Goa, Pondicherry and Maharashtra. In the state of Andhra Pradesh in India, JE epidemics occur every 2 to 3 years. However, JE outbreaks are being reported every year in Uttar Pradesh since last decade. In endemic areas, JE virus can be isolated from the mosquitoes.

Prevalence is generally higher in males and fatalities varies from region to region such as 10 per cent China, 30 per cent Japan, 21-40 per cent India and more than 40 per cent Korea (Umenai *et al*., 1985). Children are primarily affected in epidemics. The spread of the disease correlates well with the densities of mosquito vectors. Several outbreaks of Japanese Encephalitis have been reported from 24 states/union territories of India (Kumar *et al*., 1990 and Suvarna *et al*., 1996). Umenai *et al*. (1985) described the following reasons for changes in epidemiological pattern of Japanese Encephalitis.

- Climatic factors related to temperature and rainfall which favours the propagation of mosquitoes.
- Establishment of large number of piggeries.
- Cultivation of paddy crops over large geographical areas.
- Prevalence of wide variety of mosquitoes in the south Asian region.

Economic impact of JE :

The economic impact on pig production is likely to be variable and not predictable. There may be little long-term impact on the consumption of pork products. JE may cause disruption to the horse industry especially for racing

Table 1 : Distribution of JE virus genotypes in different regions of the world

Region	Country	Genotype
1.	Indonesia (excluding New Guinea) and Malaysia	I, II, III, IV and V (*i.e.* all genotypes)
2.	Australia and New Guinea	I and II
3.	Taiwan and Philippines	II and III
4.	Thailand , Cambodia and Vietnam	I, II and III
5.	Japan, China and Korea	I and III
6.	India Sri Lanka and Nepal	III

organizations. This is because of restrictions on the movements of the animals particularly in the area of outbreaks. The current OIE code does not take account of the protection provided by vaccination in the safe movement of animals. JE causes high mortality in piglets and horses (up to 5%). However, the rate of mortality in horses may be very high that is up to 30-40 per cent in severe outbreaks of disease. Therefore, it is responsible for high losses to the swine and equine industries. In human beings, the disease poses a high financial burden in the form of vaccination, hospitalization and treatment.

Public health importance of JE :

Japanese Encephalitis is a vector-borne viral zoonotic disease. It causes high mortality (20-40%) in the human beings. Children are most commonly affected. The disease causes fever, encephalitis, neurological problems and death. The disease affects the health and growth of children.

Transmission :

Transmission occurs principally in rural agricultural locations where flooding irrigation is practised, some of which may be near or within urban centres. Transmission is related mainly to the rainy season in south-east Asia but may take place all year round, particularly in tropical climate zones. In the temperate regions of China, Japan, the Korean peninsula and eastern parts of the Russian federation, transmission occurs mainly during the summer and autumn.

Pigs and various wild birds represent the natural reservoir of this virus, which is transmitted to new animal hosts and occasionally humans by mosquitoes of the genus *Culex*. Pigs and birds such as egrets and pond herons have been incriminated as the most important host for maintenance of JE virus. JE is transmitted by mosquito vectors. Trans-ovarian transmission of JE virus in mosquitoes has been proven. Human infection occurs through infected mosquito bite. Japanese Encephalitis is transmitted by culicine mosquitoes such as *Culex tritaeniorhynchus, Culex vishnui* and *Culex gelidus* along with some anophelines. The main vector of JE virus is *Culex tritaeniorhynchus*, which hatches in the rice fields. Its multiplication is increased by 50 per cent in fertilized fields. The increase in JE cases in India can be explained by the increased use of fertilizers in the rice fields. The seasonal occurrence of JE in northern region is caused by migrating birds especially herons. Man is an "accidental dead end host". Transmission from man to man or animal to animal has not been reported.

Disease in the animals :

Under natural conditions, several vertebrates such as pigs, cattle, goats, cats, dogs, birds, bats, snakes, and toads are infected. However, in apparent infections occur in cattle, sheep, goats, dogs, cats, rodents, snakes and frogs.

Table 2 : First time reported JE (year and county-wise)

Year	Country
1935	Japan and China
1938	Russia
1947	Guam
1948	Sri Lanka
1949	South Korea
1951	Malaysia
1955	India
1965	Vietnam
1969	Thailand
1970	Bangladesh
1974	Myanmar
1990	Saipan
1992	Pakistan
1995	Nepal, Indonesia, Australia and New Guinea

Cattle and buffaloes are not the natural host of JE virus. They act as "mosquito attractant". Infection in humans and horses may cause severe and often fatal encephalitis, but these species are incidental hosts. Some species of birds such as pond herons, poultry and ducks appear to be involved in the natural history of JE virus. The birds are found to develop viraemia.

Among the animals, pigs have been incriminated as the major vertebrate host for JE virus. In some places, up to 100 per cent of pigs may be infected with JE virus. The JE virus rapidly replicates in the pigs thus, it is considered as amplifiers of the virus (WHO, 1979). Adult non-pregnant pigs do not show overt disease. However, pregnant sows may abort, produce mummified fetuses or give birth to stillborn or weak piglets at term. In boars, it causes infertility, swollen testicles etc. The disease occurs as non-suppurative Encephalitis in pigs under 6 months of age which is associated with neurological signs and may cause death.

In horses, most of the JE infections do not show overt disease. However, three clinical syndromes are associated with JE infection in the horses. The transient type is associated with fever up to 40ºC for 2–3 days, with anorexia, sluggish movement, congested or jaundiced mucous membranes and uneventful recovery. The lethargic type shows fluctuating fever up to 41°C with pronounced lethargy, loss of appetite, difficulty in swallowing, jaundice, petechial hemorrhages in mucous membranes, in co-ordination, staggering and falling, transient neck rigidity and radial paralysis, and usually recovery within a week. The hyper-excitable type shows symptoms of high fever with aimless wandering, violent and demented behaviour, blindness, profuse sweating, muscle trembling, collapse and death. The mortality rate in clinically-affected horses is generally about 5 per cent but may be as high as 30-40 per cent in severe outbreaks.

Disease in the humans :

The incubation period is 4-14 days. The rate of clinical manifestations is in the range of 0.1 to 4 per cent. Most infections in humans are asymptomatic. In symptomatic cases, severity varies from mild to severe form of disease. Mild infections are characterized by febrile headache or aseptic meningitis followed by an uneventful recovery. Severe cases have a rapid onset and progression with headache, high fever and meningeal signs. Permanent neurological sequelae are common among survivors. Approximately 25 per cent of severe clinical cases have a fatal outcome. The case-fatality rate among those with encephalitis can be as high as 30 per cent. Permanent neurologic or psychiatric sequelae can occur in 30 per cent–50 per cent of those with encephalitis (WHO, 2014). The disease in

Table 3 : Prevalence of JE in India

Year	Cases	Deaths
1996	2244	539
1997	2516	632
1998	2090	507
1999	3428	680
2000	2593	556
2001	1171	303
2002	3251	641
2003	970	325
2004	816	290
2005	5975	1402
2006	2830	635
2007	3298	750
2008	1500	310
2009	4482	774
2010	1896	251
2011	2300	460
2012	3500	1070
2013	2000	358
2014	3803	674

man occurs in three stages.

Prodromal stage :

The onset of illness is usually acute and heralded by fever, headache, malaise and non-specific respiratory and gastrointestinal disturbances. There may be change in consciousness, irritability or restlessness, tremor or convulsion and letharginess. The duration of this stage is 1-6 days.

Acute encephalitis stage :

Fever is usually high (100-105°F). The prominent features are fever, nuchal rigidity, focal CNS signs, convulsion, and altered sensorium, which may lead to coma.

Late stage and sequelae :

Neurological signs become stationary or tend to improve. The case fatality rate varies between 20- 40 per cent. The average period between the onset of illness and death is about 9 days. Post mortem lesions include pan-encephalitis, infected neurons scattered throughout CNS, occasional microscopic necrotic foci and thalamus generally severely affected.

Diagnosis :

Individuals who live in or have travelled to a JE-endemic area and experience Encephalitis are considered a suspected JE case. To confirm JE infection and to rule out other causes of Encephalitis requires a laboratory testing of serum or, preferentially, cerebrospinal fluid. Diagnosis can be made on the following bases.

Tentative diagnosis :

A tentative diagnosis can only be made in connection with the epidemiological situations (history of traveling or epidemiology).

Confirmatory diagnosis :

It can be made by demonstration of virus specific IgM antibodies in the cerebro spinal fluid (CSF).

Isolation of JE virus :

Diagnosis can also be made by isolation of the JE virus from brain tissue of affected individuals. In epidemic areas the virus can also be isolated from the mosquitoes.

Molecular diagnosis :

More recently, RT- PCR has been recommended to confirm the diagnosis in postmortem, but it has not been recommended in ante-mortem diagnosis. PCR can also be used to detect the virus in mosquitoes for disease control.

Disease management in the animals :

Disease in the animals can be managed in the following ways :

Table 4 : Important JE vectors in some countries

Country	Important JE vector(s)
India	*Culex tritaeniorhynchus*
Sri Lanka	*Culex tritaeniorhynchus* and *C. gelidus*
Japan	*Culex tritaeniorhynchus*
China	*Culex tritaeniorhynchus*
Malaysia	*Culex gelidus* and *C. fuscocephala*
Thailand	*Culex gelidus* and *C. fuscocephala*
Australia	*C. annulirostris, C. steins* and *C. palpalis.*

Control of mosquitoes :

Control of mosquitoes is important to prevent the transmission of Japanese encephalitis in animals as well as in human beings.

Vaccination in the animals :

In case of rapidly-spreading outbreak of JE in pigs the vaccine is need to obtained speedily and applied quickly to a high proportion of the population to achieve an effect. The vaccination of pigs is expected to slow the spread of the virus and may reduce the challenge to human populations in situations where significant human and pig populations interface. In countries where the disease is endemic, inactivated and attenuated ('live') virus vaccines can be used for vaccination.

Vaccination in pigs :

The usefulness of inactivated vaccines in the protection of pigs is highly suspect. Vaccine manufacturers have advised that three 10 ml doses of inactivated vaccine are required to produce protective immunity in pigs. A recent unpublished trial in Queensland demonstrated that two 10 ml doses of inactivated vaccine given one month apart produced protective immunity in only one of six pigs vaccinated. Inactivated vaccines alone therefore, cannot be relied upon to produce protective immunity in pigs. Attenuated virus vaccine represents the only means by which pig populations can be effectively vaccinated. Protective immunity develops in pigs within 14–21 days of vaccination with a single dose of the attenuated vaccine. Piglets under 4 months should receive a second dose of attenuated virus vaccine after an interval of 4 weeks. Immunity for 2 years is claimed but an annual booster vaccination is recommended. The vaccine is administered in a 1 ml dose, subcutaneously in the neck. The attenuated virus vaccine is considered safe for administration to pregnant sows and the vaccine strain does not spread between animals. An alternate regime is to use an attenuated or inactivated combination of vaccinations in series. This enables the dose of inactivated vaccine to be reduced to 2 ml when used as a booster to an initial attenuated virus vaccination.

Vaccination in horses :

Vaccination of horses protects valuable animals but not influence the epidemic spread of JE. Horse owners in likely infected areas are advised to vaccinate their unvaccinated horses. A formalin-inactivated tissue culture vaccine prepared from pig kidney cells infected with JE virus derived from the Beijing strain is commercially available and widely used in Japan and Asia. The primary course consists of two doses each of 1 ml administered subcutaneously in the neck with an interval of 4 weeks between each vaccination. A booster dose of 1 ml is injected annually. For maximum protection it is recommended that vaccination be scheduled so that the primary course is completed before

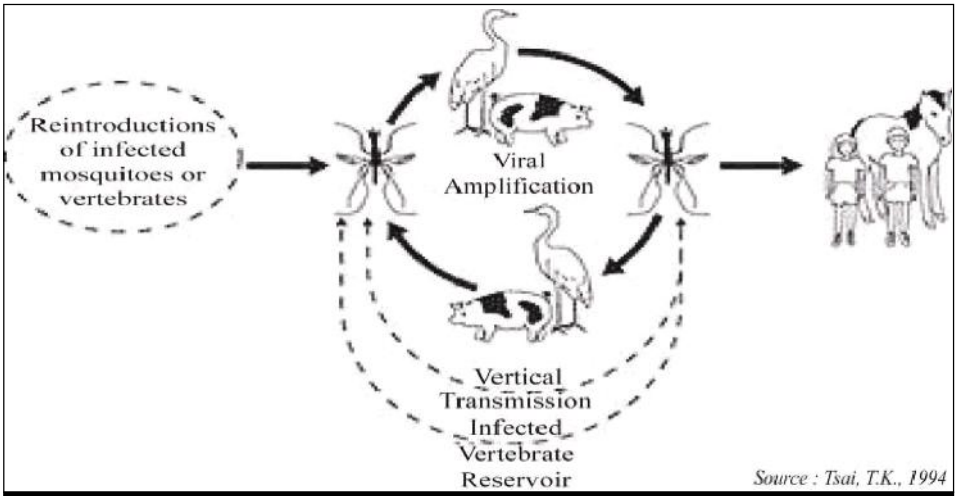

Fig. 1 : Transmission cycles of Japanese encephalitis

the epizootic season for JE. Inactivated vaccines are also used in Hong Kong and Singapore to protect racehorses, all of which are imported from non-endemic areas. A marked decline in the incidence of clinical disease in horses has been noted in Japan, Singapore and Hong Kong following the introduction of vaccination. Apart from an occasional transient local reaction at the site of injection, no side effects have been reported. An attenuated vaccine has been used in China in more than 5, 00,000 horses with a seroconversion rate of 80–90 per cent after a single dose. Foals born to immunized mares acquired maternal antibodies which persisted for 4–5 months and interfered with active immunization. In Korea, foals inoculated intramuscularly with a vaccine of the *Anyang* strain attenuated in chick embryo fibroblast cells developed solid immunity and showed no adverse reactions. Foals with maternal antibody at a serum neutralizing antibody titre of less than 320 international units also acquired solid immunity after a single inoculation.

Treatment :

There is no specific treatment for Japanese encephalitis. Only symptomatic treatment and supportive therapy are useful to overcome the problems of disease.

Avoid contact :

Avoid the contacts of ardeid birds like pond herons and egrets to the pigs at the farms in order to prevent the transmission of JE virus in pig population.

Disease management in the humans :

JE in human beings can be managed by prevention and control in the following ways :

Vector control :

Mosquitoes can be controlled by adopting following measures :

Chemical control :

Insecticides belong to organochlorine, organophosphorus and carbamate group of compounds can be used for killing of mosquito vectors. Synthetic insecticides such as fenthion, chlorpyrifos and abate are most effective larvicides. Abate at concentration of 1 ppm has been found to be very effective larvicide. Fogging with ultra low volume (ULV) insecticides such as malathion and fenthion is helpful in reducing the mosquito population. Aircraft-mounted areal spray of insecticides is also effective especially in dense vegetation or forest area to control the mosquito population. Larvicides can be used to reduce the mosquito's population. The commonly used larvicides are mineral oils, Paris green and synthetic insecticides. Application of oil to the surface of water is the oldest known mosquito control measures. The oils most widely used are kerosene, diesel oil and fuel oil. Oils kill the larvae and pupae within short time after application. Oil rapidly spreads on the surface of water and form a thin film which prevents the air supply to the mosquito larvae and pupae. The usual application rate is 40-90 lt per hectare (WHO, 1973). Paris green or copper acetoarsenite is an emerald green, micro-crystalline powder practically insoluble in water. Paris green is a stomach poison and to be effective it must be ingested by the larvae. Paris green is applied as 2 per cent dust which is prepared by mixing 2 kg of Paris green and 98 kg of diluent such as slaked lime in a rotator mixer.

Biological control :

Growing of the water fern *Azolla microphylla* in rice field was evaluated as a biological agent against mosquitoes breeding in rice fields (Rajendra and Ruben, 1991). But long term, cost-effective and eco-friendly technology to reduce/eliminate JE vectors are not within scope so far (Kabilan *et al*., 2000). Biological control of mosquitoes can be done by using larvivorous fish as a natural enemy by introducing them into the natural habitat of mosquito larvae that is water. The best known fish are *Gambusia affinis* and *Lebister reticulatus*. These fish can be burrowed into pits, sewage and oxidation ponds. In the recent years, there has been a revival of interest in the biological control of mosquitoes through the use of fish.

Environmental control :

The best strategy to control the mosquito population is to prevent the breeding places of mosquitoes. This is known as source reduction of mosquitoes. Source reduction includes filling, leveling and drainage of breeding places. Source reduction also implies the rendering of water such as change in the salinity which makes the water unsuitable for mosquito breeding. For control of population of *Culex* spp., the control programme should be executed by abolition of domestic and peridomestic sources of breeding such as cesspool and open ditches and arrangements for collection, removal and disposal of sewage and waste water. For control of *Aedes* spp., the environment should be cleaned up and got rid of water holding containers such as discard tins, empty pots, broken bottles, coconut shells and other water holding objects. Filling and drainage measures can be adopted for control of *Anopheles* mosquitoes. Mosquito population can also be controlled by water management. Agricultural fields should be irrigated intermittently. Water logging should be prevented in residential areas to avoid propagation of mosquitoes. Put all used cans and bottles into covered dustbins. Water for plants should be changed at least once a week and water in the saucers underneath flower pots should not be left. All drains should be kept free from blockage. All water containers, wells and water storage tanks should be covered.

Genetic control :

Mosquito population can also be controlled by genetic methods such as sterile male technique, cytoplasmic incompatibility and chromosomal translocation.

Use of electronic devices :

Some electronic devices such as killer lamp, killer rackets, traps, electronic mosquito zappers and buzzers (electronic ultrasonic mosquito repellers) are also available to kill, catch or repel the mosquitoes.

Newer methods :

New and innovative methods such as use of chemosterilant and sex attractants can be used for control of mosquitoes.

Integrated approach :

Since no single method of control is likely to provide a solution in all situations, the present trend is to adopt an integrated approach (use of two or more methods) with a view to obtain maximum results with minimum effort and to avoid excessive use of any one method.

Reservoir control :

Pigs are potential source of JE virus. Therefore, control of pigs particularly in residential areas is important. Wild animals can serve as reservoirs for JE virus. The species most likely to harbour the virus are rufous night herons, egrets and other water birds, pigs and reptiles. Wild animals infected with JE virus can be determined by serological sampling for future epidemiological reference. While wild pigs may play a significant role in maintaining and disseminating JE virus, it is difficult to limit their role in the epidemiology of JE infection. However, strategic control of wild pigs near centres of population should be considered.

Movement control :

Placing restrictions on the movement of horses, cattle, sheep and goats from infected premises or areas is not beneficial. Movement controls on pigs to prevent spread of virus requires careful consideration. Even if the virus has established in an insect vector population, it is necessary to control spread by pig movements from premises where there is evidence of active infection. Controls on the movement and congregation of pigs may be relaxed once the situation has been fully assessed. The movement of pigs for immediate slaughter at times of low mosquito activity is a lower risk activity than the movement of pigs for restocking purposes.

Immunization :

Safe and effective vaccines are available to prevent JE. WHO recommends JE vaccination in all regions where the disease is a recognised public health problem. There are two types of JE vaccines currently available internationally and several in late-stage development. Some countries have conducted routine immunization with an inactivated mouse brain-derived JE vaccine for many years.

Inactivated mouse brain-derived vaccine (strain–Beijing 1 and Nakayama of JE virus) :

Biken, Japan has been the largest manufacturer of killed mouse brain vaccine (strain –Beijing 1 of JE virus). Other manufacturers are South Korea, Taiwan, Thailand, and Vietnam. Efficacy of 80-91 per cent after a 2-dose primary series and ongoing protective efficacy over 90 per cent following booster doses has been observed. Immunization with killed mouse brain vaccine is carried out as follows.

Primary immunization :

2 doses of 1ml of each should be administered subcutaneously at an interval of 7-14 days (Note: 0.5 ml for children under the age of three years).

Booster dose :

1ml of vaccine should be administered subcutaneously after few months (before 1 year). Protective immunity develops in about a month's time after the second dose.

Revaccination :

Revaccination is to be carried out every 3 years.

Cell culture-based vaccines :

The inactivated mouse brain-derived (IMB) vaccine is now commonly replaced by cell culture-based vaccines (WHO, 2014). There are different types of cell culture vaccines against JE virus.

Live attenuated vaccine (SA 14-14-2 strain) :

A live attenuated vaccine based on the SA 14-14-2 strain of the JE virus is widely used in China and in an increasing number of countries within the Asian region including India, the Republic of Korea, Sri Lanka, and Thailand. In China, the first dose is given subcutaneously at age 8 months, followed by a booster dose at 2 years of age. In some areas, an additional booster is offered at 6–7 years of age. However, protection for several years may be achieved with a single dose of this vaccine and in many countries one dose without subsequent boosters is recommended.

Inactivated Vero cell-derived alum-adjuvanted vaccine (SA 14-14-2 strain) :

A vero cell-derived inactivated and alum-adjuvanted JE vaccine based on the SA 14-14-2 strain was approved in 2009 in North America, Australia and various European countries. The primary immunization consists of two intramuscular doses are administered 4 weeks apart. A booster dose is recommended 1–2 years after the primary immunization. This vaccine has been given concomitantly with hepatitis A vaccine without significant interference with the safety and immunogenicity of either vaccine. Data on concomitant administration with other vaccines frequently used in travelers are currently unavailable.

Inactivated Vero cell-derived vaccines (Beijing-1 strain) :

Another vero cell-derived inactivated JE vaccine was licensed by the Japanese authorities in February 2009 and a similar Japanese vaccine was licensed in 2011. These vaccines use the same strain of JE virus (Beijing-1) as the mouse-brain-derived vaccine. Clinical trials have shown that the vaccines are safe and immunogenic, with seroconversion rates exceeding 95 per cent. Primary immunization consists of three doses at days 0, 7 and 28, or two doses given preferably 4 weeks apart (0.25 ml for children <3 years, 0.5 ml for all other ages). One booster dose is

recommended 12–14 months after completion of the primary immunization and thereafter every 3 years.

Live chimeric vaccine (with yellow fever 17D as backbone) :

In addition, a new live attenuated, JE–yellow fever chimeric vaccine has recently been licensed in Australia and Thailand. A single dose of this chimeric JE vaccine was found to be safe, highly immunogenic and capable of inducing long-lasting immunity in both preclinical and clinical trials. A single dose is recommended; the need for and timing of a possible booster dose have not yet been determined.

Precautions and contraindications regarding JE vaccination :

A history of allergy or hypersensitivity reaction (erythema, tenderness, and swelling at the injection site) to a previous dose of mouse brain-derived JE vaccine is a contraindication to receiving additional doses. Rare but serious neurological adverse events attributed to IMB vaccine have been reported, but no causal relationship has been confirmed. Children below one year of age should not be vaccinated. Vaccination with live attenuated vaccine is contraindicated during pregnancy.

Treatment :

There is no antiviral treatment for patients with JE. Treatment is supportive to relieve symptoms and stabilize the patient. Treatment is focused on relieving severe clinical signs and supporting the patient to overcome the infection. Anticonvulsive drugs are used for seizures and mannose infusions are given in case of increased intracranial pressure.

Community awareness :

The public should be aware of hazards posed by the mosquitoes and co-operate for prevention and control of Japanese encephalitis. All efforts should be made by the public in order to control the mosquito population. The JE virus can affect humans shortly after incursion. The public should be aware about the pathogen of JE which is capable of causing encephalitis with a significant mortality rate and serious sequelae. Horse owners should also be aware about the threat of the JE virus. The public should also be informed and aware that the consumption of pork products presents no risk to their health. The public should be made aware about the nature of the virus's introduction, the protective capacity of vaccination and the importance of mosquito control.

Personal protection :

It can be done by using mosquito repellents, mosquito nets, protective clothing and vaccination of occupational groups. Mosquito repellent such as diethyl toluamide (deet) has been found to be an outstanding repellent. There are some other repellents such as ethyl hexanediol, dimethyl phthalate, dimethyl carbamate, indalone etc. has also been found effective mosquito repellents but have short duration of action. Mosquito net protects against mosquito bites during sleep. The size of the openings in the net should not exceed 0.0475 inch. Appropriate clothing also reduces human infection rates. People living near and working in piggeries may need to be vaccinated along with animal health personnel carrying out investigations in the endemic area.

Use of natural products :

Fumigation with Neem cake can also be used to reduce the incidence of mosquito bite.

Surveillance :

Livestock owners of pigs and horses in the endemic areas are potentially at risk and they should be assessed from time to time and advised to observe their stock daily for clinical signs of disease. In horses, daily monitoring of rectal temperature may provide an early warning of JE virus activity. Blood should be taken from clinically affected animals and tested for antibody to JE virus. Follow-up sampling may be necessary to demonstrate antibody developing after the clinical signs. Serological surveillance can be used to demonstrate the extent or distribution of infection. Therefore, effective surveillance system is required to timely disseminate information and to take appropriate preventive

and control measures.

Application of GIS and remote sensing :

These help in mapping the breeding clusters of the vectors and thereby help in the risk assessment and disease prevention and control processes. Such map gives detail information regarding the pattern of water logging sites with mosquito breeding (Dale *et al*., 1998).

Risk for travelers :

The risk of Japanese encephalitis is very low for most travellers to Asia, particularly for short-term visitors to urban areas. However, the risk varies according to season, destination, duration of travel and activities. Vaccination is recommended for travellers with extensive outdoor exposure (camping, hiking, working, etc.) during the transmission season, particularly in endemic countries or areas where flooding irrigation is practised. In areas at risk, Japanese encephalitis is primarily a disease of children, but it can occur in travellers of any age.

Conclusion :

Largely as a result of immunization, the incidence of Japanese encephalitis has been declining in Japan and the Republic of Korea, in some regions of China, and more recently in Nepal, Sri Lanka, Thailand and Vietnam. The transmission of the virus remains unaffected by immunization, and non-immunized individuals remain at risk. However, Japanese encephalitis can be controlled by interruption of transmission cycle between reservoir/ amplifier host, biological vectors and susceptible population. In Japan and Korea, the JE has been reduced due changes of pig farming, reduced rice crops, use of insecticide to control mosquitoes and mass vaccination of the population. Japanese encephalitis can be successfully controlled by keeping rice crops and pig farming in separate locations. Moreover, the public should be encouraged to avoid the exposure to mosquitoes by using protective clothing, mosquito net and mosquito repellents.

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