



Research Article

Emerging and Re-emerging Tickborne Diseases of Public Health Importance in India

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A B S T R A C T

Ticks have been associated with human afflictions since time immemorial as evidenced by earlier records from many countries of the world. They are the obligatory blood feeding arachnids and playing role as vectors for transmission of many infectious diseases in man and animals. Various wild and domestic animals are the reservoirs for Tick borne pathogens of livestock and human hosts. In recent times many of the newly emerging and reemerging diseases of zoonotic origin are found to be transmitted by ticks. Tick borne diseases are prevalent in specific risk areas having favorable environmental conditions for the propagation of individual tick vector species. Indian Tick Typhus (ITT) was the first recognized Tick borne disease in India, is caused by *Rickettsia conorii*, earlier reported sporadically from mountainous and forested areas and now increasingly reported from various states. Kyasanur Forest Disease (KFD) is an emerging zoonotic tickborne arboviral disease affecting monkeys and man. This disease was first discovered in 1957 from Shimoga district of Karnataka state following monkey deaths and human cases. The various causative factors for the first emergence of disease was attributed to deforestation, inundation of forest areas by construction of dam and large-scale conversion into agricultural land and human inhabitations. The major vector ticks are *Haemophysalis spinigera* and *H.turturis* and the virus is maintained by various small mammals and birds. Monkeys are the susceptible and man is the dead-end host. In recent years the disease has reemerged from its territory to many districts of the Karnataka state and also centripetally spread to neighboring Kerala, TamilNadu, Goa and Maharashtra states. Creman Congo Haemorrhagic Fever (CCHF) is another emerging disease was first time reported from Gujarat in 2011, however cases were recorded from Rajasthan and UttarPradesh states. CCHF is the fatal Tick borne viral disease is transmitted by ticks of *Hyalomma analoticum* and *H.marginatum*. There are sporadic records available for the occurrence of other tickborne diseases viz., relapsing fever, Lyme disease and Ganjam virus disease from various parts of the country time to time. The current scenario of tickborne diseases in the country warrants urgent need for the systematic surveillance and initiation of appropriate control measures.

Keywords: Tickborne Diseases, Emerging and Reemerging Diseases, Creman Congo Haemorrhagic Fever, Indian Tick Typhus, KFD



Introduction

Ticks are known for their human affliction since time immemorial and are ranked only second after mosquitoes as vectors of human pathogens. These organisms have spread and expanded horizons due to agricultural activity and encroachment into unutilized lands thus increasing contacts between humans, domestic and wild animals. Since ticks are obligate haematophagous ecto parasites of animals and responsible as reservoirs for emerging infectious diseases arise from zoonotic pathogens in recent times. The world is changing rapidly due to rapid increase in the urban population, as the microbes evolve many non-virulent forms become virulent and there are many probable public health threats from time to time. Emerging Infectious Diseases (EID) are the infections that newly appear in a population and the reemerging diseases are rapidly increasing in incidence in a geographic range. Public Health Emergency of International Concern (PHEIC) is an extraordinary public health event which constitutes a public health risk to other countries through international spread of disease, which potentially requires a coordinated international response.¹

Emerging and Reemerging Zoonotic Diseases

India is one of the hotspots for the emergence of various diseases due to its extensive land area, long coastline, sharing border with seven countries having tremendous diversity of climate and physical conditions, possessing rich fauna and inhabited by more than 1.3 billion population. Point of concern is that India occupies 2.4% of world surface area, yet it supports and sustains a whopping 17.5% of world population and more than 58% of them engaged in agriculture. Approximately 70% of population are rural and in close contact with large domestic animal population. The farmers are keeping animals for milk, meat, wool, hide and for various farm operations. Diminishing boundaries between domestic and wild life due to deforestation and agriculture practices, economic development and increased land use are the driving factors for the emergence of new diseases. Many emerging zoonoses have spread globally at the human-animal interface, international travel, change in agricultural practices, environmental factors, change in lifestyle, deforestation, are the risk factors for emergence of many new diseases.¹⁻⁵

Tickborne Diseases Prevalent in India

Among a total of 106 tick species reported from India, a few of them are playing the role vectors of disease pathogens. ITT is the first recorded Tickborne disease in the country, mainly reported from forest and mountains areas, however recently it is prevalent in many states of the country. This is attributed due to the ubiquitous presence of its vector *Rhipicephalus sanguineus* (Indian dog tick) in

various localities of rural and urban areas. KFD is the first discovered Tickborne arboviral disease from Shimoga district of Karnataka in 1957, after its discovery more attention has been paid on the study of tick borne diseases in India. Despite the high potential of virus transmission by these vector ticks that are distributed throughout the country, the incidences of these viruses are compartmentalized or restricted in geographic locations. Ticks of the genus *Haemaphysalis* and *Hyalomma* serve as vector as well as reservoir for KFD virus (KFDV) and Crimean-Congo haemorrhagic fever virus (CCHFV), respectively. Numerous wild animals, birds and livestock serve as amplifying hosts for these viruses. Transmission to humans occurs through bites of infected ticks or unprotected contact with infected animal/human. Human-to-human spread of CCHF cases occurs due to unprotected contact with infectious blood or body fluids. While human acquires KFD infection by the bites of infected *H. spinigera*, there is no evidence of human-to-human transmission. More recently KFD is prevalent in seven districts of Karnataka state as well as from four neighboring states sharing borders with the state. CCHF was first identified in 1944 on the Crimean Peninsula in what was then Soviet Union. Later the Congo appellation was added in 1969 after the discovery of the same disease from central African in 1956. CCHF is a zoonotic viral disease that is asymptomatic in infected animals, but a serious threat to humans was first recorded in 2011 from Gujarat and is spreading to neighboring states. Due to occurrence of many Tickborne diseases as emerging and reemerging zoonotic diseases from various states of the country, it is an alarm for the future probable outbreak of similar dreaded diseases.⁴⁻⁷

ITT

In India ITT was recognized as early as in 1917, is known as a type of Rickettsial spotted fever similar to Rocky Mountain Spotted Fever (RMSF) and is caused by *Rickettsia conorii*. The disease is also known as Boutonnesse fever and the clinical symptoms include fever, headache and malaise lasting for 10-12 days with the appearance of macular Papular rash from 2nd to 5th day of infection. The dog tick, *Rhipicephalus sanguineus*, is the principal vector of ITT although some species of *Haemaphysalis* and *Hyalomma* Spp. may also transmit the infection. Small and medium sized mammals including rodents, insectivores and dogs harbor the potential tick vectors and act as the reservoir of the disease in nature. Due to lack of proper laboratory diagnosis, particularly in rural areas the easy cure of cases with antibiotics and the role of vector aspects and epidemiology the disease has been a neglected one for a long time. The disease is reported from Maharashtra, Tamil Nadu, Karnataka, Kerala, Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Rajasthan, Assam and West Bengal.^{2,8}

KFD

It is a reemerging zoonotic Tickborne arboviral disease affecting monkeys and man. This disease was first discovered in 1957 from Kyasanur forest area, Shimoga district of Karnataka state following monkey deaths and human cases. KFD is a Tickborne viral haemorrhagic fever caused by KFDV, a member of the virus family Flaviviridae. It is also called as monkey fever which is of zoonotic origin and transmitted by the bite of infective ixodid ticks, especially at its nymphal stage. During the year 1957, reports of monkey deaths in the forested areas of Sagar-Sorab Taluks, Shimoga District, Karnataka state followed by human cases with typhoid like fever in villages adjoining the forests occurred almost at the same time. The coincidence of a large numbers of monkey deaths as well as human cases it was initially suspected as yellow fever. Later it was ruled out and ixodid ticks of the genera *Haemaphysalis* were found as the vectors and a number of forests dwelling small mammals and birds maintain the natural cycle of the virus. A wide range of hosts including human, wild primates black faced langurs (*Semnopithecus entellus*) and red-faced bonnet monkeys (*Macaca radiata*) get the virus infection by tick bite and they act as amplifying host and also susceptible to the infection. The monkey death area is treated as hot spots and when man visit these areas due to forest related occupation get the infection of the virus by tick bite. It is also evident that many birds, number of tick species, several small mammals like rodents, shrews and an insectivorous bat are maintaining the enzootic cycle of the virus. High mortality of monkeys is observed during the months of January to May, which coincided with the seasonal activity of nymphal stage of *Haemaphysalis* ticks. When the infected monkeys die the ticks drop from their body, thereby generating hotspots of infectious ticks that further spread the virus. KFD epizootics in monkeys are a regular feature during the primary KFD season in disease endemic area. The major vector ticks for KFD are *H. spinigera* and *H. turturis* found to inhabit the forest floors and vegetation and also infest various mammals and birds and they are three host ticks. In addition to above virus isolations were also made from eight other species of the genera in nature. The immature stages of *H. spinigera* infest a variety of hosts are highly susceptible and maintain the natural enzootic cycle of the virus. Ticks life cycle has four life stages viz., egg, six-legged larva, nymph and adult. Blood-engorged female drops off the host and takes shelter under leaves, stones or buried itself under surface soil. After few days, female lays eggs (1000-8000) in a gelatinous mass and they hatch into larva which climb up vegetation and cluster at tip of grass, waiting for suitable host and this phenomenon is known as "questing". The larvae, nymph and adults attach onto their host for feeding and drop to ground and take shelter,

thus completing the life cycle since they are called three host ticks.⁹⁻¹¹

KFD Epidemics and the Involvement of Community for Control

The KFD epidemics occurred every year and the number of cases averaged 400-500 a year and around 1000 cases in a few years. The Case fatality rate of 2-10% are reported annually and all age groups are affected but incidence in working age group is high. Persons visiting forest for collecting wood/forest products will contract infection by accidental tick bites. The disease has seasonal occurrence mainly during dry periods (November - June). People engaged in occupations viz., hunters, herders, forest workers and farmers are visiting the forest areas during this period without adequate protective measures increases the risk of exposure. Formalin inactivated tissue culture KFD vaccine is in use since 1990, two doses, followed by a booster 6-9 months after second dose and annually thereafter for 5 years. The vaccine was found to be immunogenic, potent stable and safe for high risk group of forest related occupations should be immunized to avoid the risk of infection of the disease. Imparting health education to community will pave the way for the effective control of KFD. It is a seasonal disease mainly reported during early and peak summer months major preparatory aspects are being carried out during non-transmission months.¹²

Eco Epidemiology of KFD Affected Area

Shimoga district, the central focus of the KFD and this disease established due to deep encroachment of human colonization on a primitive sylvan territory. This area is characterized by the presence of forest land having closed forests with few open forests. The type of vegetation is tall rain forest interspersed with deciduous and semi-deciduous forest on the slopes, with mixed bamboo and shrub jungle at the edges situated in Western Ghats. Initially the KFD was mainly confined to three taluks (Sagar, Shikaripur and Sorab) of Shimoga district of Karnataka, until 1972. Later cases were reported from Chikmagalur, Dakshina Kannada, Udupi and Uttara Kannada. Spread of KFD to newer areas attributed to changes in environment including deforestation, new land use practices for farming and timber harvesting, might have led to the spread of this disease to newer localities. Grazing of cattle in forest areas with infected ticks will lead to introduction of these ticks to new areas. Presence of wild monkeys and other animal reservoirs is also conducive for the spreading of KFD to newer territories. The KFD newly reported areas also similar to Shimoga and possess the environmental perils like deforestation and conversion into plantations and human habitations etc.¹²⁻¹⁷

CCHF

Crimean fever was first identified in 1944 on the Crimean

Peninsula in what was then Soviet Union. The Congo appellation was added in 1969 after the discovery of the same disease in central Africa in 1956. CCHF is a zoonotic viral disease that is asymptomatic in infected animals, but a serious threat to humans. Nairovirus of the family *Bunyaviridae* is the causative agent. Human as an indicator host for CCHF, vector, amplifying host and climatic conditions exist for centuries. Serological evidence of CCHF in camel, sheep and goats was reported by National Institute of Virology (NIV) Pune 2010. Neighboring countries have been reporting for decades. Nosocomial infection is reported in January 2011 in Gujarat at present cases were also reported from Rajasthan and Uttar Pradesh. CCHF outbreaks constitute a threat to public health because of its epidemic potential, high case fatality (>50%), potential for nosocomial outbreaks, and difficulties in treatment and prevention.¹⁸

Bionomics of Hyalomma Ticks

The members of the genus *Hyalomma* are hard ticks, often existing under varied climatic conditions of cold, heat and aridity. The geographic distribution of CCHF coincides with that of *Hyalomma* ticks the principal vector and the virus is maintained by a cycle involving transovarial and transstadial transmission. *H. anatolicum* and *H. marginatum* are the vectors of CCHF. The engorged larvae and unfed adults of the *H. anatolicum* exhibit overwintering phenomenon by hibernating in cracks and wooden crevices in animal shelters of Russia and in rodent burrows in African deserts. There are several differences in the bionomics of the *Hyalomma* ticks, the behaviour of dropping rhythm governs the epidemiology of the CCHF to human. The survival of larvae is up to 241 days, nymphs up to 246 days and adults over one year. *H. marginatum* often occurs in high numbers and is an aggressive human parasite and the unfed adults survive over 2 years and may oviposit 4 to 15,000 eggs in their lifetime. CCHFV circulates in an enzootic tick-vertebrate-tick cycle. Antibodies against CCHFV have been detected in the sera of horses, donkeys, goats, cattle, sheep and pigs. Domesticated ruminants including cattle, sheep and goats are viremic for one week after experimental infection. Hard ticks are the reservoir and vector of CCHF virus and in addition the infected animals may also act like a reservoir during the period of viremia. The CCHF virus may infect a wide range of wild animals like hare, rodents and domestic animals such as sheep, goats, cattle and camel. Many birds are resistant to this infection except ostriches in endemic areas. Animals become infected with CCHF virus by the bite of infected ticks and various environmental factors also influence the transmission of the virus.^{18, 19}

Epidemiology of CCHF

CCHF is one of the most widely distributed viral haemorrhagic fevers recorded from Turkey, Bulgaria, Central Asia (Afghanistan, Iran, Pakistan), the Middle East,

and Africa and seasonal outbreak occur during June to September months. Climate and anthropogenic factors such as changes in land use, agricultural practices and movement of livestock that may influence host-tick- virus dynamics and it is a rural and occupational disease. Human infections begin with nonspecific febrile symptoms, but progress to a serious haemorrhagic syndrome with a high case fatality rate. Mode of transmission of CCHF is from animal to human through tick bite or infected tick is crushed between the fingers and there is no evidence of clinical disease in animals other than humans. High risk groups are animal herders, livestock workers, abattoir workers and healthcare workers in endemic areas. CCHF can be transmitted from one infected human to another by contact with infectious blood or body fluids by nosocomial infection. Documented spread of CCHF has also occurred in hospitals due to improper sterilization of medical equipment, reuse of injection needles and contamination of medical supplies. The transmission of the CCHF infections and deaths among healthcare workers has been reported in parallel with outbreaks in the general population. CCHF being a zoonotic vector-borne disease, multi-sectoral integrated approach involving medical, veterinary and other specialties is the key for prevention and control of outbreaks and breaking the chain of transmission.^{2, 19}

Other Tickborne Diseases

Tickborne relapsing fever have been reported in India from Jammu & Kashmir state. The disease is caused by spirochete *Borrelia carteri* and the vector soft ticks are genus *Ornithodoros crossi* and *O. lahorensis*, however the knowledge on the disease and vector, Argasid (soft) ticks are scanty. Serological evidence and human cases of Lyme disease has been reported from Nilgiris hills of Tamilnadu and Wayanad areas of Kerala and also from few other states. Babesiosis is caused by various species of protozoan parasite *Babesia microti* is known to cause malaria like illness in parts of USA and Canada, however a lone human case has been reported in India. Many viruses like Ganjam, Bhanja and Kaisodi are associated with ticks, human isolation of strains of Ganjam and Bhanja viruses from isolated cases of south India in the past. Other Tickborne diseases are sporadic and reported from some regions of the country more particularly from mountainous and forest fringed biotope.^{2, 3}

Spread of Tickborne Diseases to Newer Areas and probable Reasons

Before the discovery of KFD little attention was paid to Tickborne diseases, since it is a seasonal disease affecting forest visiting people. KFDV is transmitted by ticks of *H. spinigera* and widely distributed in the enzootic area and causing epidemics of the disease. KFD newly reported areas constitute a number of diverse biotypes such as

forest, cultivated clearings and grass lands. Clearing of the forest area for cultivation causes changes in tick fauna, and is considered as the temporary risk factor which resulted in the recent KFD outbreaks. The organized disease surveillance system has helped the proper diagnosis and prompt undertaking of disease specific control measures from the above areas. Though the CCHF main endemic foci are in Gujarat state, it has been suspected in other parts of the country, based on earlier serology data and reporting of cases from adjoining states. In general, as the incidence of Tickborne diseases increases in any area, surveillance in other/adjoining geographic areas should also be expanded. Similarly, a joint initiative has been taken up by Indian Council of Medical Research (ICMR) and Indian Council of Agricultural Research (ICAR) to conduct a survey of Immunoglobulin G (IgG) antibodies against CCHF in domestic animals in different states of India. Understanding vectors and their bionomics must be taken on priority, so that better interventions can be made to control such zoonotic infections. Increasing awareness among rural population and change in their behaviour for keeping animal sheds away from houses and taking anti-tick precautions would help in reducing the incidences of these diseases.²⁰⁻²²

Prevention and Control of Tick Infestation

Preventive measures used in tick infested areas include the wearing of protective clothing, topical application of insect repellents such as DEET, DMP oil in body. Large scale tick control measures like insecticidal application should be carried out in areas for the control of Tickborne diseases. In areas of monkey death hot spot areas, treatment of insecticide on the ground in a 50 meter radius around by dusting of 5% malathion powder or other synthetic pyrethroids are recommended. For long term measures control of vector ticks spraying of forest ground should be done along the tracks frequently used by villagers. Phenothrin 85% in combination with Methoprene can be applied on tick infested animal for tick control. The heavy tick infested animals also treated with insecticidal dusts and formulation on their body. CCHF vector tick control measures should be under taken on the tick host and habitat. Various insecticidal formulations can apply to domestic pets, such as dogs, to get rid of their ticks. Recommended treatment includes solution of 0.5% Dichlorvos (DDVP), 1% Carbaryl (Sevin) or 3-5% Malathion can be applied to the coats of animal habitats. The dipping of sheep and cattle, and sometime other livestock, in acaricidal bathes, or spraying them with insecticides. It is crucial if ticks and Tickborne diseases of man as well as livestock rate to be effectively controlled.^{22, 23}

Conclusion

KFD and CCHF are both of high importance for public health in India, as cases are observed almost every year in Karnataka

and Gujarat states, respectively. It is important that the health system should be able to distinguish these Tickborne haemorrhagic diseases from other diseases, which have diverse and often overlapping, clinical presentations. KFD was originally assumed to be restricted only to Karnataka state, but there is now evidence of its spread, CCHF is not restricted to one district of Gujarat and more recently human cases were reported from neighboring states. The Integrated Disease Surveillance Project (IDSP) an organized surveillance system developed in the country has helped the proper early diagnosis and prompt undertaking of disease specific control measures newly reported Tickborne diseases. The "One health concept" put forward by World Health Organization (WHO), for the control of zoonotic diseases, in which public health, veterinarians and other stake holders unify their efforts by contributing towards early diagnosis are very much needed for effective and control of reemerging and newly emerging diseases. Routine surveillance early and prompt detection and deploying of appropriate disease specific control strategies and strengthening of existing health infra structure will pave the way for control of Tickborne diseases in the country on long term basis.

Conflicts of Interest: None

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