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Kyasanur forest disease: Unveiling the spread, consequences, and emerging risks

[1]Rithunanda TS, [2]Dr. BM Veeregowda, [3]Dr. Shrikrishna Isloor, [4]Dr. Sharada R, [5]Dr. Leena G and [6]Dr. Kavitha Rani B

[1]Student, MVSc Microbiology, Veterinary College, Hebbal, KVAFSU, Bidar, Karnataka, India

[2]Professor, Department of VMC, Karnataka, India

[3]Professor & Head, Department of VMC, Karnataka, India

[4]Professor, Department of VMC, Karnataka, India

[5]Professor & Head, Department of VPE, Karnataka, India

[6]Professor, Department of VPL, Shivamogga, Karnataka, India

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Corresponding Author: Rithunanda TS

Abstract

Kyasanur Forest Disease (KFD), colloquially known as monkey fever, is a tick-borne viral infection that leads to severe fever, encephalitis, and hemorrhagic symptoms in both humans and nonhuman primates. The disease is transmitted to humans via bites from infected hard ticks (*Haemaphysalis spinigera*), and its transmission involves intricate interactions between various hosts, including humans. Originally restricted to Shivamogga district, KFD has progressively extended across the Western Ghats, expanding beyond its traditional sylvan habitat. The spread of KFD is closely associated with deforestation, human activities, and climate shifts. Despite its emergence being somewhat unexplained, there is an urgent need for rigorous surveillance to halt its further spread. Given the lack of a definitive cure and the limited effectiveness of the current vaccine, KFD remains a significant public health challenge. This review offers a concise overview of the disease's epidemiology.

Keywords: Kyasanur forest disease, flavivirus, *Haemaphysalis spinigera*, KFD, monkey fever

1. Introduction

Kyasanur Forest Disease (KFD) was first identified in 1956 in the forests of Shivamogga, Karnataka (Work and Trapido, 1957; Work *et al*., 1959) [31,32]. In March 1957, the virus was isolated from a black-faced Hanuman langur monkey (*Semnopithecus entellus*) in the Sorab taluk of Shivamogga (Work and Trapido, 1957; Work, 1958) [31,33]. Further serological studies showed that this novel illness was caused by a virus within the Russian spring-summer encephalitis (RSSE) complex, now recognized as part of the tick-borne encephalitis (TBE) flavivirus group. This finding led to speculation about a yellow fever-like incident in primates in India, though this theory was later disproven (Bhatt *et al*., 1966; Work and Trapido, 1957) [3,31]. The Virus Research Centre in Pune, alongside the Rockefeller Foundation and state health officials, collected ticks from various animals around the forested regions of Soraba and Sagara taluks in Shivamogga. The virus was subsequently isolated and identified as P9605 (Government of Karnataka, 2020) [7]. The Kyasanur Forest Disease Virus (KFDV) is classified as a high-risk pathogen, and its transmission cycle involves a wide array of vertebrates such as monkeys, bats, rodents, birds, and shrews, making it an unpredictable endemic infection (Carroll *et al*., 2010) [4].

2. Genetic Evolutionary Analysis

Kyasanur Forest Disease virus (KFDV) shares its ancestry with *Alkhurma hemorrhagic* fever virus (AHFV), both of which belong to the tick-borne encephalitis virus sero-complex of flaviviruses, responsible for severe hemorrhagic fever in humans (Charrel *et al*., 2001; Simmonds *et al*., 2017; Work, 1958) [6, 27, 33]. In 1994, AHFV was identified in a butcher fatally infected in Makkah, Saudi Arabia. The clinical features of both KFD and AHFV are strikingly similar, presenting with sudden fever, muscle pain, encephalitis, and severe bleeding (Madani *et al*., 2010) [18]. Genetic comparison revealed over 92% homology, indicating divergent evolution over the last 700 years (Dodd *et al*., 2011) [8]. In 1989, a similar strain of KFD virus was isolated from Yunnan province, China, known as the "Nanjianyin virus" (Wang *et al*., 2009) [30], with migratory birds identified as the primary vectors in the emergence of the virus (Ghosh *et al*., 1975; Venugopal *et al*., 1992) [10,29]. These birds, migrating from South India, carry infected ticks (Gong *et al*., 1989; Gong *et al*., 2001) [11,12].

3. Transmission Pathways

KFDV, a member of the Flaviviridae family, has a genome composed of linear, positive-sense, single-stranded RNA of

approximately 11 kb in length (Maclachlan *et al*., 2017) [17]. The virus is mainly transmitted through the bite of infected ticks (*Haemaphysalis spinigera*) to primates such as *Semnopithecus entellus* and *Macaca radiata*, and occasionally humans (Ajesh *et al*., 2017; Pattnaik, 2006; Work and Trapido, 1957) [1,24,31]. When an infected monkey dies, ticks detach from the carcass, potentially creating new hotspots (Sadanandane *et al*., 2017) [26]. Neutralizing antibodies have been identified in several animals, including cattle, buffaloes, porcupines, and birds (Pattnaik, 2016) [24]. Though direct transmission from rodents to humans is possible, person-to-person transmission has not been reported (Pattnaik, 2016) [24]. The tick lifecycle includes three stages—larvae, nymph, and adult—each facilitating virus transmission via bites (Mourya *et al*., 2014) [21]. Ajesh *et al*. (2017) [1] reported both transovarial and transstadial transmission in ticks. Co-feeding transmission, where virus exchange occurs between ticks without involving a host, is another efficient transmission method (Randolph, 2011; Mansfield *et al*., 2017) [25,19]. Additionally, unfed nymphs tend to transmit the infection primarily to humans (Pattnaik, 2006) [24].

4. Spatial Distribution

KFD was first detected in the forests of Shivamogga district in Karnataka, a region within the Western Ghats of India. The disease has since spread to other areas of Karnataka, including Chikkamagalore, Uttara Kannada, Dakshina Kannada, and others. By 2013, KFDV was detected in monkey necropsies in Nilgiris district, Tamil Nadu. Over the years, reports of monkey deaths and human cases have emerged from neighboring states, including Kerala, Goa, and Maharashtra (Arunkumar *et al*., 2016; Mourya and Yadav, 2016) [2,20]. The disease's geographical spread is also reflected in serological studies, which show the presence of antibodies in individuals from regions as distant as Andaman and Nicobar Islands, Gujarat, and Rajasthan, suggesting the existence of potential silent infection foci (Chakraborty *et al*., 2017) [5].

5. Disease Pattern Trends

From 1957 to 2017, approximately 9,594 KFD cases were documented along India's western coast. The first major outbreak in Shivamogga in 1957 saw around 500 cases, with annual cases generally dropping below 200, except for 1975 when 226 cases were reported. However, the outbreak in 1981 saw more than 500 cases in Shivamogga, and by 1982, the disease spread to Dakshina Kannada, with 1,984 cases in 1983. Over the years, KFD spread to additional regions, with the most significant recent outbreak occurring in 2017, reporting 462 cases (Chakraborty *et al*., 2017) [5].

6. Recent Outbreaks

From 2018 to 2022, Shivamogga district recorded 609 KFD cases and 17 deaths, with Thirthahalli taluk accounting for 54% of cases and 35% of deaths. In 2022, Thirthahalli's share of cases rose to 86%. The correlation between human cases, tick pool positivity, and monkey carcass detection indicates the involvement of multiple transmission pathways. Middle-aged adults were at higher risk of infection and mortality, with only 37% of this group fully vaccinated (including boosters). The decline in reported cases from 2020 to 2021 may reflect underreporting due to COVID-19-induced staff shortages or an actual decrease in cases due to movement restrictions (Srividya *et al*., 2024) [28]. The first fatality of 2025 was reported in February, with 48 confirmed KFD cases across Shivamogga, North Kanara, and Chickkamagalur districts of Karnataka (Udayavani, 2025).

7. Ecological Influences on KFD Spread

Deforestation is a major driver of KFD transmission, with the virus spreading through human activities and animal movement (Jha *et al*., 2000) [14]. Outbreaks are more common from December to May, coinciding with peak nymph activity. Migratory birds and bats have also been implicated in introducing KFD to new areas such as Goa, Maharashtra, Kerala, and Tamil Nadu (Ajesh *et al*., 2017) [1]. Climate change, exacerbated by deforestation, also plays a role in KFD's spread, influencing tick populations and the geographic distribution of both hosts and vectors (Ogden *et al*., 2005) [23]. Global warming is likely to increase the prevalence of vector-borne diseases in India (Karunamoorthi, 2012) [15].

8. Prevention Strategies

The current vaccine against KFDV is a formalin-inactivated version, with an effectiveness rate of 62.4% for individuals receiving two doses. Boosters increase efficacy to 83%, but vaccine coverage remains low in affected regions (Kasabi *et al*., 2013) [16]. Other prevention measures include personal protective strategies, landscape modifications, and the application of acaricides. Comprehensive actions, such as trimming vegetation and managing wildlife reservoirs, can also help reduce tick exposure (Eisen and Stafford, 2021) [9].

9. Conclusion

The growing spread of KFD, combined with its zoonotic potential, presents significant challenges in disease control. The involvement of various wildlife species and vectors complicates efforts to manage outbreaks. Enhanced surveillance, increased vaccination efforts, and heightened public awareness are critical to addressing this ongoing threat. As the disease continues to spread beyond traditional regions, collaboration among public health authorities, researchers, and veterinarians is vital to combating this emerging health crisis.

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