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Review article

Malaria, dengue and chikungunya in India – An update

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ABSTRACT

Malaria, Dengue and Chikungunya are important public health problems in India and pose an enormous burden to the health system. Controlling the vector remains the most effective method of preventing the diseases. This paper looks into the current status of the three vector borne diseases and the latest development in terms of management, prevention and control.

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1. Malaria

1.1. Agent

Malaria is a vector borne disease caused by protozoan parasite, "Plasmodium". There are nearly 200 species of *Plasmodium* which can infect a wide variety of hosts [1]. In humans, there are 4 species which cause malaria, i.e. *Plasmodium falciparum*, *P. vivax*, *P. malariae*, *P. ovale* and transmitted by bite of female *Anopheles* mosquito.

Plasmodium knowlesi was the recently discovered fifth species of *Plasmodium* affecting mankind. It was first described in the long tail macaque (*Macaca fascicularis*) in 1931 [2]. It also causes naturally acquired malaria in pigtail macaques (*Macaca nemestrina*), the mitred leaf monkey (*Presbytis melalophos*) that live in the broad-leaf rain forests, *Macaca inus* and *Saimiri scirea* [3]. The main mosquito vector is *Anopheles lateens* that bites both humans and monkeys. Previously it was used as an alternate pyretic agent for neurosyphilis by transmitting the infection artificially to humans through blood inoculation. However, the practice was discontinued due to life-threatening nature of the infection. The first natural infection of *P. knowlesi* in humans was reported in 1965 in an American traveller returning from Malaysia [4] and the first

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large focus of human infection was reported in Malaysian Borneo in 2004 [5]. Subsequently, the parasite was recognized as the fifth human malaria parasite [6], with the major infective foci described in Malaysia. Cases have been increasingly detected in other South-East Asian countries such as Thailand, Vietnam and Cambodia, as well as in travellers from several countries such as Japan, Spain, Germany, France, Italy, New Zealand and Netherlands [7–11].

Till now, *P. knowlesi* malaria cases are not officially reported in India, but a recent report from Andaman & Nicobar Islands showed that out of 445 samples analysed, 53 had *P. knowlesi* specific gene sequences, of which 33 had mono infection and rest were coinfections with *P. falciparum*/*P. vivax* [12]. *P. knowlesi* can be easily misdiagnosed as *P. malariae* or *P. falciparum* with routine microscopy. So, it might already be present in the country but might have been missed.

India has larger chances for becoming an endemic country for *P. knowlesi* because North Eastern states share borders with already known endemic countries [13], frequent travellers exist between India & other South East Asian countries; and, both the suitable vector (*A. dirus*) and host (pig tailed macques) are present in India (mainly in North Eastern states).

1.2. Vector

Vector for Malaria is Anopheles species of mosquito. There is a total of 58 Anopheles species in India, only six are epidemiologically important for malaria transmission with regional distribution [14] (Table 1), other species may be key local vectors. Multiple vector species may be present across any region, but none is found throughout India [15–17].

1.2.1. *P. vivax*

India has the highest burden of *P. vivax* among all the countries, in 2014, there were 2.14 million confirmed *P. vivax* cases globally, 18% of which occurred in India [16]. Within the Urban Malaria Scheme, 98% of all malaria cases were *P. vivax* in 2014 [17]

Reasons might be due to-

a Variation in relapse patterns:

- There is variation in relapse patterns both across and within states.
- Strains with different relapse patterns can coexist, which complicates the measures to control transmission; e.g. in Delhi, *P. vivax* malaria populations are polymorphic for relapse: Group I (tropical type), the most common type, with relapse between 1 and 3 months; Group II, relapse between 3 and 5 months; and Group III (temperate type), relapse between 6 and 7 months [18,19]. In contrast, in Mumbai the relapse pattern is predominantly of the tropical type [20].
- Inaccessibility to radical cure:

To clear the dormant hypnozoite stage in *P. vivax*, a 14-day course of primaquine (0.25 mg/kg), known as radical cure was prescribed along with Chloroquine. Mishra N et al. [21] shows that radical cure was prescribed to only 87% patients attending public sector, 52% attending private health facilities for confirmed *P. vivax* Malaria.

In many communities where “less-than-fully-qualified (quacks)” are main healthcare providers in the private sector, radical care is totally inaccessible [22]. Proper measures must be taken to increase the access to radical cure everywhere in the country, otherwise *P. vivax* malaria cases will continue to rise because several relapses can be caused by one infective bite and relapses maintain *P. vivax* transmission.

1.3. Differences in magnitude of malaria

Malaria is common in Eastern and Central part of the country; mainly states with largest forest, hilly & tribal areas are affected like Odisha, Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra and north-eastern (NE) states [23]. Reasons might be due to large amount of hilly and forest areas; poor access, inadequate health infrastructure and low community awareness among the tribal population

1.4. Recent outbreaks

In 2010, a malaria outbreak occurred in Balasore, a coastal district of Odisha. Anopheles culicifacies, *A. annularis*, and *A. subpictus* were involved in transmission during the outbreak, which was thought to have been triggered by 3 days of heavy rain which filled five ponds, followed by high temperatures (42 °C) in the area, plus a low density of cattle in the area, leaving humans as the preferred food source [24].

Gujarat recorded highest number of deaths due to malaria in 2011 (127 deaths), no clear cause had been identified.

1.5. Insecticide Resistance

Insecticide usage started in 1950s with the introduction of DDT, but after some days mosquitoes started becoming resistant to this DDT, followed by introduction of different types of insecticides like HCH/Dieldin, Malathion, Pirimphos methyl, Fenitrothion, Carbamates like Propoxore, Synthetic pyrethroids like Deltamethrin, etc., Mosquitoes started becoming resistant to these also, resistance to synthetic pyrethroids has also been documented [25,26]

To prolong the life of an insecticide in vector control programme is to devise rotation policy, wherein use of unrelated compounds is rotated as has been done with considerable success in agriculture and Onchocerciasis Control Programme in Mexico [27]. Integrated vector management approach suggested by WHO promotes judicious mix of various vector control options [28].

Table 1
Distribution & Breeding sites of important Anopheles species in India.

S. No	Species	Distribution	Breeding area
1.	Anopheles culicifacies	rural, peri-urban areas and in the plains	rural, peri-urban areas and in the plains
2.	Anopheles stephensi	Urban areas	Curing waters in construction sites
3.	Anopheles dirus	forest areas of north-eastern regions	temporary water collections
4.	Anopheles minimus	forest areas of northeastern regions	slow-flowing streams
5.	Anopheles fluviatilis	hill and foothill areas	Moving water
6.	Anopheles sundaicus	Andaman and Nicobar Islands	brackish water

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