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## Malaria in the Andaman and Nicobar Islands: Challenges and opportunities for elimination

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## ABSTRACT

Malaria has been endemic to Andaman and Nicobar Archipelago for over a century. However, the cases were observed to decline during the past few years. *Plasmodium vivax* and *Plasmodium falciparum* are the predominant malaria causing parasites, but the occurrence of *Plasmodium knowlesi* has also been reported recently. *Anopheles sundaicus* is the incriminated vector of malaria parasites, and they breed both in fresh and brackish water. This mosquito is predominantly endophagic and zoophagic. Cytogenetic and molecular studies revealed the presence of *Anopheles sundaicus* cytotype "D" alone. The annual parasite incidence in the archipelago ranged between 6.0 and 11.9 till 2010, which decreased and reached 1.2 in the year 2014. The slide positivity rate also varied significantly, and declined from 3.09% in 2005 to 0.74% in 2014. Bioenvironmental control strategy, especially through the use of larvivoracious fishes was the main contributory factor for the cases to decline. Although malaria transmission is being suppressed through effective interventions, it is likely to resurge if these measures are not continued. There is a window of opportunity to achieve the goal of malaria elimination in this archipelago, by sustaining the gains achieved and by strengthening the control activities in areas where the cases are still persistent.

## 1. Introduction

Andaman and Nicobar Islands (92° to 94° East and 6° to 14° North) is a centrally administered territory of Indian Republic, historically known for high malaria transmission. It is an archipelago of 555 islands/islets, stretching over 700 km from north to south, in the Bay of Bengal[1]. The territory is bifurcated into three districts, viz., South Andaman, North and Middle Andaman and Nicobar. There are 38 inhabited islands with a population of approximately 380581 (census 2011). The topography of the island is hilly and abounds in evergreen forests. The climate is tropical (24 to 30 °C) and humid (mean relative humidity of 78.5%) with abundant rainfall (normal annual rainfall = 3180 mm), supporting a luxuriant and rich vegetation. Many creeks traverse the islands with tributaries of varying lengths. During high tides, sea water incursion

creates swamps and marshes, which nurture the thriving mangrove ecosystem.

## 2. Malaria situation in the archipelago

Malaria has been endemic in these Islands for over a century, and was the major cause of morbidity and mortality in the penal colony of Andaman Islands from 1858 to 1945. During this period, engineering works along the shoreline often increased malaria due to the breeding of vector mosquito, *Anopheles sundaicus* (*An. sundaicus*), which prefers brackish-water bodies[2]. During 1992–2004, the annual parasite incidence (API) ranged from 1.4 to 4.5 per thousand population. After the devastating tsunami (in 2004), vector breeding was observed in 77% of the habitats under the influence of spring tide. The breeding occurred in 46% of the habitats flooded during tsunami and in 25% of the habitats, where daily seawater intrusion occurs during high tide[3]. Migrant workers hailing from non-endemic or moderately endemic states became victims to malaria during their work in the Nancowry group of

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Islands, which was highly endemic, subsequent to tsunami waves[4]. During the years 2005-2013, a declining trend in malaria cases was observed. The API values ranged between 6.0 and 11.9 till 2010, which decreased further and reached 1.2 in the year 2014. Month wise API values were observed to decline over time (Figure 1). The overall slide positivity rate (SPR) in the archipelago decreased from 3.09% in 2005 to 0.74% in 2014.

Even though there was an overall decline in the malariometric indices, the two Andaman districts had comparatively lower indices than the Nicobar district. Analysing the 3 districts in 2005 (immediately after tsunami), there was an increase of 1 243 per cent in API (from 0.64 to 8.15) for Andaman District and it was almost 816 per cent (from 8.0 to 73.27) for Nicobar District. In the subsequent years, the malaria situation in the archipelago differed from island to island. The SPR ranged from 3.28 to 9.03 in Nicobar, while it was < 1.5 in two Andaman districts. There was a gradual decline in indices over years, and recently in 2014, the SPR in 3 districts were 0.31%, 0.12% and 2.17% in the South Andaman, North & Middle Andaman and Nicobar districts respectively (Table

1). Similar trend was observed for API. Among three tehsils of the Nicobar District, the northern most tehsil, viz., Car Nicobar, was found with least number of cases (API in 2014 was 1.2), while the other two tehsils, viz., Nancowry and Campbell bay, has been observed with more cases.

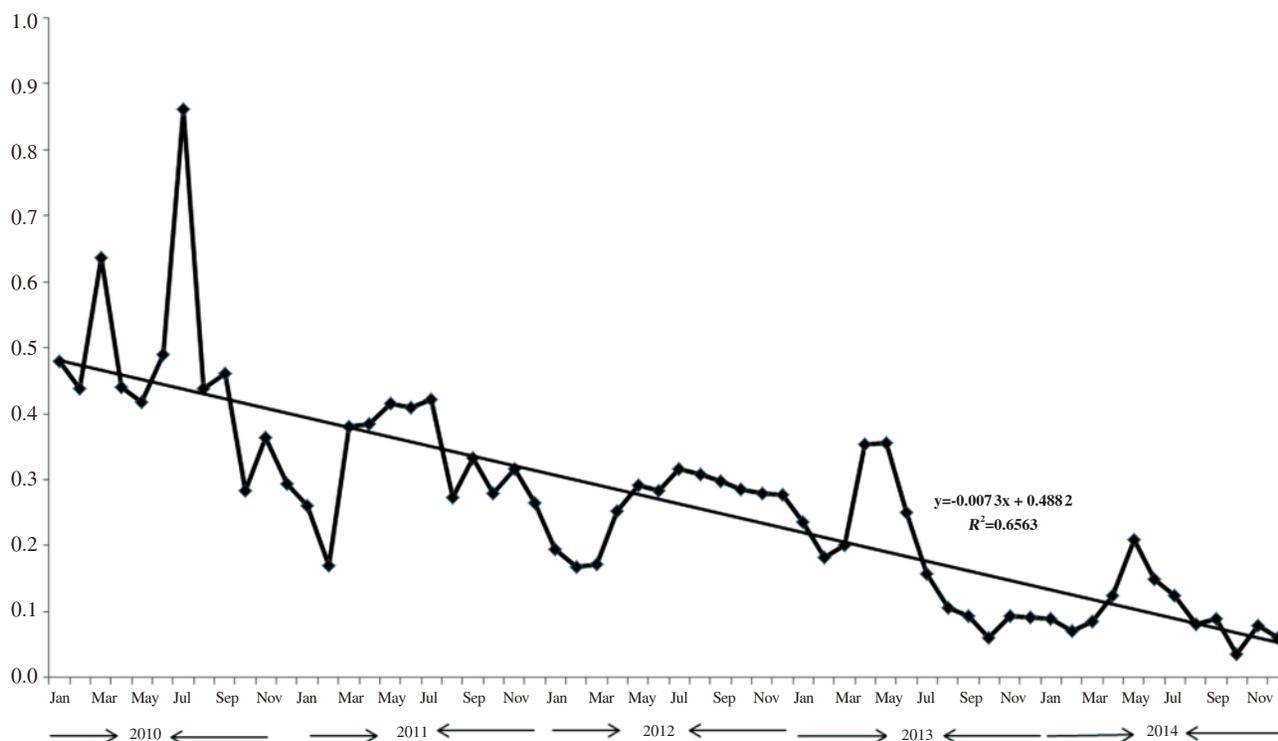
### 3. Vectors and parasites of malaria

A total of 23 anopheline species have been reported from these islands[5,6]. *An. sondaicus* is the incriminated vector of malaria parasites. These vector mosquitoes breed both in fresh and brackish water. Filamentous floating algae and aquatic plants appear to be crucial for the development of the larvae. This mosquito is predominantly zoophagic (*i.e.*, prefer to feed on animals). *An. sondaicus* significantly bite indoor than outdoor, and this species show bimodal biting activity with first peak between 21:30 and 22:30 pm and the second between 1:30 and 2:30 am[7]. Molecular studies revealed the existence of *An. sondaicus* cytotype "D" alone throughout the archipelago[8].

**Table 1**

Malariometric indices in the three districts of Andaman and Nicobar islands.

Year	Annual blood examination rate			SPR			API		
	South Andaman	N & M Andaman	Nicobar	South Andaman	N & M Andaman	Nicobar	South Andaman	N & M Andaman	Nicobar
2005	22.95		91.70	0.82		8.33	1.88		76.35
2006		24.16	82.33		1.16	5.26		2.81	43.33
2007	22.82	50.31	134.62	1.43	0.94	4.67	3.27	4.72	62.93
2008	23.11	24.13	120.21	0.79	1.42	5.78	2.00	2.90	69.43
2009	18.15	17.98	102.17	0.78	1.14	9.03	1.42	1.98	92.28
2010	21.39	25.59	83.59	1.31	1.25	3.45	2.80	3.08	28.66
2011	14.09	17.53	70.13	0.77	1.03	4.57	1.08	1.85	32.03
2012	13.80	18.46	64.53	0.79	0.58	3.93	1.06	1.14	25.26
2013	13.80	13.88	48.98	0.72	0.41	3.28	0.99	0.57	16.07
2014	12.37	14.52	47.77	0.31	0.12	2.17	0.38	0.18	10.36



**Figure 1.** Monthly API in Andaman & Nicobar Archipelago (2010-2014).

Two *Plasmodium* parasites causing malaria, viz., *Plasmodium vivax* and *Plasmodium falciparum* (*P. falciparum*), are reported in these islands. Equal proportion of both species was observed till 2009, but *Plasmodium vivax* was the predominant species (60%) observed during the last few years. Emergence of simian parasite was observed in this archipelago. Earlier, malaria zoonosis of simian origin as a natural phenomenon was reported in Greater Nicobar island by Kalra[9], which was suggested to be due to the presence of crab-eating macaque monkey, viz., *Macaca fascicularis umbrosa* Miller, 1902[10], and the susceptible *Anopheles* mosquito vector. Kalra found two out of 13 monkeys to be parasitized by *Plasmodium cynomolgi*. Recently, human infection with *Plasmodium knowlesi* (*P. knowlesi*) (11.9%) was observed from the archived DNA samples of malaria patients collected from different health centres of Andaman and Nicobar Islands[11]. They suggested that the *Plasmodium cynomolgi* parasite reported by Kalra was indeed *P. knowlesi*, since it is difficult to distinguish these parasites by light microscopy. The probability of a malaria zoonosis involving *P. knowlesi* on these islands is very high, since they are very close to the South-East Asian countries where *P. knowlesi* human infection exists[12]. Probably, *P. knowlesi* could have been introduced to the Andaman and Nicobar Islands through the poachers from Thailand and Indonesia, who come to these islands for the collection of sea and forest wealth. They temporarily migrate to these islands and stay for a certain period of time before returning to their country.

#### 4. Malaria among the indigenous tribes

Mortality due to malaria among the tribal communities of India is very high, even though they form less than 10% of the total population. The situation can be improved by community-level awareness about malaria using culturally-appropriate health education materials and making traditional healers as partners in malaria control[13]. In the Andaman and Nicobar Islands there are two distinct racial groups of primitive tribes viz. negritos in the Andamans (Great Andamanese, Onges, Jarawas and Sentinelese) and mongoloids in the Nicobar (Nicobarese and Shompens). The total population of these tribes is 28530 (7.5% of the total population). A malaria survey undertaken among the Jarawas, during an outbreak of febrile illness in 2001 revealed 17% due to *P. falciparum* ( $n = 179$ ) [14]. Genetic diversity studies revealed low level of polymorphism in the infection, indicating the possibility of recent introduction of the parasite.

#### 5. Malaria control in the archipelago

National Vector Borne Disease Control Program (NVBDCP) is the central nodal agency, which takes care of all major vector borne diseases in India and the malaria control in Andaman and Nicobar islands[15]. During 1989, bioenvironmental control was evaluated as an alternative strategy in the Car Nicobar Island, through minor engineering works, large scale production of larvivorous fishes [*Gambusia affinis* (*G. affinis*)] and by applying *Bacillus sphaericus*

in marshy, mangrove and inaccessible areas. The malaria in this island has declined significantly since then (except a spurt in number of cases during the catastrophic tsunami). It was observed that *G. affinis* could establish themselves in the perennial water habitats preventing the breeding of anophelines. Indoor residual spray with DDT is being implemented biannually in all the villages, in addition to the year round larviciding with *Abate* and *Bacillus sphaericus*[16].

Healthcare facilities in Andaman and Nicobar Islands are reasonably good. Primary health care services are provided to the rural community through a network of sub-centres, primary health centres and community health centres, based on the population norms of the Government of India. Ample tools and opportunities are available for malaria elimination in Andaman and Nicobar Islands. The treatment of malaria is based on the national drug policy as per the guidelines put forth by the NVBDCP[17]. The available strategies include the bioenvironmental control, up-scaling of long lasting impregnated net distribution[18], and intensification of indoor residual spray. Traditional knowledge providers in the tribal communities of Nicobar District can be solicited to report the malaria cases occurring in their respective villages. Additionally, effective communication-for-behavioural impact plan for better awareness of malaria and its vectors to the target community plays a significant role during the process of elimination. The use of biological means is considered a fundamental part of the recently launched malaria elimination program and has so far shown promising results, although this approach is still in its infancy[19]. In Car Nicobar Island, bioenvironmental control of malaria by the use of larvivorous fishes (*G. affinis*) was found to be very effective and a feasible strategy[20]. This strategy could be intensified in areas where malaria is a persistent problem. More number of fish hatcheries can be created and fishes could be released in water stagnating bodies through the involvement of local youth volunteers. Even though indoor residual spray is being carried out bi-annually, the development of resistance in vector mosquitoes to the insecticides used need to be monitored on regular basis. Similarly, susceptibility of malarial parasites to the anti-malarial drugs needs to be evaluated. A study conducted during 1994 found *P. falciparum* to be resistant to chloroquine in seven patients at the Car Nicobar Island[21]. Among them, five patients showed RI level of resistance and one patient each showed RII and RIII level of resistance. Such studies have not been carried out since then. Continuous monitoring of antimalarial efficacy is essential in order to combat the disease effectively[22].

#### 6. Window of opportunity for malaria elimination

Although malaria transmission can be suppressed through effective control measures, it can resurge if these interventions are discontinued with respect to the factors related to ecology, efficiency of mosquito vectors, and socioeconomic characteristics. Almost all events of malaria resurgence (91%) were attributed to the weakening of malaria control programmes for a variety of reasons[23]. There is a great window of opportunity to achieve the goal of malaria elimination in the Andaman and Nicobar Archipelago. The incidence

of malaria is fast declining in the two districts of Andaman, and also in one of the tehsils (Car Nicobar) in the Nicobar District. Hence, the control operations can be focussed more in two tehsils of Nicobar districts, viz., Nancowrie and Campbell Bay, where the problem still persists. However, sustaining the gains achieved in malaria control in the above areas needs to be monitored continuously, to prevent the resurgence of cases. The migrant labourers from other states with high malaria incidence should be monitored continuously, especially in areas where transmission has become negligible. Prevention of re-introduction of malaria must be ensured especially in the elimination phase<sup>[24]</sup>. It is very important that, as enthusiasm for elimination in these areas (as in Car Nicobar) progressively gains attention, control measures in other regions with persistent malaria transmission (such as other tehsils in Nicobar District) is not deterred.

### Conflict of interest statement

We declare that we have no conflict of interest.

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