



सत्यमेव जयते

Government Of India

Malaria : Epidemiology, Current Scenario and Public Health Tools for Disease Control

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Govt. of India

Malaria–Background

- Chronic infectious disease caused by the parasite Plasmodium sp
- Transmitted by the bite of an infected female Anopheles mosquito
- Ancient disease, evidence of malaria from as far back as ancient India and Mesopotamia
- Outbreaks associated with foreign invasion and travel to endemic areas: defensive pathogen

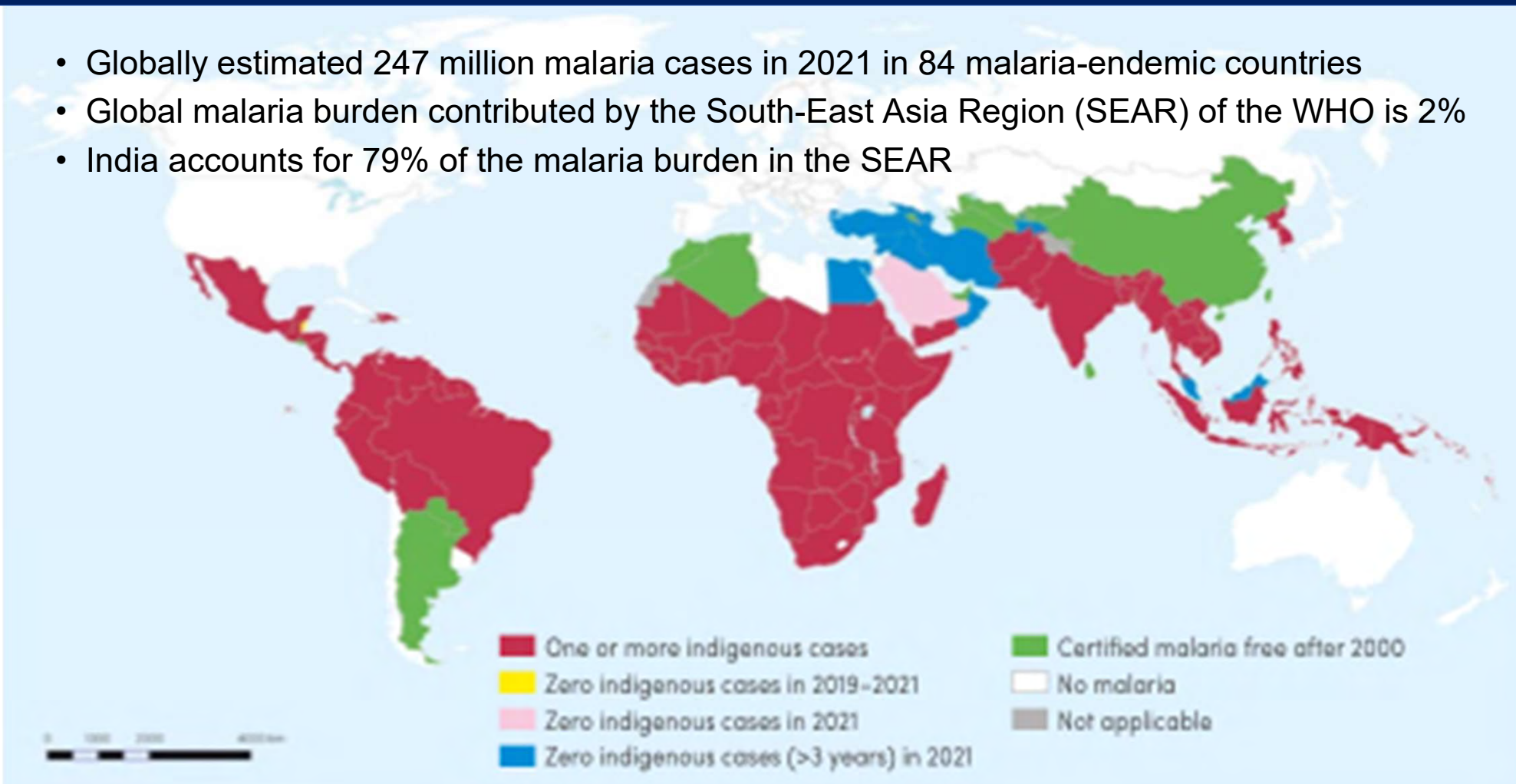
When unable to defend herself by the sword

Rome could defend herself by means of fever

The poet Godfrey of Vitrevo, 1167

Global Malaria Burden

- Globally estimated 247 million malaria cases in 2021 in 84 malaria-endemic countries
- Global malaria burden contributed by the South-East Asia Region (SEAR) of the WHO is 2%
- India accounts for 79% of the malaria burden in the SEAR



India Malaria – State Categorization & Targets

Category 1 (15)

- API less than 1 case per 1000 population
- 3% of cases
- Eliminated by 2020

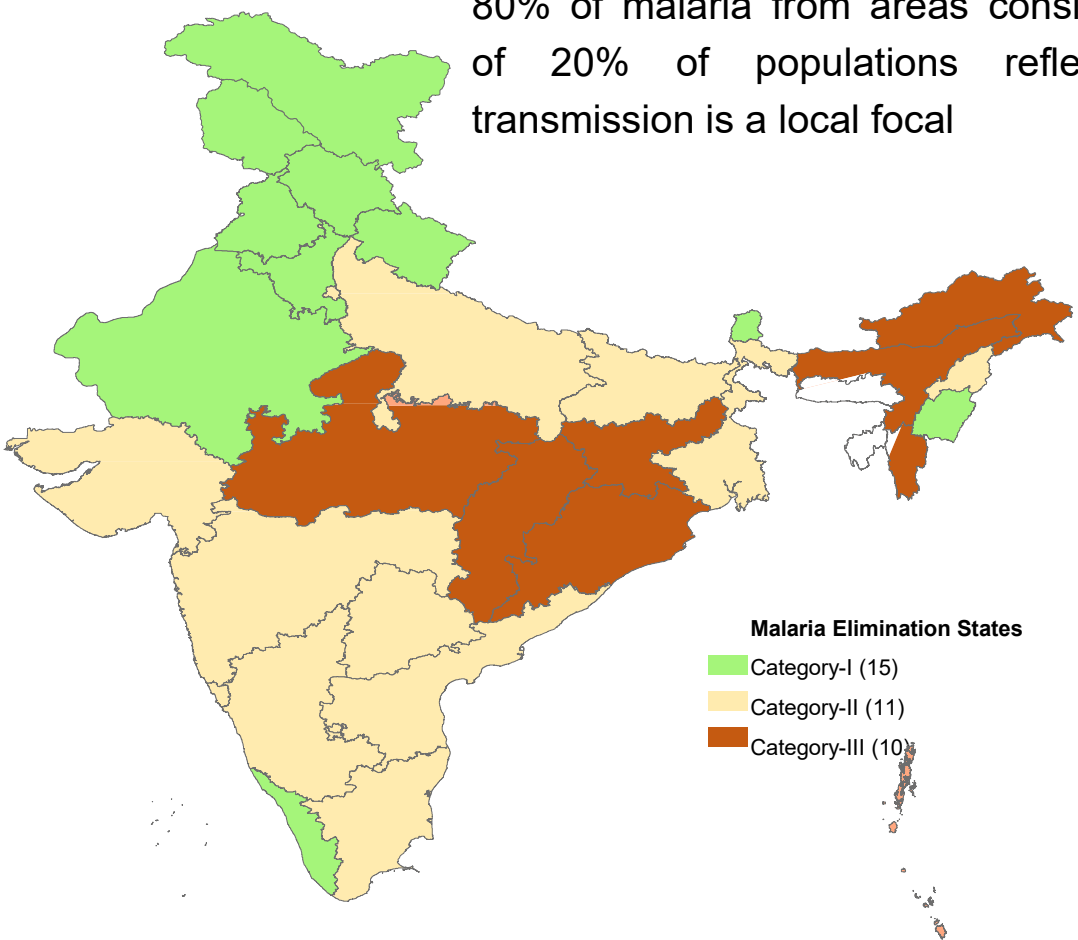
Category 2 (11)

- State < 1 API but some districts report API of 1 case per 1000 population
- 39% of cases
- Eliminated by 2022

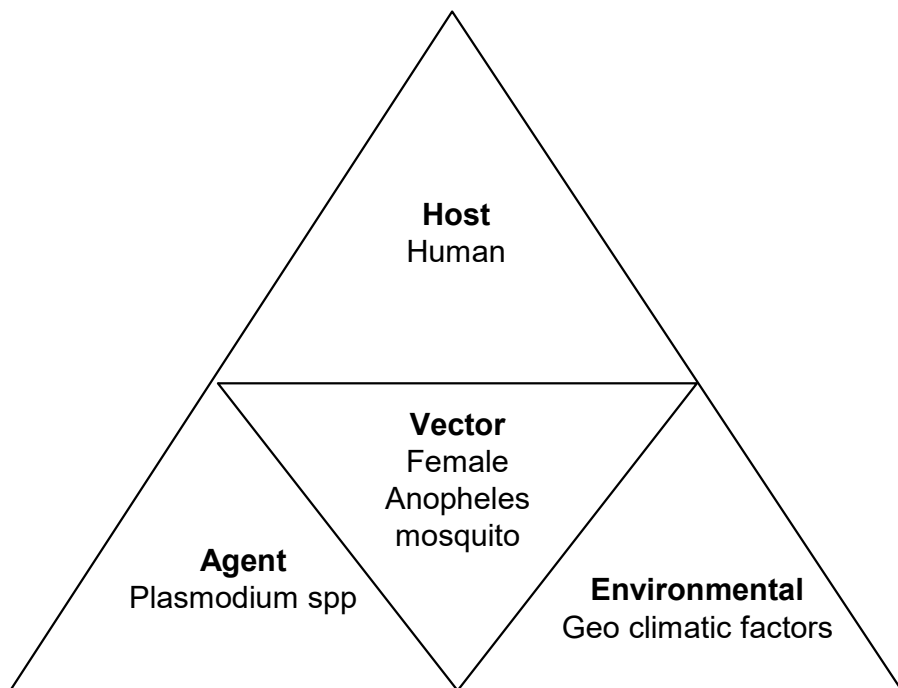
Category 3 (10)

- States with API of 1 or more per 1000 population
- 58% of cases
- Eliminate by 2027

80% of malaria from areas consisting of 20% of populations reflecting transmission is a local focal



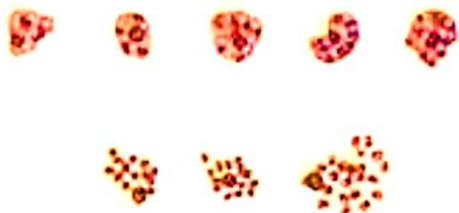
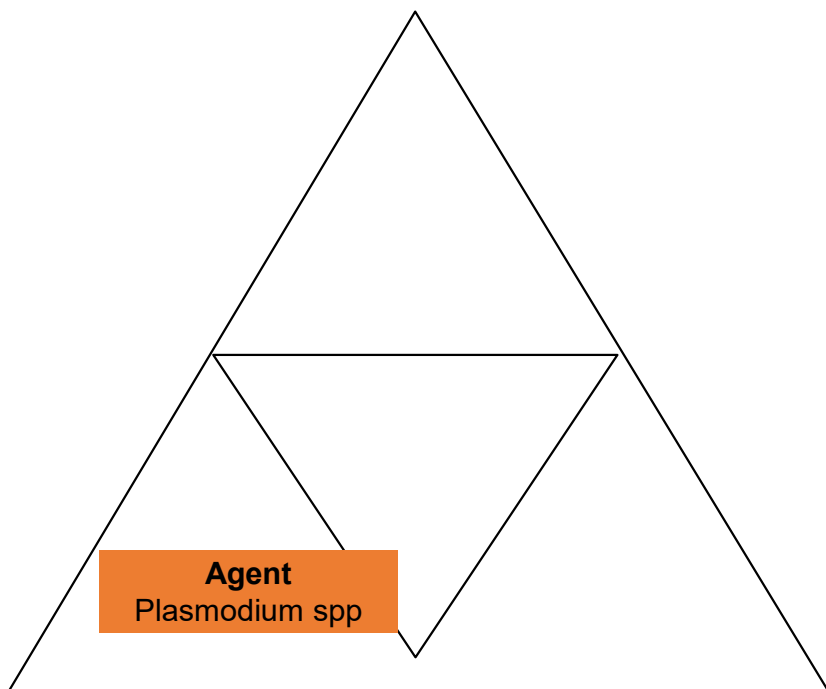
Malaria–Epidemiology



Epidemiological Triad

- Risk of malaria dependent on interactions between the host, parasite, mosquito vector, and environment
- Changes in any one of these elements may profoundly impact risk of infection.
- Measures of risk of malaria may be broadly classified as either indirect or direct

Malaria Epidemiology—Agent

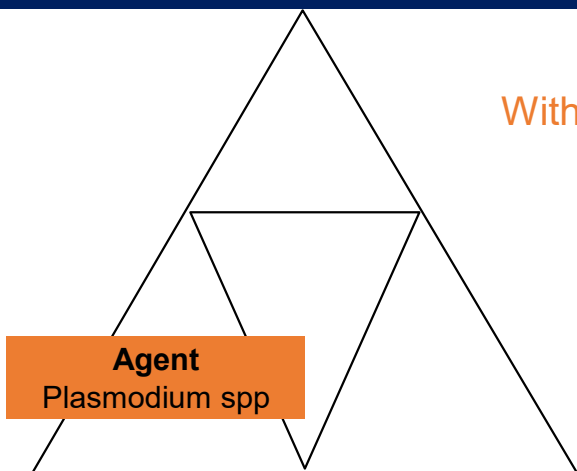


- *Plasmodium* is a genus of parasitic protozoa which infect erythrocytes of vertebrates and cause malaria
- Species infecting humans commonly

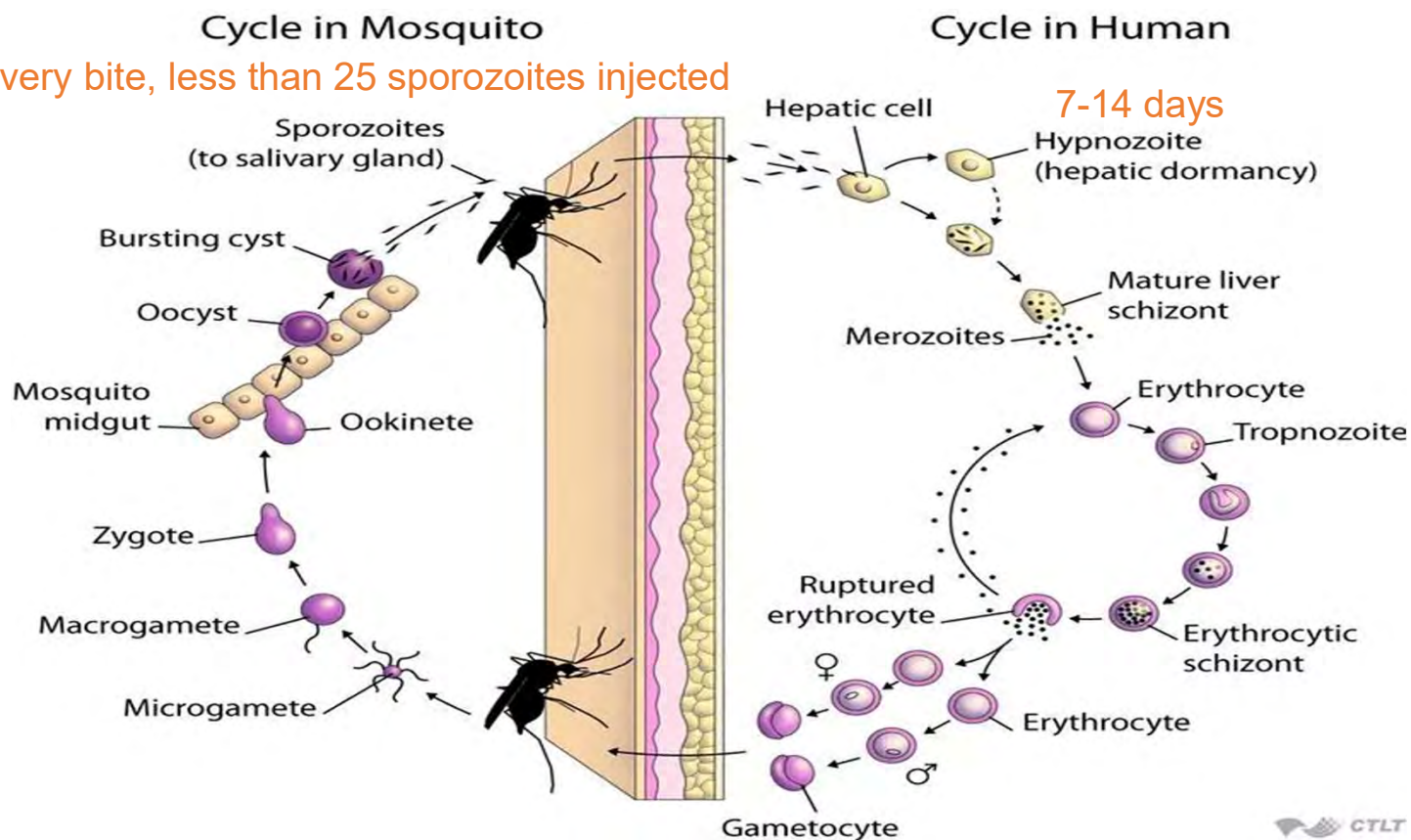
P. falciparum	Tropical regions	Severe infections, recrudescence
P. vivax	Everywhere, except Africa	Relapse
P. malariae	Everywhere	-
P. ovale	Africa	Relapse

- Three developmental stages seen in blood films:
 - A. Trophozoite
 - B. Schizont
 - C. Gametocyte

Malaria Epidemiology —Agent



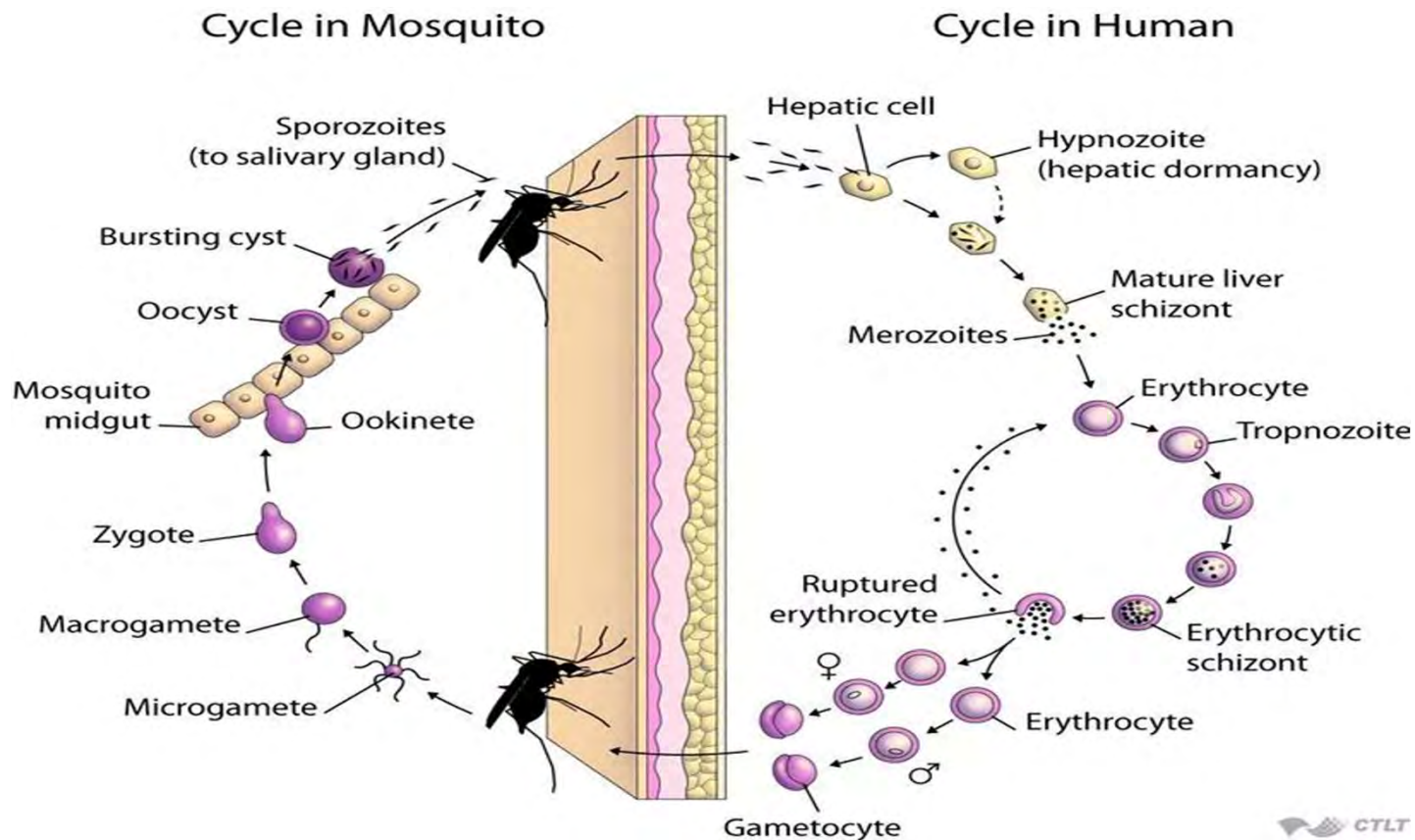
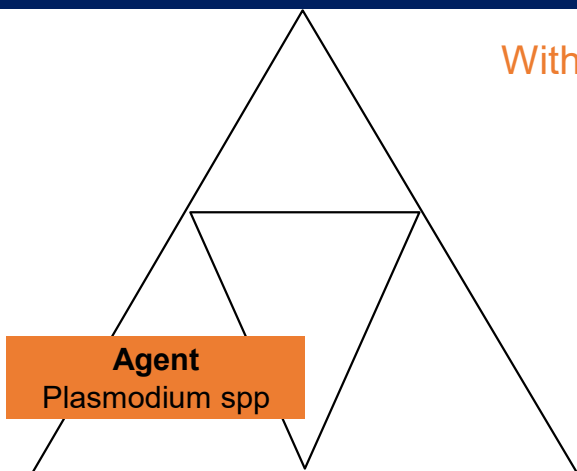
With every bite, less than 25 sporozoites injected



- Complex life cycle
- More than 12 stages
- Life cycle of Plasmodium: two distinct phases, *asexual* cycle in human and sexual cycle in mosquitoes
- Mosquito cycle=7-12 days under optimum temp (> upto 23 days, temp fall to 20 degree)

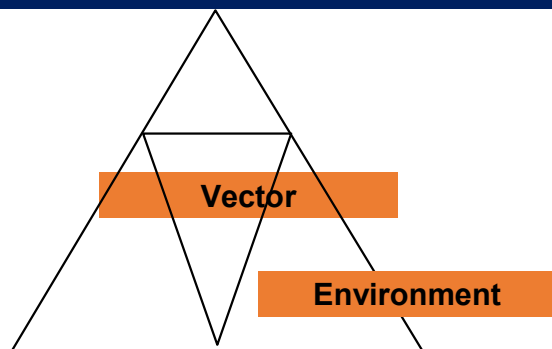
Malaria Epidemiology —Agent

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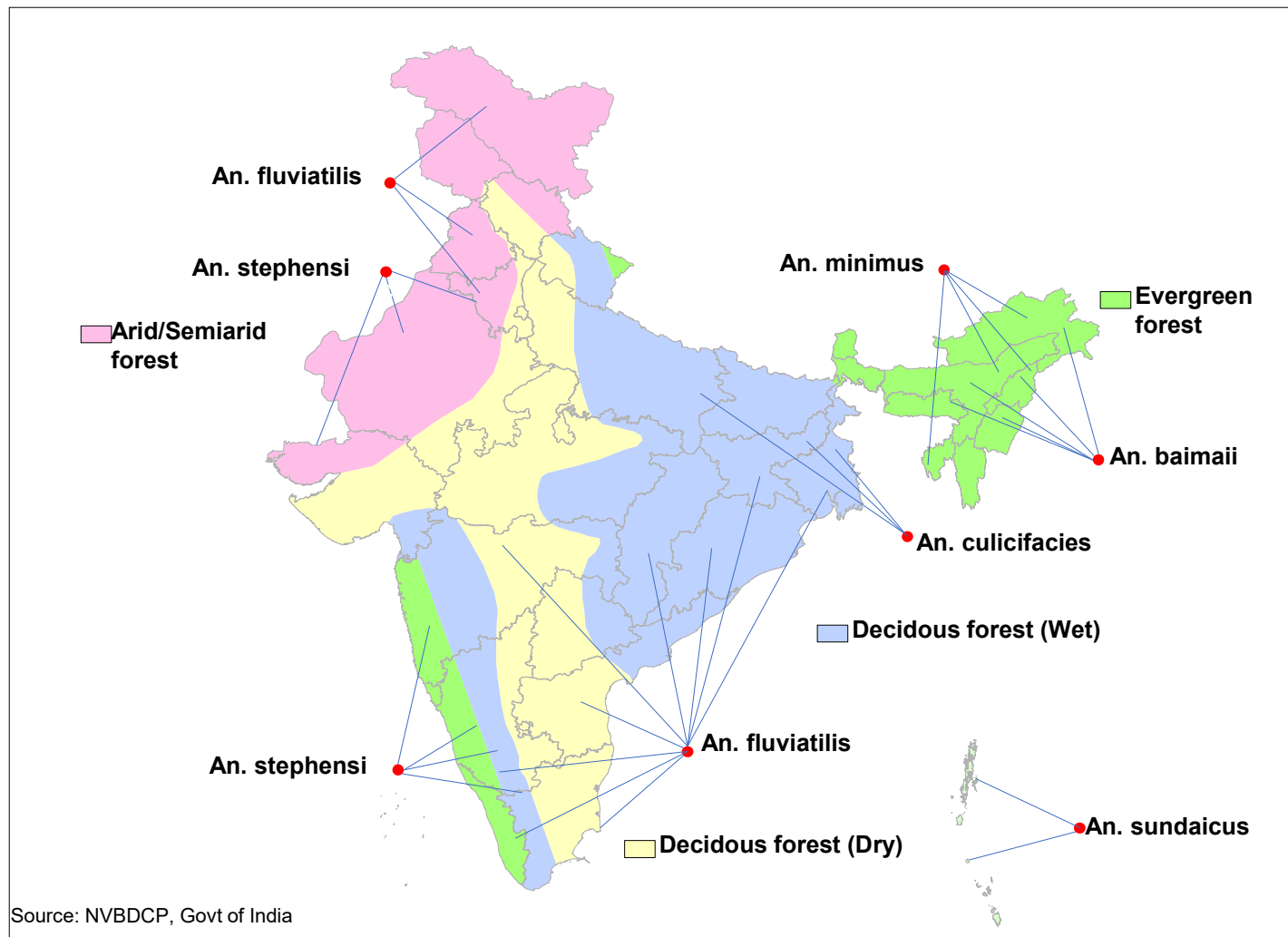
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Malaria Epidemiology — Vector, Environment

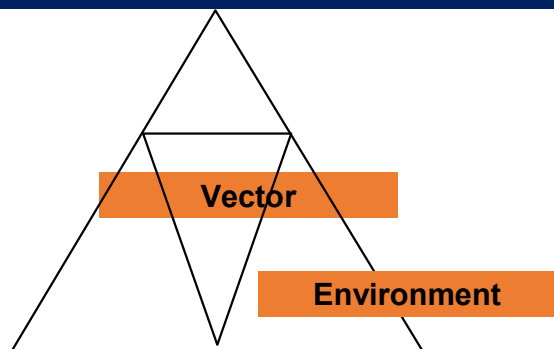


	Habitat preference	Resting	Biting time and host preference
<i>An. culicifacies</i>	Clean water eg irrigation channels, paddy fields, ponds, slow moving streams	Rests indoors in human dwellings and cattle sheds, highly	throughout the night Zoophilic sp
<i>An. fluviatilis</i>			Dusk, completes feeding before midnight Anthropophilic sp
<i>An. stephensi</i>	Breeds in confined spaces like, wells, water tanks, cisterns, rainwater collections in roof gutters, peri domestic containers		peak biting activity is generally from 22.00 to 24.00 hrs. Indiscriminate feeder

Malaria Epidemiology — Vector



Malaria Epidemiology — Vector, Environment

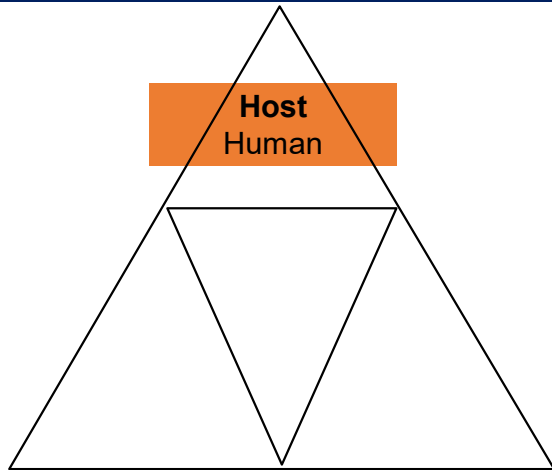


Environment Factors

Natural	Temperature, humidity; elevation, soil condition, vegetation
Man-made	Irrigation systems, urbanization, infrastructure development (road/railway, canals etc), climate change and extreme weather events

	Habitat preference	Resting	Biting time and host preference
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Malaria Epidemiology —Host



- Malaria disease a result of parasitic multiplication and host defense
- **Risk of infection:** Travellers, blood recipients (rare), mother to child
- **Risk of severe disease:** Undernourishment and micronutrient deficiency, pregnancy, infancy and under 5 age
- **Clinical presentation:** High-grade fever with chills and rigor, vomiting, headache, fatigue, and others, etc

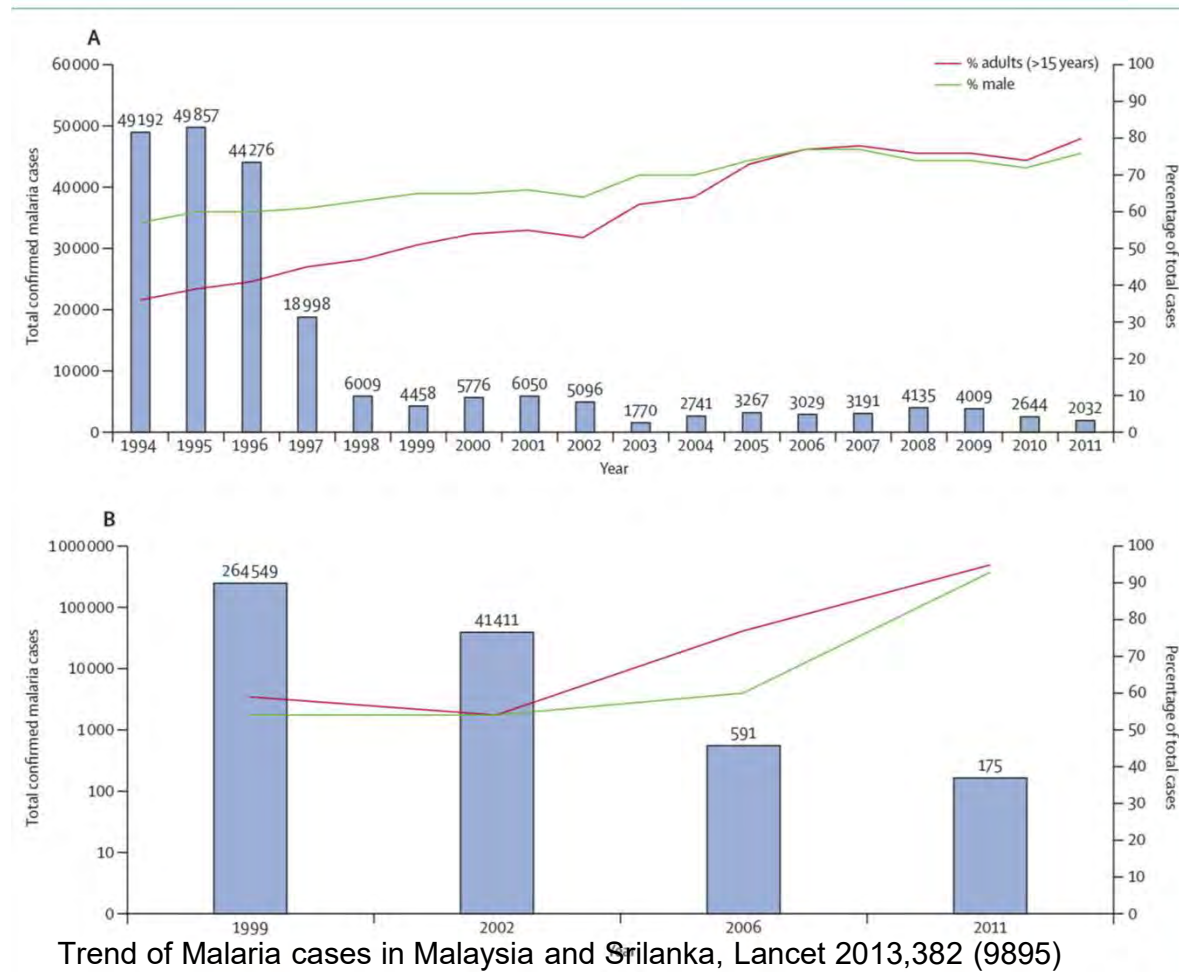
“Shake with a violence that can propel an iron bed to floor”

- **Relapse** linked to *P. malaria* and *P. ovale*
- Cerebral malaria in *P. falciparum*
- Chronic exposure causes spleen enlargement.

Malaria—Epidemiological shift

Host shift:

- Higher proportion of adults and men due to occupational and behavioural factors
- Migrants and hard to reach groups

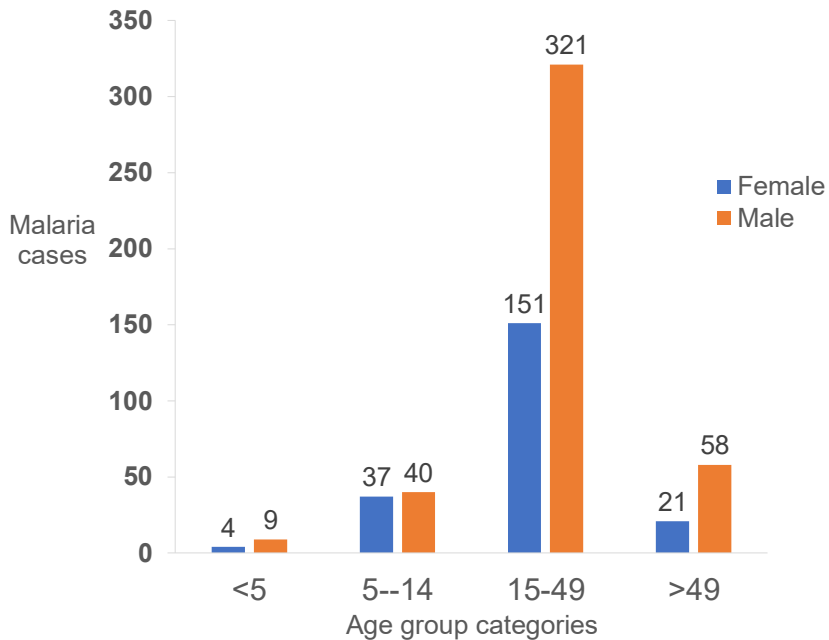


Trend of Imported Malaria cases in Saudi Arabia, Lancet 2013,382 (9895)

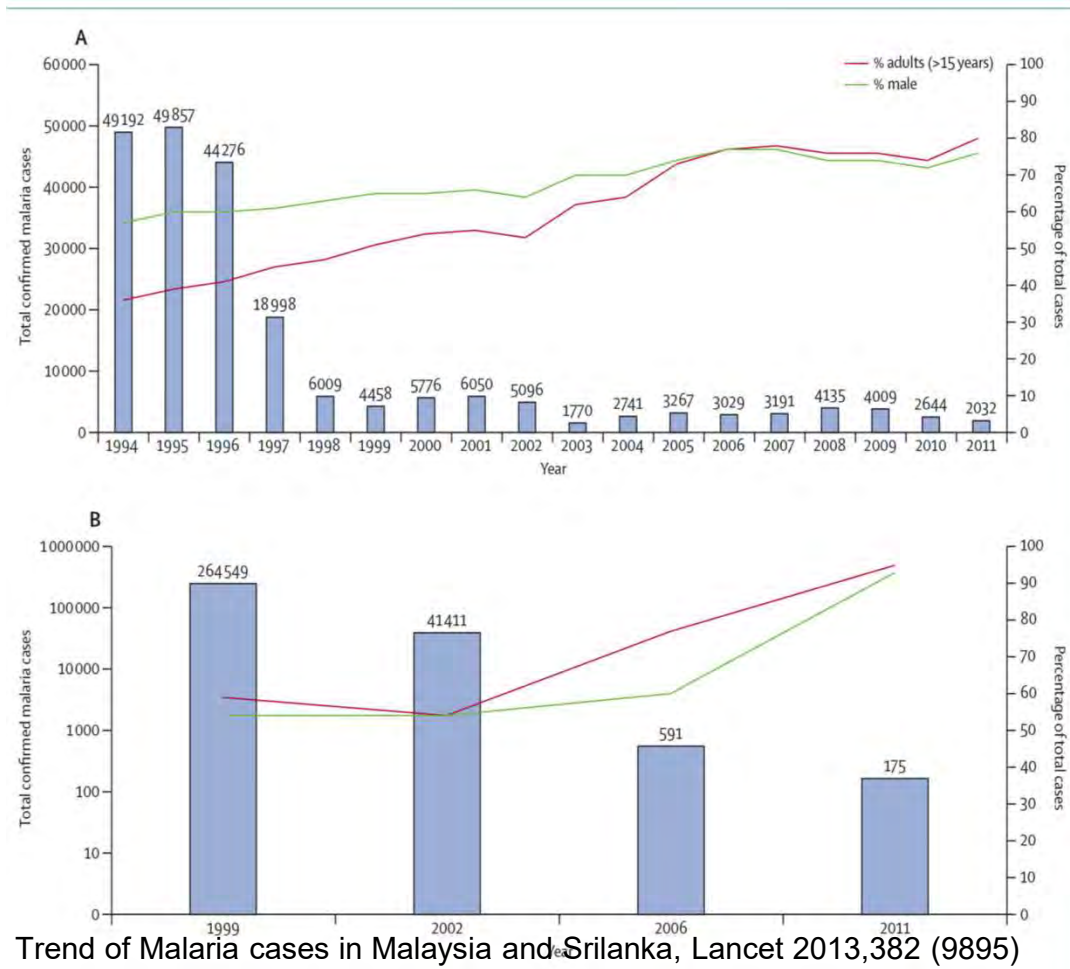
Malaria—Epidemiological shift

Host shift:

- Higher proportion of adults and men due to occupational and behavioural factors
- Migrants and hard to reach groups



Malaria cases in Vishakhapatnam, 2018-22, Data source: NVBDCP



Trend of Malaria cases in Malaysia and Sri Lanka, Lancet 2013,382 (9895)

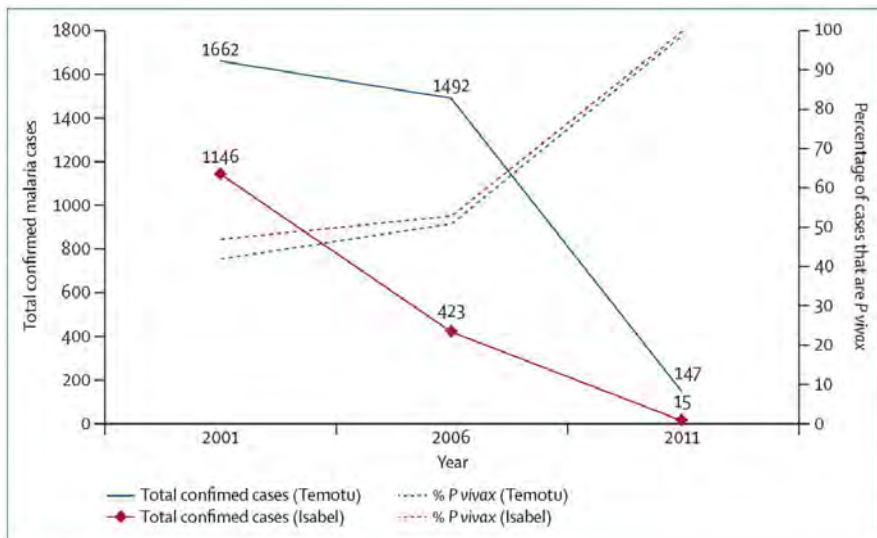
Malaria—Epidemiological shift

Host shift:

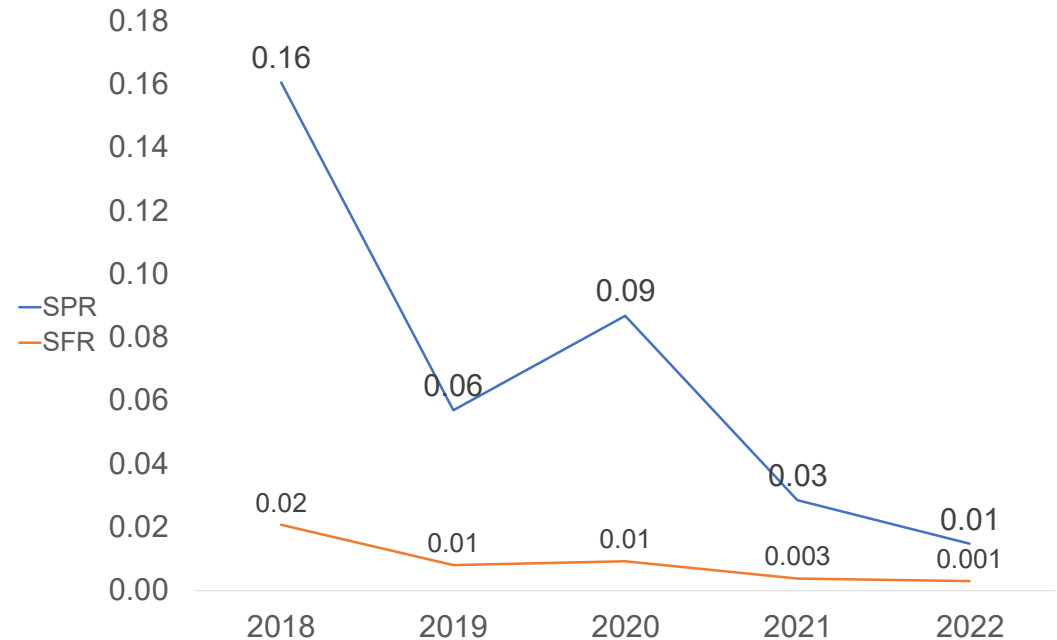
- Higher proportion of adults and men due to occupational and behavioural factors
- Migrants and hard to reach groups

Agent shift:

- Proportion of malaria cases with *P. vivax* increasing

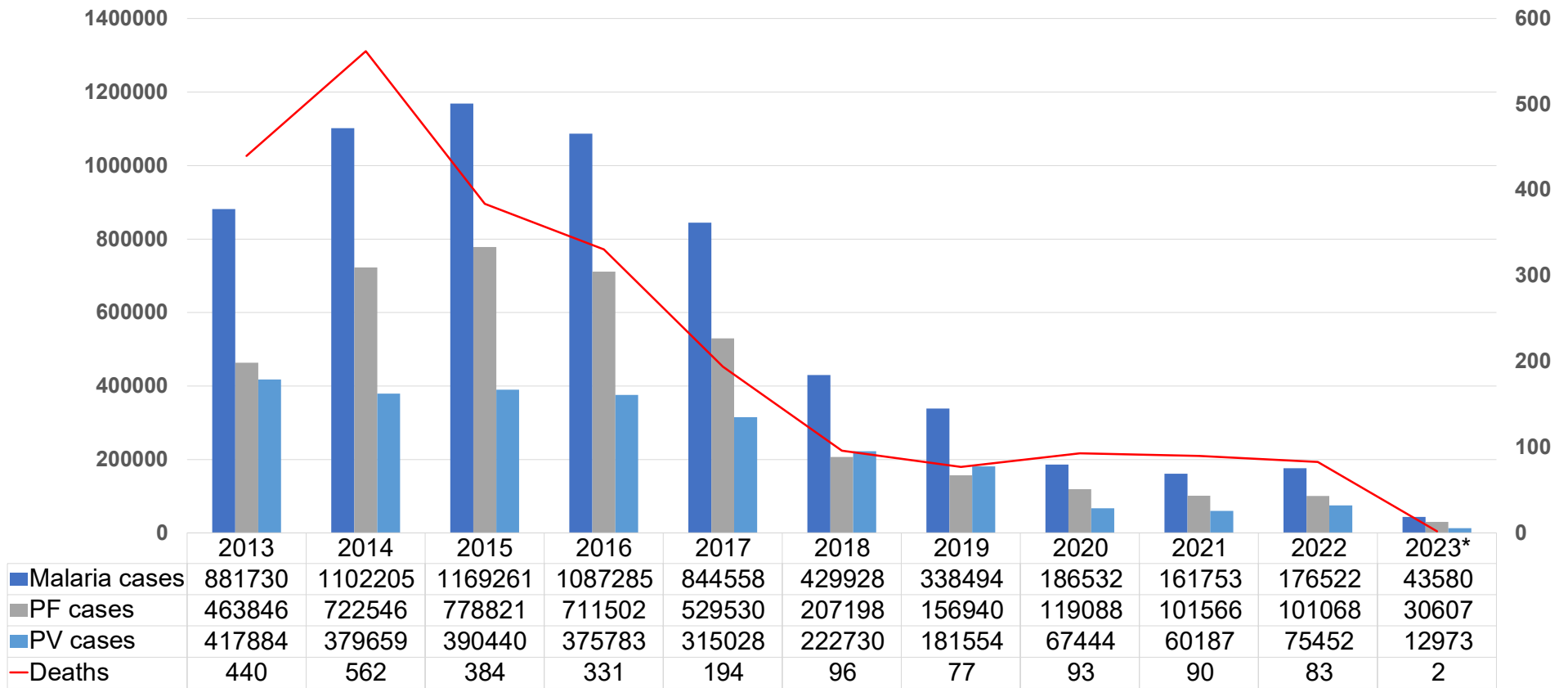


Trend of Imported Malaria cases in Saudi Arabia, Lancet 2013,382 (9895)



Trend of Community Malaria cases in Vishakhapatnam, 2018-2022, Data Source: NVBDCP

Trend of Malaria Cases and Deaths, India, 2013-23



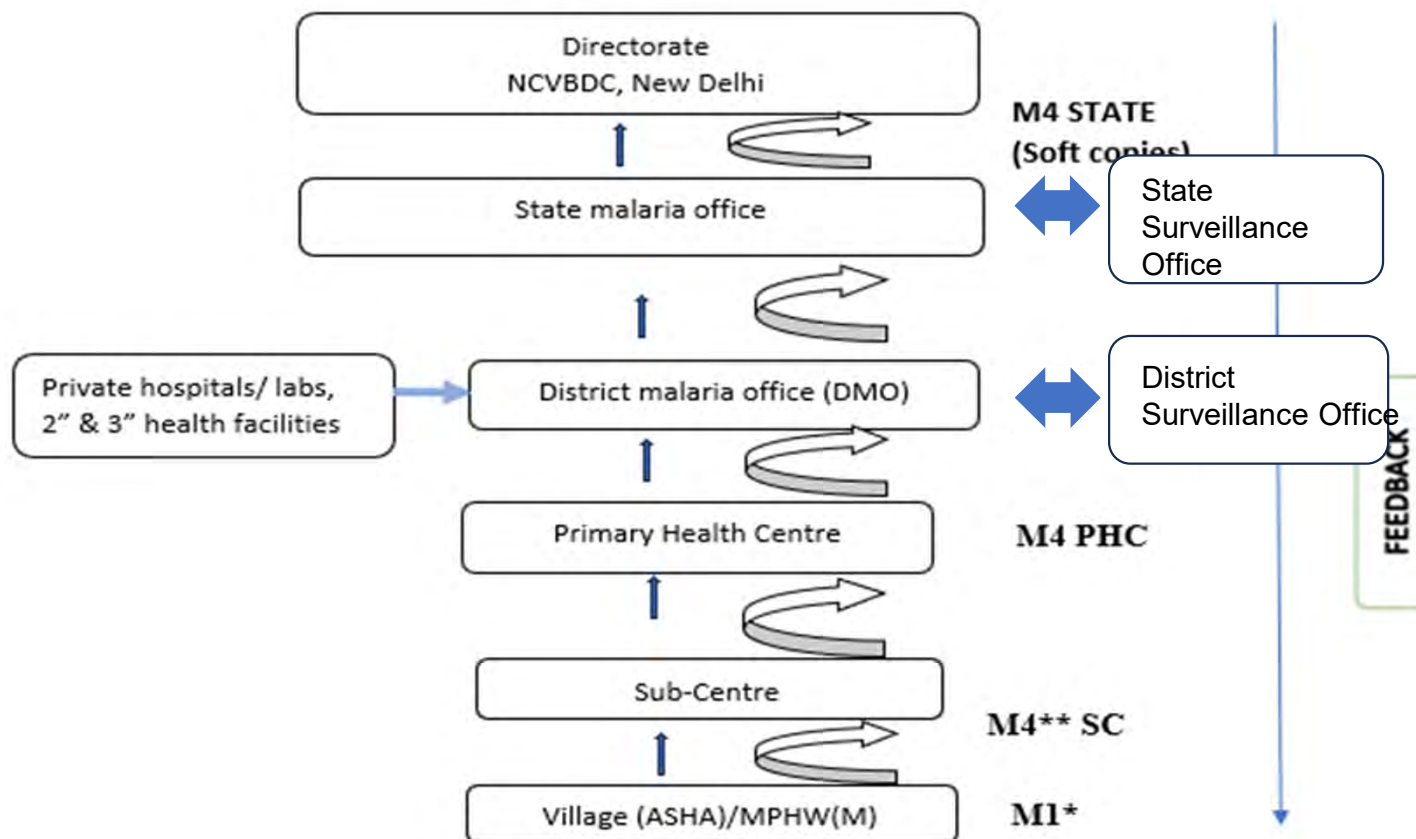
■ Malaria cases ■ PF cases ■ PV cases — Deaths

*Provisional data for 2023, NVBDCP

Malaria Surveillance Data Reporting in India

Malaria surveillance operates in 758 districts on two platforms

- Under the malaria program division of NCVBDC in M4 format (fortnightly/monthly) with 7 epidemiological indicators
- Under the IDSP-IHIP portal on a daily basis in P form and L form

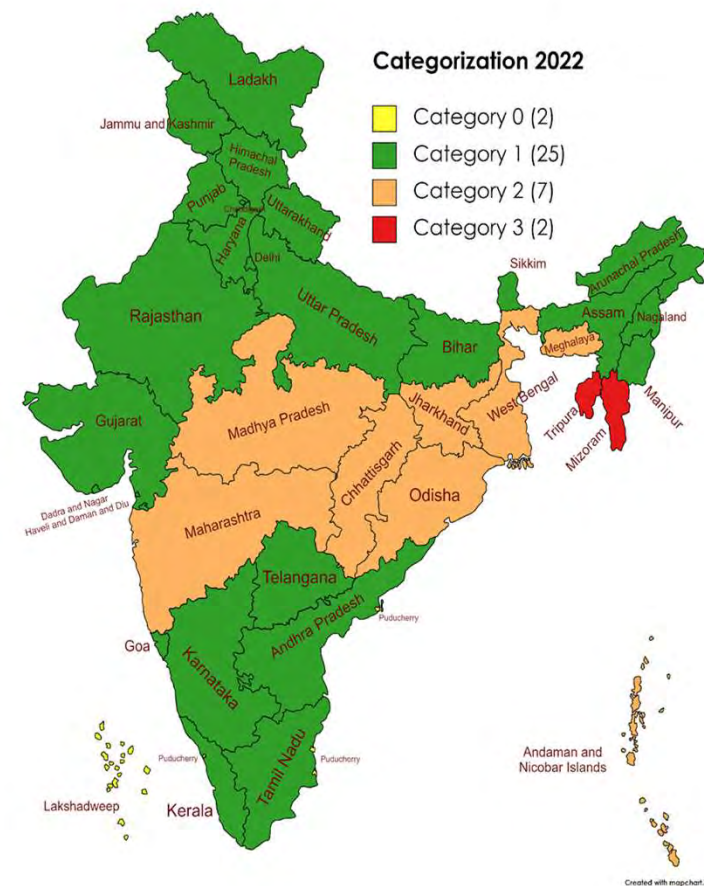


Categorization of Districts based on API in India

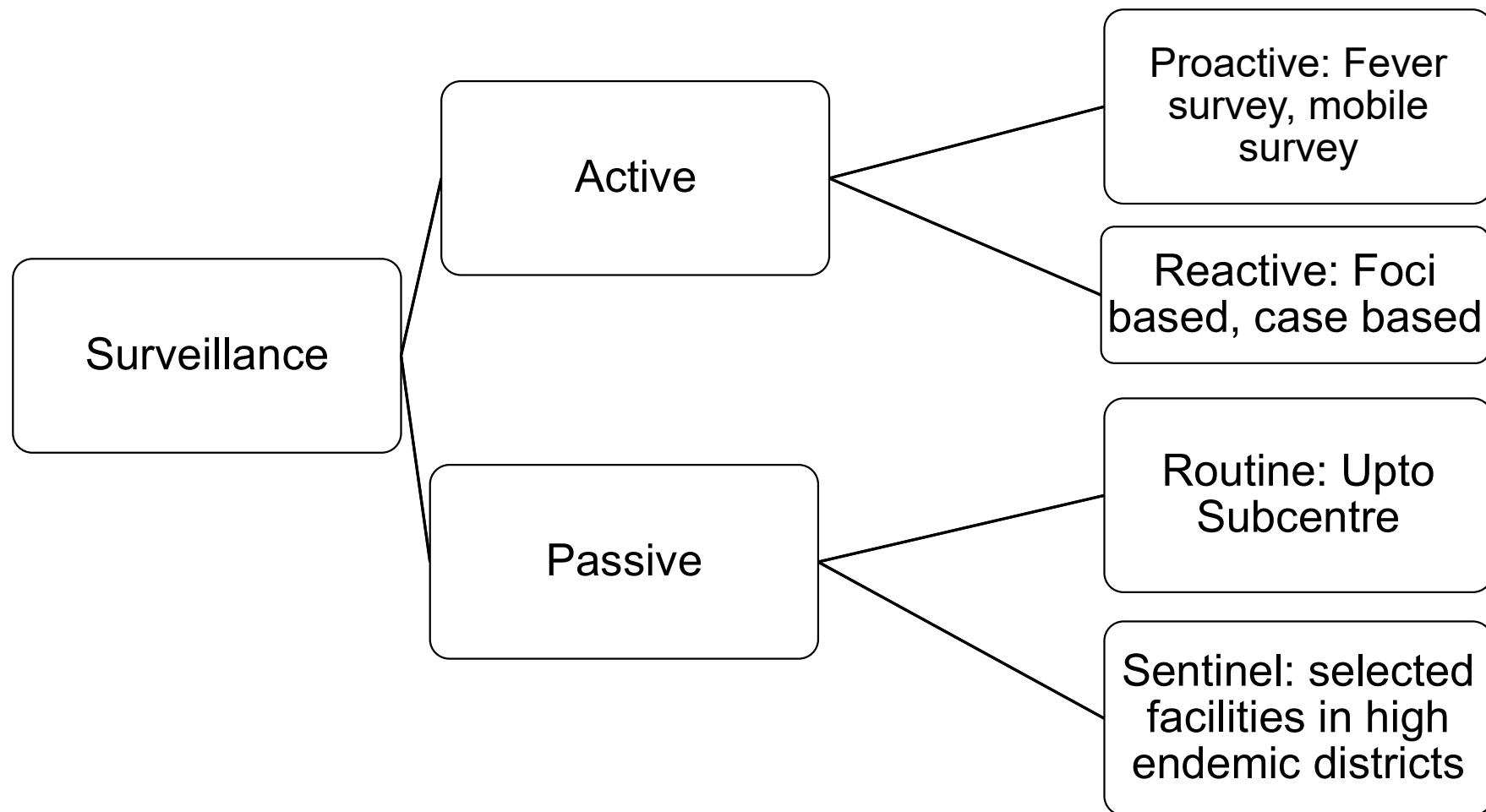
API: The number of new infections per year per 1000 population

cat	Phase	Definition
0	Prevention of re-establishment phase	States/ UTs with zero indigenous cases of malaria reported for last 3 years
1	Elimination phase	States/ UTs with API <1/1000 PopIn & their districts reporting API <1
2	Pre-elimination phase	States/ UTs with API <1/1000 PopIn & their districts reporting API ≥1
3	Intensified control phase	States/ UTs with API ≥1/1000 Population

In India, there are 8 high burden states with API >1 i.e., Jharkhand, Chhattisgarh, Odisha, Mizoram, Tripura, Maharashtra, Meghalaya, West Bengal, Andaman Nicobar Islands in 2022 (MP though in category 2 it is not under high burden district state)



Types of Malaria Surveillance for Data Capture



Estimates of Malaria risk calculated from Surveillance Data

General details: Health center name (SC/PHC/CHC/ Others), the residence of the patient, village Population, year of reporting, type of malaria, blood slides collected

Acronym	Abbreviation	Formula	
MBER/ABER	Monthly/Annual Blood Examination Rate	$\frac{\text{The number of slides examined + RDT in a month/year}}{\text{Total population}} \times 100$	Indicator of state /district performance as per targets set by program (surveillance indicator)
API	Annual Parasite Incidence	The number of new infections per year per 1000 population	Implies burden and quantifies transmission
AFI	Annual Falciparum Incidence	The number of new falciparum infections per year per 1000 population	(DTO) in terms of falciparum
Pf%	Plasmodium falciparum percentage	$\frac{\text{Pf cases in the year "Z"}}{\text{total malaria cases in the year "Z"}} \times 100$	Indicates the % of malaria cases can turn into severe malaria
SPR	Slide Positivity Rate	$\frac{\text{Total slides Positive} \times 100}{\text{Total slides examined}}$	Indicator of Burden and impact
SFR	Slide Falciparum Rate	$\frac{\text{Total slides Positive for falciparum and mixed} \times 100}{\text{Total slides examined}}$	

Estimates of Malaria risk calculated from Entomological Surveillance

1. Human landing rate = anophelines captured/person-night.
2. Infected mosquito = oocysts in stomach wall by dissection.
3. Infective mosquito = sporozoites in salivary gland by dissection.
4. Sporozoite rate = infective anophelines/anophelines captured.
5. Entomological inoculation rate = human landing rate \times sporozoite rate.
= infective mosquito bites/person-night.

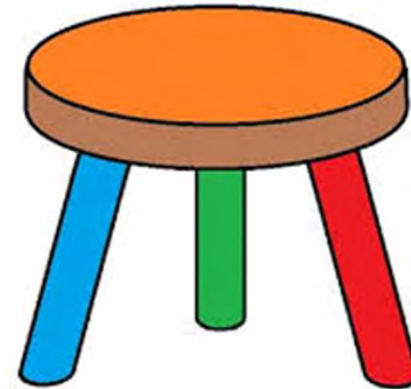
Estimates of Malaria risk calculated from Clinical Data

Table 1
WHO Criteria for Classification of Endemicity by Spleen Rates

Endemicity	Children aged 2–9yr (%)	Adults (>16 yr)
Hypoendemic	0–10	No measure
Mesoendemic	11–50	No measure
Hyperendemic	>50	“High” ($\geq 25\%$)
Holoendemic	>75	“Low” ($< 25\%$)

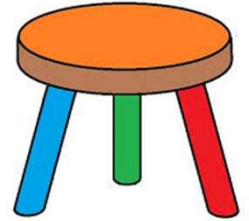
Three Pronged Approach for a Vector-borne Disease Outbreak investigation

- . Epidemiologic investigation
- . Laboratory testing
- . Environmental assessment



Three Pronged Approach for a Vector-borne Disease Outbreak investigation

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Outbreak investigations for:

- Characterizing outbreaks by time, place and person for risk assessment
- Identifying exposures and risk factors for outbreak
- Instituting evidence based control measures

Malaria outbreak in Mumbai

[Comments](#)

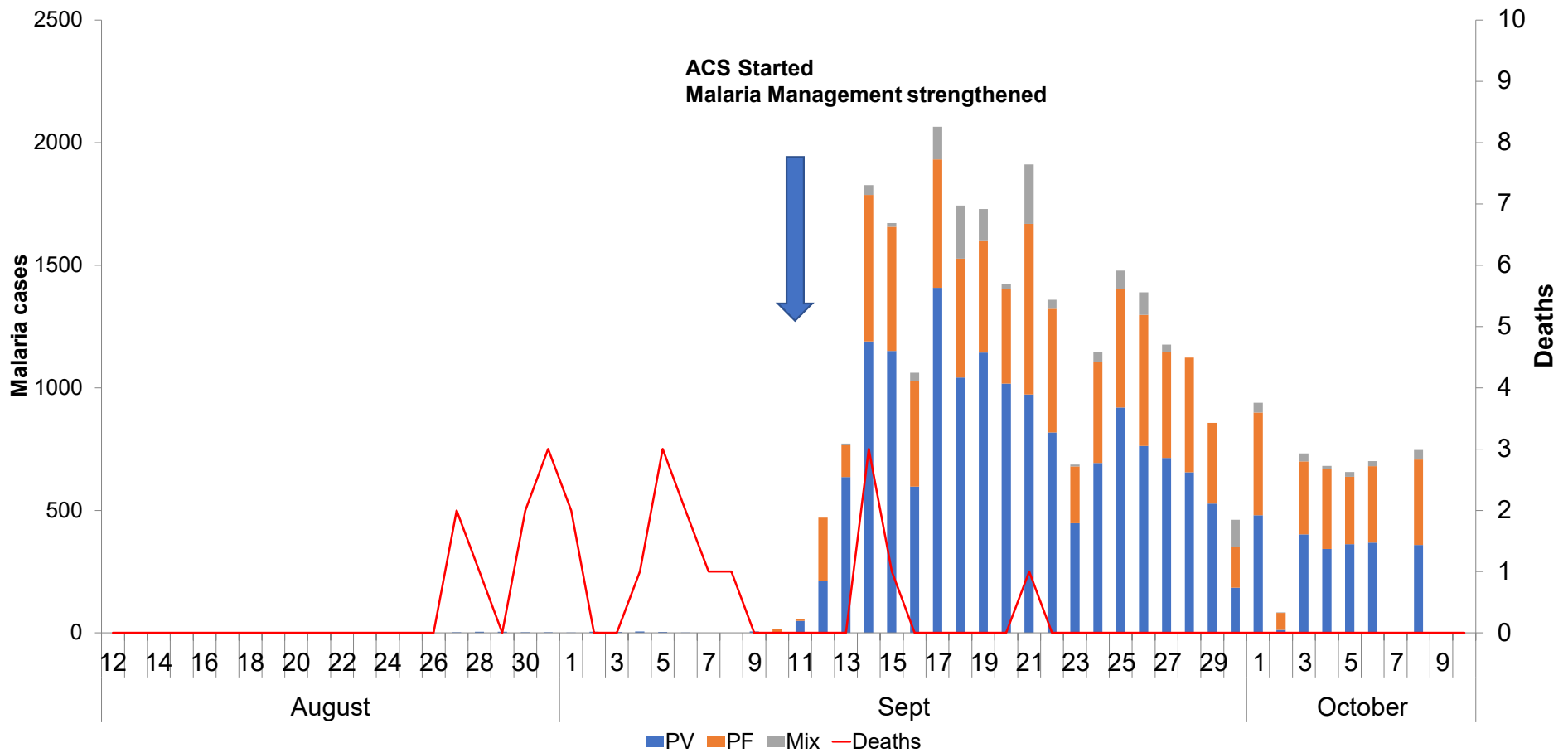
[Bookmark](#)

Mumbai - India is battling record levels of malaria infection in Mumbai, health officials said on Friday, with a similar number of cases in the first half of the year to the figure for the whole of 2009.

Authorities in the financial hub have drafted in experts from Medecins Sans Frontieres to tackle an outbreak which has seen nearly 4 000 cases this month alone, with the most virulent form of the potential killer having struck 10% to 15%.

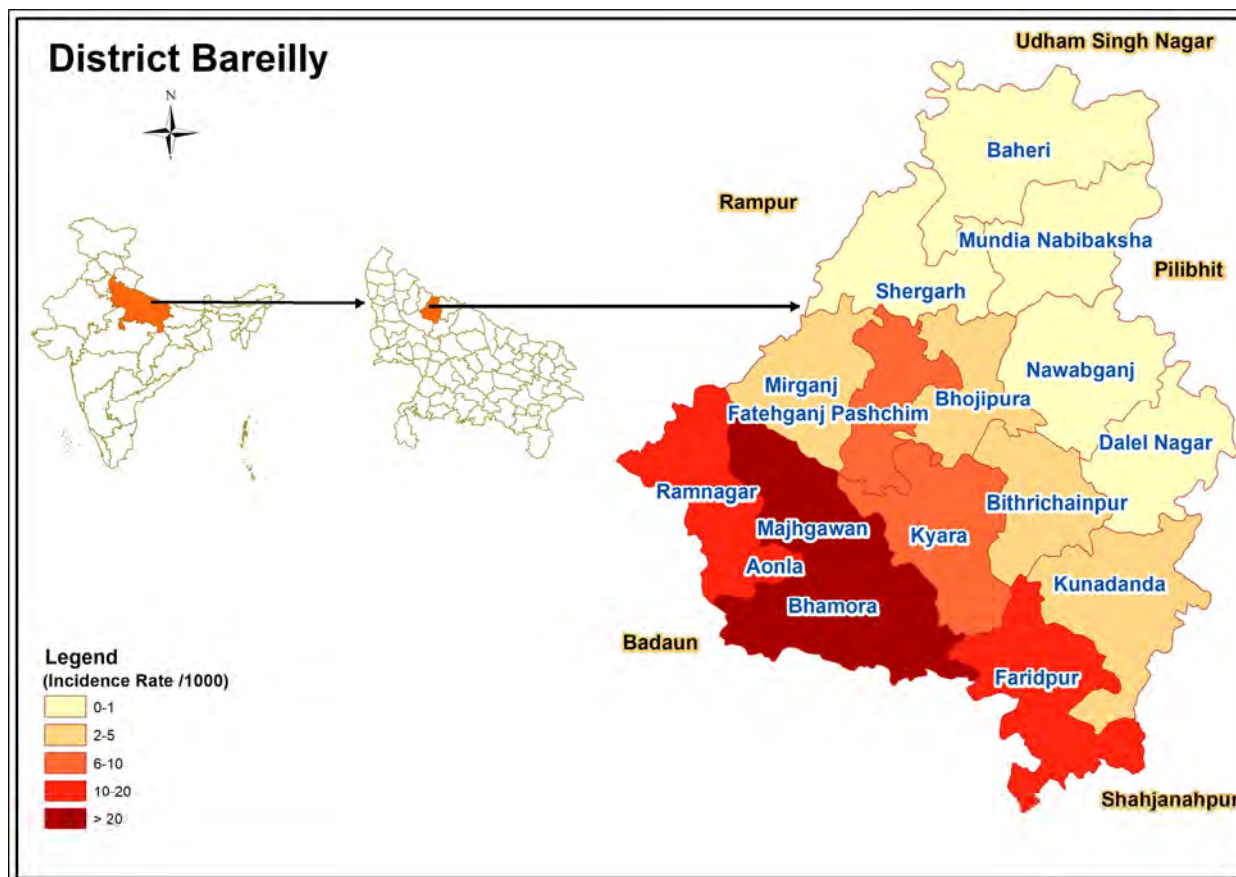
"It's an exceptional year. We're definitely seeing a rise in cases. It's a record number," said assistant health officer Dr Daksha Shah.

Distribution of Lab Confirmed Malaria cases by Date of Detection, Bareilly District, Uttar Pradesh, 16 Aug -7 Oct, 2018 (N=28, 998)



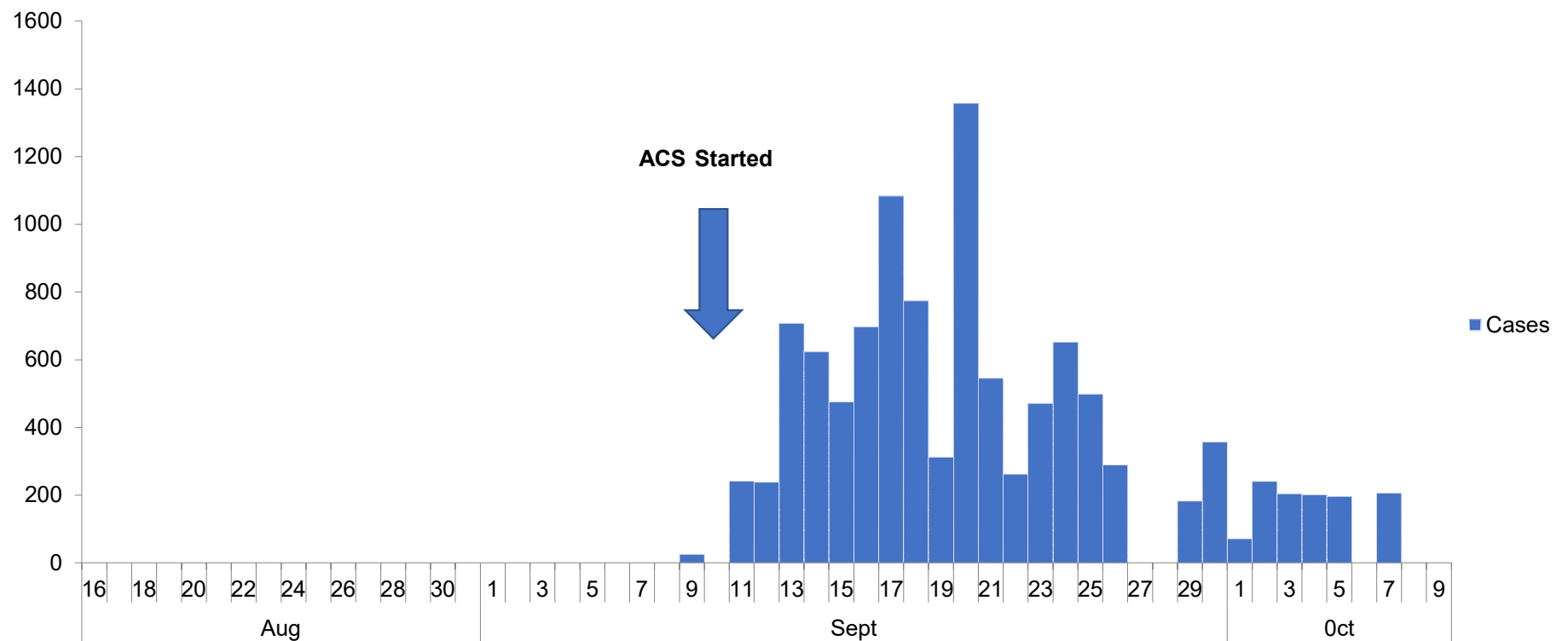
Source: EIS Programme, NCDC, Govt of India

Confirmed Malaria cases Block wise, Bareilly District, Uttar Pradesh, 16th August - 24th September, 2018 (N=28, 998)



Source: EIS Programme, NCDC, Govt of India

Distribution of Confirmed Malaria by Date of Detection, Block Majhgawan, Bareilly, Uttar Pradesh, India 16 August- 7 October 2018 (N=10,902)



Source: EIS Programme, NCDC, Govt of India

Distribution of Malaria Confirmed cases in Majhgawan, District Bareilly, Uttar Pradesh, August-September 2018 (N=4,709)

Cases	N	n/N (%)
Male	2488	53
Median age in year	19(3 month-95 year)	
Child < 5year	423	9
6-15 year	1604	34
16-40	1987	42
>40 year	695	15

Source: EIS Programme, NCDC, Govt of India

Lab Confirmed Malaria Cases, Majhgawan Block, Bareilly, Uttar Pradesh, India 16 August-8 October 2018

Lab confirmed Malaria cases	10902
Total PV cases, n (%)	4370(40%)
Total PF cases, n (%)	5313(49%)
Total Mix cases, n (%)	1216(11%)
Total deaths due to Malaria	3
Total affected villages, n (%)	123 (83%)

Adult Mosquito Affected Villages, Bareilly, Uttar Pradesh, India 16 August-8 October 2018

Districts	S.No.	Name of Village	Species	PMHD	PRD
Bareilly	1.	BehtaBujurg	<i>An. Culicifacies</i>	3.0	-
	2	<i>Kandharpur</i>	<i>An. Culicifacies</i>	5.5	ND
	3	<i>Manona</i>	<i>An. Culicifacies</i>	5.0	2.0
	4	<i>KundaraiKhurd</i>	<i>An. Culicifacies</i>	2.0	ND
	5	<i>Rampura</i>	<i>An. Culicifacies</i>	-	0.5
	6	Andupura	<i>An. Culicifacies</i>	5.0	1.5

Source: EIS Programme, NCDC, Govt of India

Larval Survey from Affected Villages, Bareilly, Uttar Pradesh, India 16 August-8 October 2018

Districts	S.No.	Area Surveyed	Species Identified	Density /Dip	Breeding site
Bareilly	1.	BehtaBujurg	<i>Cx. vishnui</i> <i>Cx. tritaeniorhynchus</i>	5	Pond and rice fields
	2	<i>Kandharpur</i>	<i>Anopheles sps</i>	6	Rain water collection
	3	<i>KundaraiKhurd</i>	<i>Anopheles sps</i>	10	Clean stagnant water
	4	Andupura	<i>Anopheles sps</i> <i>Cx. tritaeniorhynchus</i>	5 5	Pit Rice field

Source: EIS Programme, NCDC, Govt of India

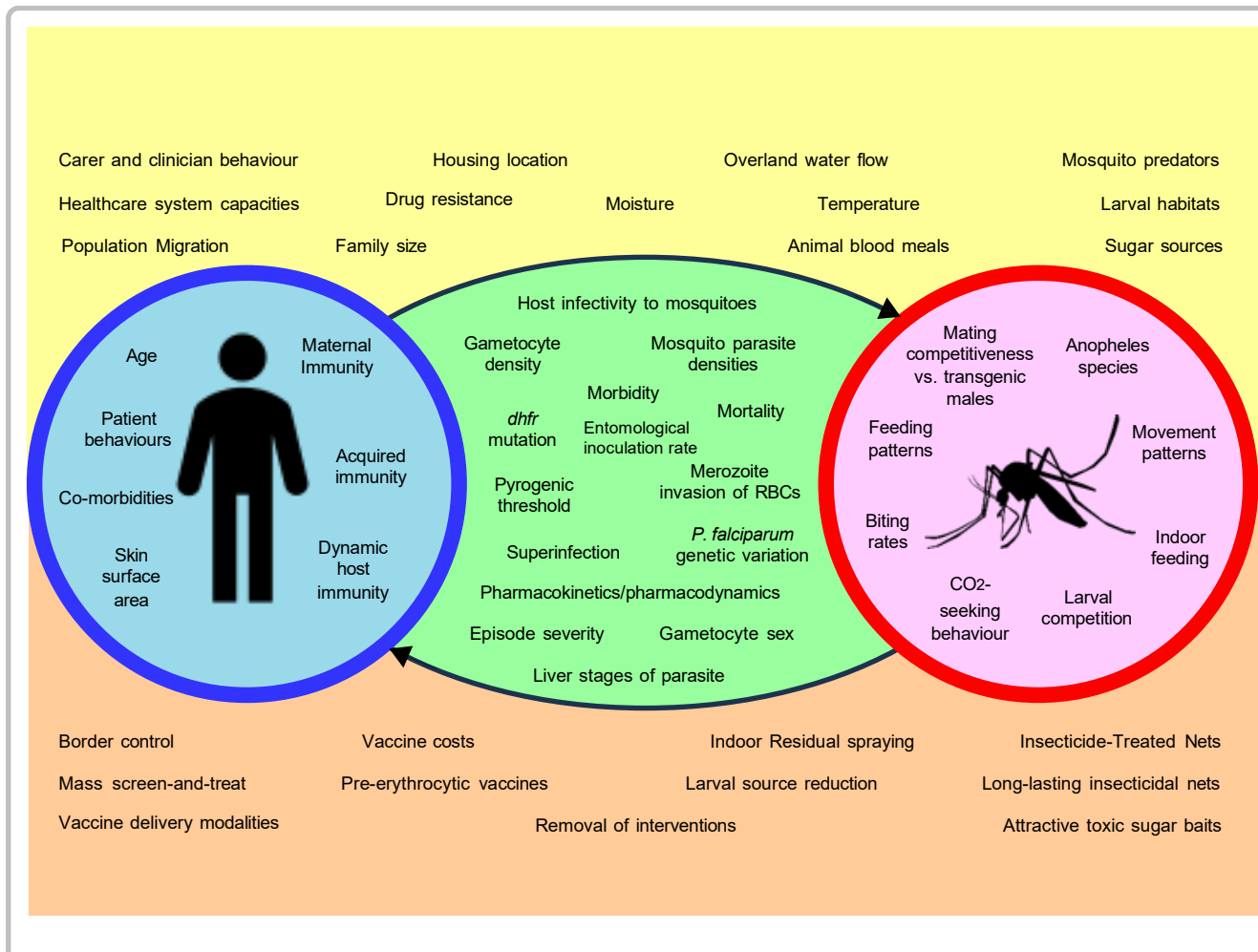
Host related Exposures in Malaria cases, Block Gangeshwari, District Amroha, Jan-Feb 2023

Exposure	Confirmed		Suspect	
	n	%	n	%
Personal factors				
Sleeping outside house	04	24	-	-
Outside stay after evening	12	71	-	-
Use of Mosquito repellents	9	53	37	16.9
Full sleeved clothing when outside	7	41	-	-
Use of Mosquito net	5	29	55	25.2
Rearing of cattle	5	29	-	-
Mesh on windows	1	6	17	7.8

Environmental Exposure in Malaria cases, block Gangeshwari, District Amroha, January 2023

Exposure	Confirmed		Suspect	
	n	%	n	%
Open drain/ ditches (within 1 km)	15	88	156	71
Puddle around house	15	88	-	-
Ponds nearby (within 1 km)	13	76	51	23
Empty artificial container around house	8	47	-	-
Waste collection around house	7	41	-	-
Semi-pukka house	6	35	-	-
Kuccha floor of house	6	35	-	-
Ongoing construction sites	5	29	-	-
House with open holes/ crevices in the walls	3	18	-	-
Entomological				
Presence of larval breeding sites	5	29	-	-

Summary of Factors in the Epidemiological Triad influencing Malaria Transmission



Conclusion and Way Forward

- Malaria continues to be a public health challenge in India
- Elimination by 2030 possible if we optimize use of available tools of epidemiological and entomological surveillance, outbreak investigation, monitoring vector control and treatment of cases
- Malaria modelling can serve as a supportive tool in forecasting and evaluating field interventions



Thank you

Case Definition

- **SUSPECTED MALARIA CASE:** Illness suspected by a health worker to be due to malaria, after ruling out other obvious causes of fever (as per operational guidelines of malaria 2016)
(A patient with fever and no other obvious cause of fever (IDSP))
- **CONFIRMED MALARIA CASE:** Malaria case or infection in which the parasite has been detected by a diagnostic test, i.e., microscopy, rapid diagnostic test, or molecular diagnostic test (as per operational guidelines of malaria 2016) (A suspected case with positive malaria parasite in peripheral blood smear detected through microscopy or positive antigen based detecting Rapid Diagnostic Tests or positive molecular diagnostic test (IDSP))

Category wise distribution of States in 2015 and status in 2020

CATEGORIES	STATES/ UTs (2015)	Status in 2020
Category 1 States with API < 1 case/1000 population in all Districts	Delhi, Goa, H P , J & K, Kerala, Lakshadweep, Puducherry , Sikkim, Chandigarh, Daman & Diu, Haryana, Manipur , Punjab, Rajasthan , Uttarakhand (15)	Delhi, Goa, H P , J & K, Kerala, Lakshadweep, Puducherry , Sikkim, Chandigarh, Daman & Diu, Haryana, Manipur , Punjab, Rajasthan , Uttarakhand, Andhra Pradesh, Nagaland, Tamil Nadu, Karnataka, Assam, Gujarat, Telangana, Bihar, Arunachal Pradesh, Dadra & Nagar Haveli, Ladakh (25)
Category 2 States with API < 1 but some districts having API \geq 1	Andhra Pradesh, Bihar , Nagaland, Tamil Nadu, Telangana, West Bengal, Assam , Gujarat, Karnataka , Maharashtra, Uttar Pradesh (11)	Uttar Pradesh, Madhya Pradesh, Maharashtra, Jharkhand, West Bengal, Odisha, Tripura, Meghalaya, Andaman & Nicobar Island (9)
Category 3 States with API \geq 1 per 1000 population	A & N Islands, Arunachal Pradesh, Madhya Pradesh, Mizoram, Chhattisgarh, Dadra & Nagar Haveli, Jharkhand, Meghalaya, Odisha, Tripura (10)	Mizoram, Chhattisgarh (2)

Reporting forms used to capture epidemiological data

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M1 form	Report of malaria surveillance by ASHA / health care provider / health facility
M2 form	Slide examination request to laboratory
M3 form	Laboratory register of slide examination in laboratory
M4 form	Fortnightly report of malaria surveillance from subcentre / PHC / district / State