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Research Article

Entomological Surveillance and Vector Management Towards Malaria Elimination in India

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A B S T R A C T

Entomological surveillance and vector control are interlinked and have been the core interventions towards malaria control or elimination. Entomological surveillance facilitates decision-making for an effective vector control strategy, selection of tools, and tackling insecticide resistance. India's goal to eliminate malaria is to achieve zero indigenous cases by 2027 in all the districts and sustain it for 3 years. The strategic plan is primarily based on surveillance (epidemiological & entomological), parasite and vector management. The entomological surveillance in India is institutionalised through 103 entomological zones and additional support from a few identified institutes of the Indian Council of Medical Research (ICMR) and the National Centre for Disease Control (NCDC).

The vector control for malaria elimination includes larval source management (LSM) and adult control (reducing density and longevity). Targeting the aquatic immature stages of mosquitoes referred to as LSM is the core intervention in urban areas of the country. It focuses on permanent or temporary disruption of standing water and regular application of biological or chemical control to water bodies to eliminate or reduce larval density. Adult mosquito control is to achieve a reduction in vector survival (longevity) and vector density, interrupting malaria transmission. The use of LLINs and IRS is effective against endophagic and endophilic vectors. The updates on entomological surveillance and vector control interventions for malaria elimination have been described in this paper.

Keywords: Entomological Surveillance, Vector Control, Malaria Elimination

Introduction

National Centre Vector Borne Disease Control (NCVBDC), Ministry of Health & Family Welfare, Government of India launched the National Framework for Malaria Elimination (NFME)[1], 2016-30 and Operational manual for Integrated Vector Management in India[2] in 2016, followed by National Strategic Plan for Malaria 2017-22[3] and Operational Manual for Malaria Elimination in India 2016[4] in 2017 towards commitment to malaria elimination by 2030. Malaria elimination in India is planned to be carried out in a phased manner. The National Strategy Plan 2017-2022 has been developed in alignment with NFME. This strategy sets ambitious but attainable goals for 2030, with milestones along the way to track progress. Entomological surveillance and vector control are cornerstones of any malaria control or elimination programme.

Entomological surveillance provides critical information on vector species, their distribution, density, bionomics and resistance status to insecticides used for malaria control. The emphasis has been indicated in the Manual on Integrated Vector Management in India 2022.[5] Vector control for malaria is based on two core interventions: indoor residual spraying (IRS) with insecticide and long-lasting insecticidal nets (LLINs), although in some settings larval source management (LSM) or personal protection measures are also used to supplement. LLINs and IRS with high coverage have been effective in reducing malaria. It has been reported that between 2000 and 2015, 68% of the 663 million malaria cases were averted globally due to the use of insecticide-treated nets alone.

Residual malaria transmission persisting in certain areas even after high coverage of intervention needs to be monitored for additional or more appropriate interventions to minimise human-vector contact. Entomological surveillance data in such situations combined with human behaviour data helps in identifying the gaps in protection and local determinants of transmission. Identifying such gaps facilitates intervention tools and tailoring them for use locally.

Entomological Surveillance

The vector surveillance needs to be tailored according to different situations. Malaria elimination has been planned in a phased manner stratifying the states and districts into high, moderate and low categories. The entomological surveillance also needs to be prioritised accordingly considering the major challenge of skilled human resources to undertake complete entomological monitoring. The country initiated entomological monitoring by putting biologists and insect collectors under the urban malaria scheme (UMS) in 1971.[6] The structured entomological surveillance[7] across the country was established in 1977 through 77 entomological zones covering 4-5 districts per zone which has now been increased to 103. These zones and some institutes of ICMR and NCDC are generating the data, however, they need to monitor in a uniform manner, especially on prioritised entomological parameters in different situations.

Entomological Surveillance in Different Transmission Settings

With the progress towards approaching the target of elimination, more areas are expected to be converted from high or moderate to low endemicity and ultimately with zero indigenous transmission. The entomological activities suggested to be prioritised for the areas during the elimination strategy are as below:

High-to-moderate Transmission Area

- Undertake preliminary surveys to generate vector occurrence data
- Identification of sentinel sites based on preliminary surveys and undertaking regular entomological surveillance to monitor the trend
- Adult vector density

Low-transmission Areas

- Regular Vector surveillance in sentinel sites
- Vector surveillance through Spot checks in persistent transmission areas

Very Low Transmission & Elimination

The areas entering into the very low or zero indigenous transmission category, the priority will be accorded to:

- Regular entomological surveillance to generate information on receptivity and recommended interventions specific to areas within feasible resources.
- Reallocation of sentinel sites to ensure they act as representatives for the area within vector influence.
- Intensified surveillance in new or resurgent foci.

Entomological Surveillance During Foci Investigation

Foci investigation has to include data from routine entomological surveillance at sentinel sites, data from spot check sites and additional entomological investigations if undertaken for any possibility of local transmission. The entomological surveillance during foci investigations should identify the features of the location, populations at risk, ongoing control measures, the vector species responsible for transmission, breeding places and insecticide resistance status during the last 4-5 years.

The minimum essential entomological parameters for malaria elimination have been depicted in Figure 1.

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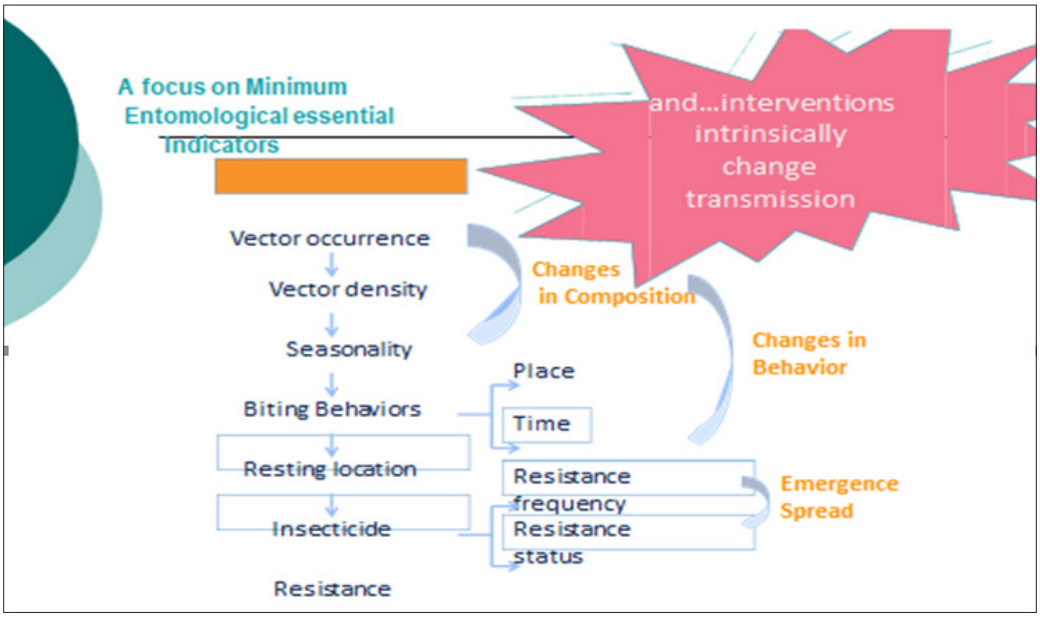

Figure 1.Essential Indicators for Malaria Elimination

Insecticide Resistance Monitoring

Widespread resistance among malaria vectors necessitating on selection of appropriate effective insecticide has been well documented in many publications. Among the six primary vectors of malaria in India, resistance to DDT has been widespread in *An. culicifacies.* The major threat to the malaria elimination programme is multiple-insecticide-resistance[8] in *An. culicifacies* which needs immediate attention for resistance management as this species is responsible for transmission of malaria cases across the country. Insecticide resistance monitoring (IRM) thus becomes an important parameter to facilitate decision-making to select appropriate insecticides for IRS. The management of resistance following WHO standard protocol becomes crucial especially when not much choice is available for the IRS as well as for LLIN. WHO has published the guidance document "Global plan for insecticide resistance management in malaria vectors" (GPIRM)[9], which, however, need to be considered for its suitability in local situation.

Vector Control

Six Anopheles species, *An. culicifacies, An. fluviatilis, An. baimaii, An. stephensi, An. epiroticus,* and *An. minimum*, have been identified as primary malaria vectors in India. In addition, *An. annularis, An. philippinensis,* and *An. varuna* are the secondary malaria vectors.

Vector control remains an essential component of malaria control and elimination as reemphasised in Mosquito and other Vector Control Response[10] (MVCR) 2020. Universal access to malaria prevention can be achieved by enhancing vector control strategies. The specific objectives are to maintain adequate integrated entomological surveillance and monitoring, determine and update the distribution, population density and larval habitats, update insecticide resistance status, strengthen capacity for evidence-driven vector control, and suggest changes in IVM strategy including insecticide resistance management. The activities related to vector control in different situations need different approaches to achieve maximum gains. These activities may be grouped broadly for elimination and pre-elimination situations recommended under the programme (Figures 2 and 3).

Feasible Vector Control Interventions

Indoor Residual Spray: Indoor Residual Spraying (IRS) is implemented by prioritising high-risk areas with proper district-wise micro plans indicating the caseload. Currently, Malathion and Synthetic Pyrethroids are used under the programme. The areas to be covered under regular rounds of IRS are identified and prioritised based on annual parasite incidence (API), which may gradually narrow down to focal spray in and around 50 houses of a malaria-positive case. The areas under the influence of multiple vectors may need entomological intelligence and more attention especially to cover the entire transmission period.

LLIN: The use of Long-Lasting Insecticidal Nets (LLINs) is another core strategy being implemented under the programme in high-burden areas. LLINs in the areas already distributed need to be sustained by replacement till zero transmission is achieved. In addition, LLIN distribution and its usage in areas of new cases and/ or vulnerable populations need to be ensured. The flexibility for distribution to achieve universal coverage in such identified areas in varying situations also needs to be advocated and monitored.

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- To map potential vector breeding sites including hidden sites.
- Regular adult vector monitoring (prevalence and density)
- Environmental management by involving relevant agencies in both rural and urban areas.
- Biological control - larvivorous fish
- Foci-based adult vector control interventions – in and around 50 houses of positive cases.
- (Focal IRS in rural areas/slums but in urban areas- Space spray followed by IRS)

Figure 3.Category 2/3 (Pre-elimination/ Control)

- Universal coverage with LLINs of all sub-centres with API above 1.
- Two regular rounds of supervised IRS (sub-centre as unit) in areas above API 1, if not covered with LLIN.
- LLIN intervention to be ensured in already LLIN covered areas with or without upsurge in cases.
- Additional round of IRS in outbreak situations.
- Larval source management (LSM) through source reduction, larvicides, biological control and environmental measures. Urban areas with focus in slums to be ensured with LSM.

Figure 2.Category 0 (No Case) and Category I States (Elimination)

Larval Source Management: Adequate advocacy is to be ensured especially at the community level and with other stakeholders on the non-creation of mosquito genic conditions. Mapping of permanent breeding habitats is a prerequisite for larval source management to ensure that these are few, fixed and findable and can be managed within the available resources. Temephos, Bio-larvicides and Insect Growth Regulators are recommended tools for larval control in all urban areas. The use of larvivorous fish is also promoted under the programme in collaboration with the Fisheries Department, Civil Society Organisations, Village Health Sanitation and Nutrition Committee (VHSN&C) under the National Health Mission and other local bodies. Reduction of larval breeding sources using environmental engineering methods are though part of guidelines, the stakeholders creating such breeding sites need to be accountable for LSM in such sites.

Vector Control in Emergency Situations

Vector control by fogging with technical Malathion/ Pyrethrum/ Cyphenothrin for immediate killing of infected/ infective mosquitoes is recommended for containment of an outbreak. WHO does not recommend space spray for malaria; however, these are still recommended only for outbreak containment. Indiscriminate use of fogging by local bodies may lead to non-judicious use of insecticide and also wastage of resources.

Environmental Code of Practice (ECOP)

Environmental Code of Practices (ECoPs)[11] on safety precautions for the use and handling of insecticides are crucial parts for those handling insecticides. Comprehensive guidelines were prepared and disseminated to states and are also available on the website. Such guidelines need to be regularly shared with all states and service providers to adhere to them.

Conclusion

Entomological surveillance and vector management are parallel tools for the control or elimination of any vector-borne disease along with parasite control. The ignorance regarding entomological surveillance may lead to improper vector control resulting in the precipitation of insecticide resistance and ultimately landing with no effective

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insecticide available for the programme. Simultaneously a paradigm shift is needed to know where and when the interventions will work; where and when interventions will NOT work; how transmission adapts to interventions and where extra domiciliary transmission occurs. For malaria elimination, there is a need to know WHERE and WHEN present transmission is coming from and such problems can be resolved with entomological inputs only.

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