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Research Article

Vector Control Options Under Elimination Settings of Malaria, Lymphatic Filariasis, Visceral Leishmaniasis and Validation Tools

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The National Center for Vector Borne Diseases Control (NCVBDC) covers the programme for the prevention and control of vector-borne diseases namely malaria, lymphatic filariasis (LF), visceral leishmaniasis (VL), dengue, chikungunya and Japanese encephalitis (JE). Malaria, VL and LF have been targeted for elimination. The states are responsible for programme implementation, whereas the NCVBDC, GoI, provides policy guidance, technical assistance and support to the states in funds and commodities. The goal of elimination by 2030 is aligned with the sustainable development goal (SDG), however, showing the progress, VL elimination has been scheduled to be achieved by 2023 and LF by 2027 as a political commitment and optimistic approach. The core strategies for elimination remain surveillance, case detection, treatment/ management and vector control along with supportive interventions. As we approach from control to elimination, the number of active cases will be reduced and the area will be marked as low endemic. Further efforts on interruption of disease transmission will make the area free from indigenous transmission but the surveillance both on case detection and vector prevalence, its longevity and infectivity need to be sustained. Parasitological confirmation in routine surveys or sentinel/ random surveys to detect imported or indigenous cases is made through established systems under primary health care, however, entomological surveillance to take appropriate vector control needs experts with special skills. Integrated vector management (IVM) will facilitate for long-term sustenance of interrupted transmission and provide documentary evidence for certification of elimination.

The elimination certification is processed based on the evidence of zero indigenous transmission of malaria, interruption of transmission below the specified threshold in the case of LF and bringing down VL cases to less than 1 per 10,000 population at the block level. To generate such evidence, various entomological tools and parameters are recommended which have been discussed in the paper.

Introduction

The National Center for Vector Borne Diseases Control (NCVBDC), under the Ministry of Health and Family Welfare, Government of India is the nodal agency to look after the programme for prevention and control of vector-borne diseases namely malaria, lymphatic filariasis (LF), visceral leishmaniasis (VL), dengue, chikungunya and Japanese encephalitis (JE).[1] Out of these six VBDs, Malaria, VL and LF have been targeted for elimination.[2–4] The government of India provides technical, financial and commodity support to the states that are the implementing agency. The Sustainable Development Goals (SDGs)[5] are the guidance document (blueprint) to achieve a better and more sustainable future for all. They address the global challenges related to poverty, inequality, climate change, environmental degradation, peace and justice. The 17 Goals are set to be achieved by 2030 and out of these 17 goals, SDG 3 is to ensure healthy lives and promote well-being for all. The health goal focuses on NTDs and Universal Health Coverage (UHC). Malaria elimination by 2030 is set to align with SDG, however, VL elimination by 2023 and LF by 2027 is targeted as a political commitment and optimistic approach.[6]

Vector Borne Diseases (VBDs) targeted for elimination have to be tackled through meticulously planned and supervised execution of programme strategies by well-trained epidemiological and entomological experts. Elimination has been planned with strategic implementation in a phased manner. The core strategies for elimination remain surveillance, case detection, treatment/ management and vector control along with supportive interventions. As we approach from control to elimination, the number of active cases will be reduced and the area will be marked as low endemic. Further efforts on interruption of disease transmission will make the area free from indigenous transmission but the surveillance both on case detection and vector prevalence, its longevity and infectivity become very crucial to be monitored. In addition, monitoring of receptivity and vulnerability along with other determinants is to be intensified under surveillance. Parasitological confirmation in routine surveys or sentinel/ random surveys to detect the imported or indigenous cases are made through established systems under primary health care, however, for entomological surveillance to take appropriate vector control, experts with special skills are needed as knowledge of vectors guides to use the appropriate VC in proper manner and suitable time. The core options of vector control are indoor residual spray (IRS), use of long-lasting insecticidal nets (LLINs), larval source management (LSM) and environmental management. These options are recommended for judicious use considering their feasibility under Integrated vector management (IVM).[7,8]

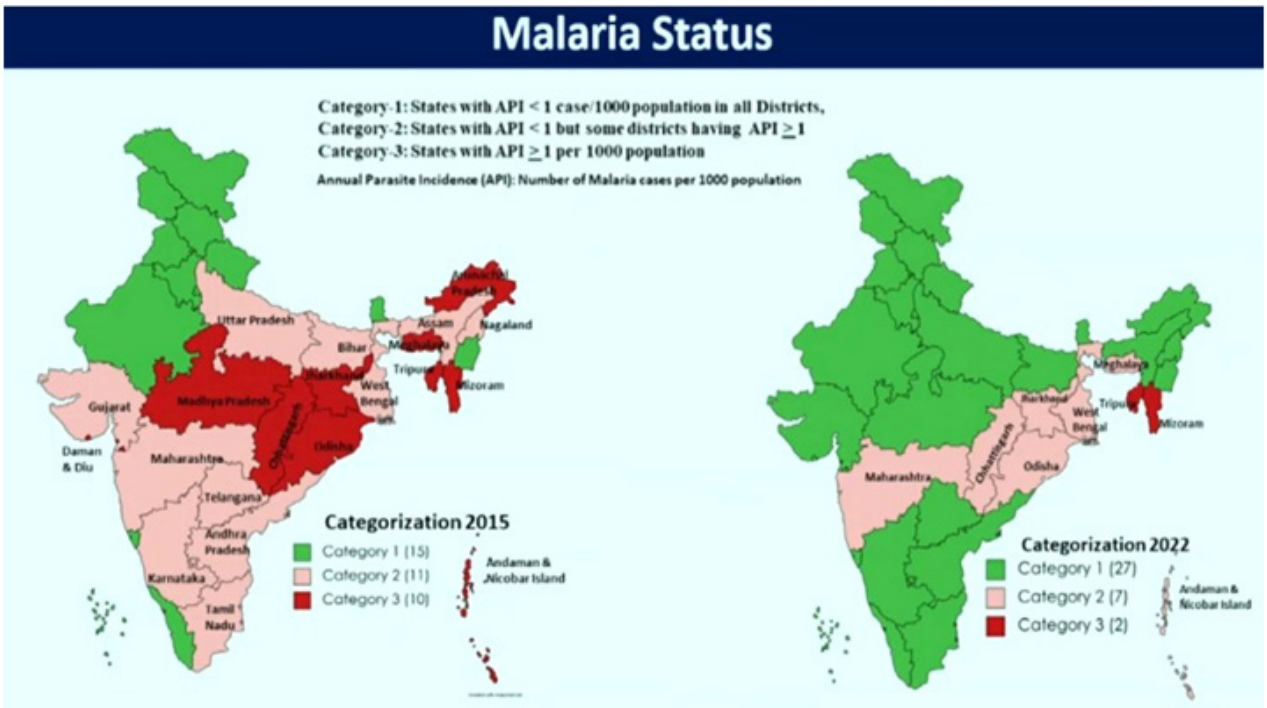

Figure 1.Malaria Status in India

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In India, malaria is endemic in almost whole of the country except a few high-altitude areas (Figure 1). It is estimated that 1.4 billion people live at risk of this disease. India has significantly reduced malaria cases as per reports received from states indicating 173,000 detected positive for malaria in 2022 which is over an 80% decline in comparison to reported cases in 2015.[9] Malaria elimination is guided by a strategic approach which can broadly be grouped into three.[4] The first is parasite elimination and disease management encompassing early case detection and complete treatment; use of new diagnostic tools and combination therapy; epidemic preparedness and rapid response. The second one is integrated vector management (IVM), which includes indoor residual spray (IRS) in selected high-risk areas; use of long-lasting insecticidal nets, augmenting use of larvivorous fish and anti-larval activities especially in urban areas. The third group of strategic approach includes supporting interventions which focus on human resource development for strengthening capacity and capability, behaviour change communication (now being changed to social behaviour change communication) and monitoring and evaluation (M&E) of the programme implementation activities.

Even with this kind of robust strategy and implementation by various states, there are variations from area to area leading to roadblocks for malaria elimination which are usually attributed to migratory populations because of problems in tracking and administering complete treatment and follow-up; persistence of asymptomatic malaria posing problem in its detection and radical treatment. Persistence of residual transmission and its liquidation through foci investigation are the challenges expected as we approach elimination.

On the vector's side, the problem with exophilic and exophagic vectors responsible mainly for outdoor transmission is one of the major challenges for the ineffectiveness of control tools designed primarily for malaria control through indoor transmission.[10] The feasibility of its implementation and effectiveness for outdoor transmission needs a relook because old tools and technology may not work as effectively as it does for indoor transmission.

The roadblocks to malaria elimination are coupled with the invasion of vectors to new areas bringing them under the influence of multiple vectors.[11] The effect of new primary and secondary vectors is also the challenge being faced by the public health programme.

Surveillance being a core strategy defined by WHO has also challenges for public health, workers as it also encompasses cases to be identified by the institutional system reporting through passive and active surveillance - the backbone of the surveillance system. Once the case is diagnosed, it is to be notified for which the basic information is to be collected and informed to the appropriate authorities. This is to be followed by a case investigation to identify the likely location of the infection, it has been contracted and spread of infection during its infection period. The basic issue of workload to be completed by the public health workers of which, the inadequacy is being flagged everywhere.

On entomological surveillance, the role of entomologist and vector control experts are clearly defined in the public health programme; besides routine entomological surveillance, the focus of infection has to be investigated using entomological parameters and guide the vector control experts to take the control measures for which a response plan has to be developed. The acute shortage of entomologists across the country and elsewhere is being raised on various platforms but somehow or the other neither the discipline of entomology is promoted in the academic institutions nor the carrier progression or retention of existing ones are visible on one or the other pretext.

Summarising the challenges for malaria elimination, the issues requiring focused attention are (1) low priority when the disease is reduced and termed as low burden, (2) clear specific strategic approach for different paradigms like malaria in tribal areas, forests, urban areas, industrial area, desert and coastal areas etc., which becomes more important because malaria is primarily a local and focal disease and general guidelines may not work effectively.

Malaria case notification and reporting by the private sector has been another challenge which is reportedly capturing more cases, especially in recent years because increase in numbers of private hospitals and clinics affecting the captured cases reflected in reports of public health departments.

The mismatch between Entomological surveillance and required human resource affect the implementation, which is evident from the fact that regular data on entomological parameters are not available from many places. Due to this lack of consistent data, mostly the old documents and studies are referred to for planning purposes. Entomological surveillance is broadly restricted to the larval checking and identification of breeding sources by domestic breeding checkers which is very unfortunate for the programme in the long-term.

Sustaining zero transmission in the post-elimination phase may be affected adversely if the resource deployment through reallocation is done based on the disease burden criteria. This usually happens during the allocation of financial resources and utilisation of human resource if the disease burden is reduced and pose a major challenge for sustaining the achievement gains which has been evidenced

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as one of the factors during the resurgence of malaria in 1976 and led to formulate modified plan of operation (MPO) guidelines in 1977.[1,12]

In malaria-risk areas, the options include universal household coverage with long-lasting insecticidal nets (LLINs) and above 90% coverage with indoor residual spray (IRS). Larval source management (LSM) is also recommended depending on the situation, especially in urban, industrial townships and where the breeding sites are few, fixed and findable. These options can be used individually or in combination in different phases viz., pre-elimination, elimination, post-elimination and to prevent the reestablishment of indigenous transmission in the area having achieved elimination.

Roadblocks

- Migratory Population
- Prevalence of asymptomatic malaria, its detection and radical treatment
- Persistence of residual transmission
- Exophilic and exophagic or endophagic and exophilic vectors
- Invasion of vectors to newer areas and spread of influence of multiple vectors
- New primary and secondary vector
- Vector control tools designed primarily for indoor transmission

In the case of Lymphatic Filariasis (LF) elimination, the Indian programme has always been in focus of the whole world due to the high burden of disease (Figure 2). The importance of the elimination of LF in India is evident from the fact that in the first meeting of the global programme to eliminate lymphatic filariasis in 2000 at Sandiago, the Secretary, Health, Government of India was made the chair and realising the magnitude of the problem in India, he stated that as per the fixed target of the global programme and WHO to eliminate this disease as a public health problem by 2020, India has to set an intermediate target.[13,14] The whole concept of elimination of LF is based on the average life span of adult female worms which is usually 5 to 6 years and that is why preventive chemotherapy (PCT) through mass drug administration (MDA) to the entire community living at risk is implemented for 5 to 6 years so as to reduce the infection level below the threshold level of microfilaria prevalence below 1% in the community. Initially, in 2004, MDA was started with diethylcarbamazine citrate (DEC) alone which was changed to coadministration of DEC with Albendazole in 2006.[15,16] Triple drug therapy with Ivermectin, DEC and Albendazole (IDA) was initiated in 2019 in selected districts to achieve the elimination.[17,18]

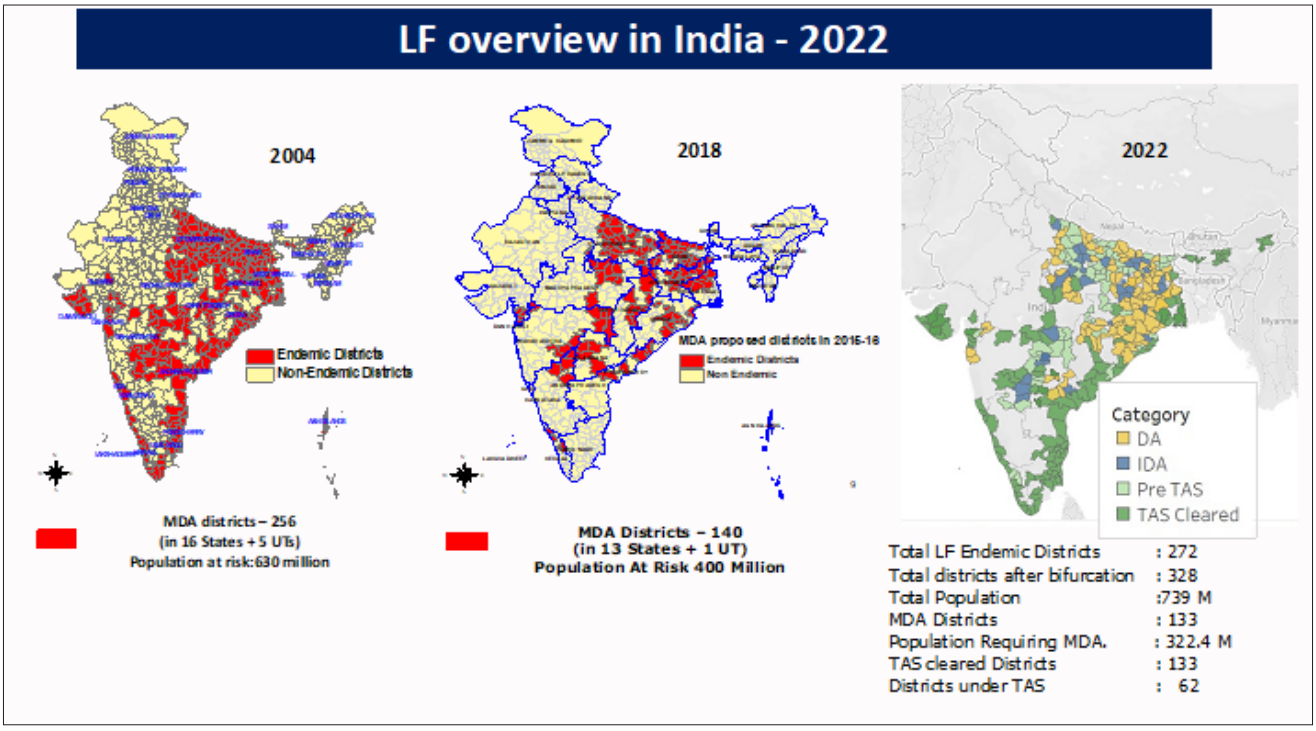

Figure 2.Lymphatic Filariasis Overview in India - 2022

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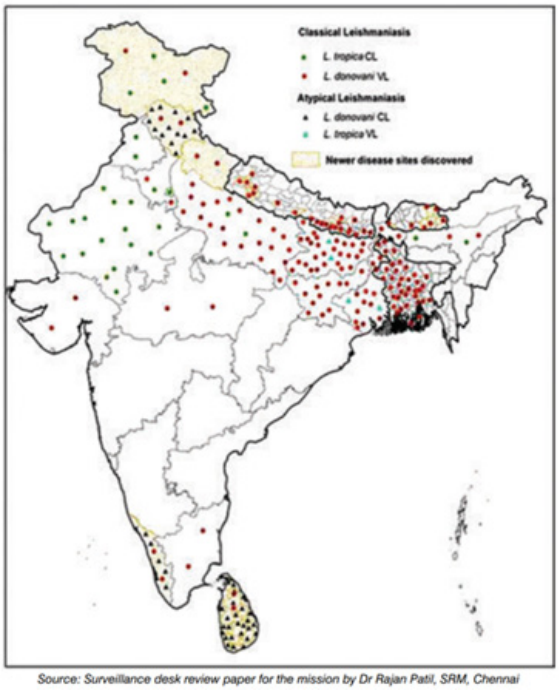
In India, over 700 million population have been at risk of LF spread over 272 districts in 21 states and Union Territories. The number of districts has increased from initially identified 257 districts to 272.[19] The number has further increased to 328 due to the bifurcation and trifurcation of endemic districts. India's progress towards LF elimination has been significant in spite of the magnitude of the problem and variation in service delivery as well as the perception among the community about this disease. The primary strategy of annual mass drug administration of anti-filaria drugs for interruption of transmission has been reduced to 134 districts out of 328 districts indicating that over 60% of districts do not require MDA. The overall strategic approach for ELF has been annual MDA, morbidity management and disability prevention (MMDP) for clinically manifested cases with capacity building.[20] However, integration with other programmes like leprosy elimination and national deworming has been initiated in the last few years. Unlike malaria, the vector control options in the case of bancroftian filariasis transmitted by *Culex* are mainly on LSM because adult control has a bigger challenge of insecticide resistance. However, in the case of brugian filariasis transmitted by *Mansonia* the vector control has been successfully demonstrated by environmental method.[21] The vector control was not included initially in the global programme as one of the main pillars of strategy probably due to cost-effectiveness, however, it has now been emphasised as one of the options, especially during the post-MDA period to sustain the achievement. The programme in spite of significant success, has many challenges viz., suboptimal compliance to MDA drugs, mismatch between desired & ground level IEC, staggered MDA due to logistics, scaling up of health facilities for MMDP package, clearing the backlog of hydrocelectomies etc.

Visceral Leishmaniasis (VL)

The incidence of VL in the Indian subcontinent has declined dramatically as a result of sustained political commitment to elimination as a public health problem (defined as < 1 case/10,000 individuals at the sub-district level (Figure 3).[22–25] India's progress is evident from the data that out of 140 million people living at risk of VL across 54 districts in 4 states, only 1276 VL cases were reported in 2021 against 32803 in 2005 showing over 90% reduction.[26] The global goal of elimination of NTDs is by 2030 aligned with SDG, however, VL elimination in India is to be achieved by 2023 which has been set as an optimistic approach and political commitment towards elimination of this disease.[6] The cases are continuously declining and in 2022, only 818 cases of VL were reported (NCVBDC). The vectors of VL are sandflies which are known for their restricted movement usually up to six feet in height, thus making IRS a very effective tool provided its quality and coverage are ensured. The elimination of VL has faced challenges of surveillance strengthening to cover low socio-economic groups even during the post-elimination stage. This is linked with filling of human resource posts and their retention. The management of logistics and coordination between partners with national programmes, especially in information sharing is another challenge. Vector control operations with different tools beyond the IRS are not in practice, especially in terms of when, where, how and what tools are to be used (Figure 4).



Source: Surveillance desk review paper for the mission by Dr Rajan Patil, SRM, Chennai

Figure 3.Visceral Leishmaniasis in India

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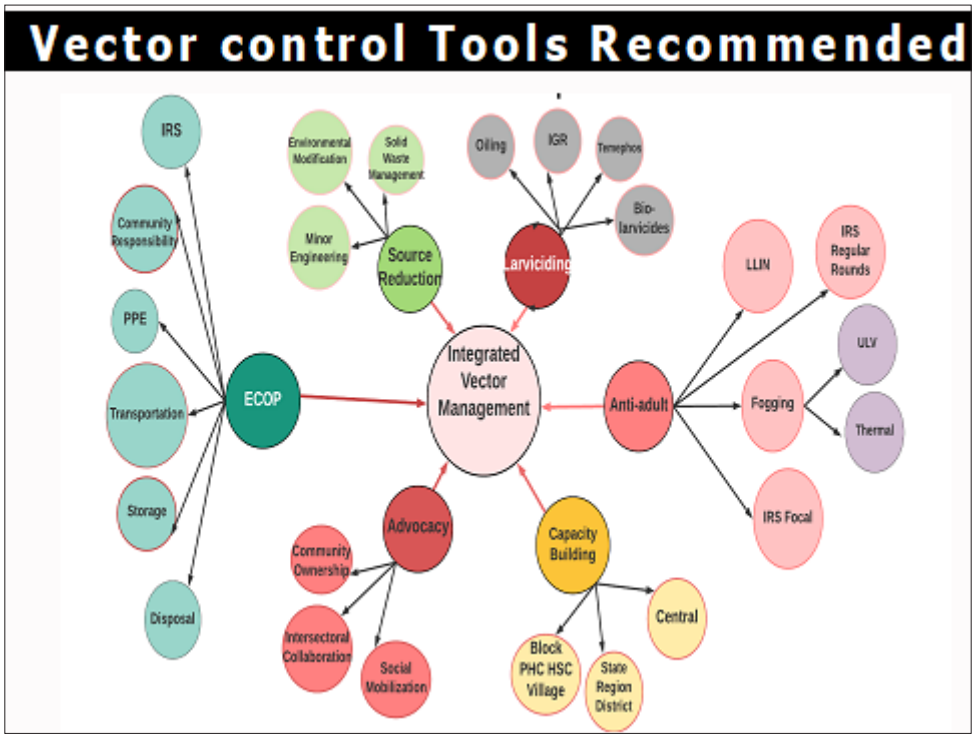

Figure 4.Recommended Vector Control Tools

Validation

Preventative measures such as the use of LLINs, IRS, personal protection with repellents, and environmental management techniques to reduce mosquito breeding sites and kill mosquito larvae are the options for the benefit of the community as well as the individual, though some are supported under public health programme and some are used by the community by obtaining it from the open market. The claim of having achieved the target of elimination after effective implementation of the strategic plan needs to be ascertained through standardised validation procedures of WHO.[27]

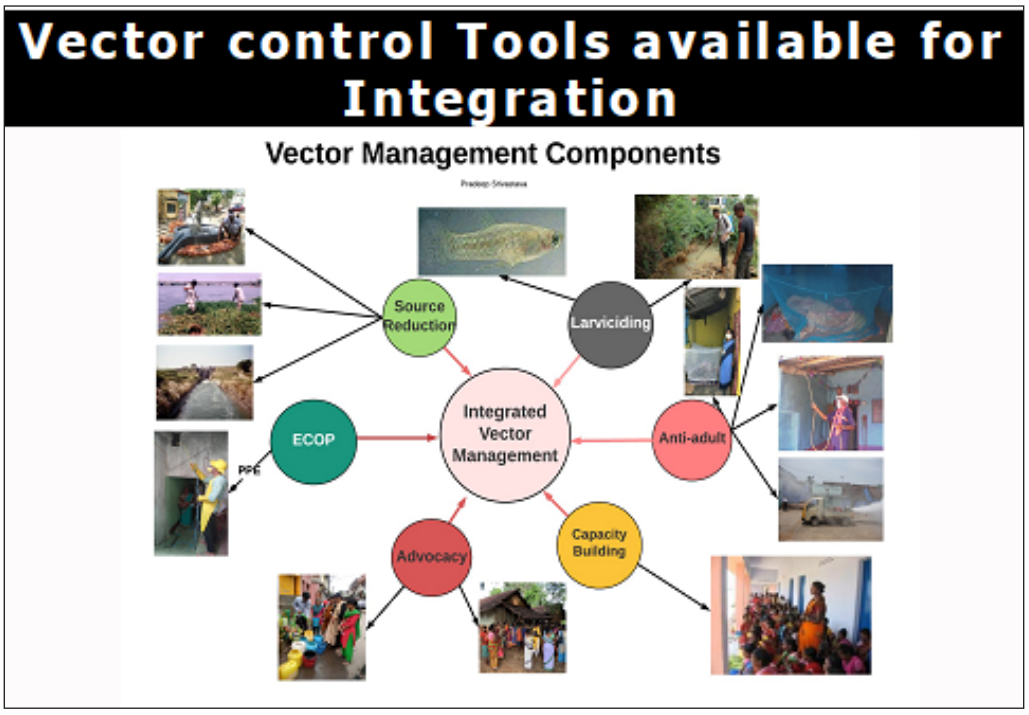

Figure 5.Vector Control Tools Available for Integration

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Malaria elimination requires documentary evidence that local malaria transmission by *Anopheles* mosquitoes has been fully interrupted, resulting in zero incidences of indigenous cases for at least the past three consecutive years, and an adequate surveillance and response system for preventing the re-establishment of indigenous transmission is fully functional throughout the territory of the country. The entomological monitoring indicator for vector control is clearly defined for species occurrence, density, behaviour, resistance to insecticide, breeding habitat-availability occupancy and larval density. The sporozoite rate, entomological inoculation rate and receptivity have been included as proxies for transmission.[28] Figure 5 shows the vector control tools that are available for integration.

Lymphatic Filariasis

However, in the case of LF, though vector control was not included initially as the main pillar of the elimination strategy,[29,30] the entomological indicators of mf prevalence in vector population, especially the presence of infective larvae are included in post-MDA surveillance.

Kala-azar Elimination

Unlike malaria and LF, the entomological monitoring indicators in VL elimination as validation tools are not clearly defined. The recent operational manual on kala-azar in 2021[31] and 2023[32] also elaborates on the occurrence, density, abdominal conditions and resistance status of vector species to facilitate decisions of IRS and monitor its impact. The elimination certification process needs proof of availability of guidelines for IRS spraying in endemic areas, monitoring of quality spray and quality assurance mechanisms, use of insecticide-treated nets and environmental management in the programme and description of entomological surveillance during pre and post-spraying, and monitoring of insecticide resistance. Validation tools for VL especially on entomological parameters will be of immense help during the certification process.

Validation Tools

The entomological tools for validation of three diseases targeted for elimination may be summarised as below:

Malaria Elimination Requires

- Documentary evidence that local malaria transmission by Anopheles mosquitoes has been fully interrupted,
- Resulting in zero incidence of indigenous cases for 3 consecutive years,
- Adequate surveillance and response system for
  - Prevention of reestablishment (POR) of indigenous transmission is fully functional throughout the country
  - Entomological indicator for vector control is monitored for
    - species occurrence, density, behaviour,
    - resistance to insecticide,
    - breeding habitat-availability occupancy
    - larval density
    - Infection in vectors and receptivity are measured for transmission.

Elimination of LF to be Validated through

- Effective coverage of MDA for a minimum of 5 years
- Successful clearance of Transmission Assessment Surveys
- MMDP clinic established in each Implementation Unit with a minimum package
- Vector control not included initially in the elimination strategy has now been included with entomological indicators of mf prevalence in vectors, especially the presence of infective larvae in post-MDA surveillance.

Entomological Monitoring Indicators in VL Elimination as Validation Tools are not Clearly Defined

The Recent Operational Manual on Kala-azar in 2023 Elaborates on

- Occurrence, Density, Abdominal conditions and resistance status of vector species to facilitate decisions of IRS and monitor its impact
- The elimination certification process needs
  - Proof for the availability of guidelines for IRS spraying in endemic areas,
  - Monitoring of quality spray and quality assurance mechanisms,
  - Use of insecticide-treated nets and environmental management in the programme
  - Description of entomological surveillance during pre and post-spraying,
  - Monitoring of insecticide resistance.

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