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Review Article

From silos to synergies: multisectoral collaboration to reach the last mile of malaria elimination in India

Shwetangi R. Shinde, Anuradha K. Shah*

Department of Community Medicine, Seth G. S. Medical College and KEM Hospital, Mumbai, Maharashtra, India

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***Correspondence:**
Dr. Anuradha K. Shah,
E-mail: anuradha.moha@gmail.com

ABSTRACT

Malaria, a public health problem in India with declining endemicity, is now being tackled with the National Strategic Plan for Malaria Elimination (2023-2027), targeting zero indigenous cases by 2027 and complete elimination by 2030. A central pillar of this strategy is vector control, yet its effectiveness is undermined by siloed efforts, where different sectors work in isolation. Malaria is a disease with various environmental, social, and behavioural determinants, requiring a multisectoral approach for control. Coordinated efforts involving the health, environment, agriculture, housing, water, and education sectors among others are crucial to address the broader determinants of mosquito breeding and disease transmission. Focusing exclusively on health sector interventions risks overlooking these critical factors. Multisectoral collaboration for vector control is central to the global vector control response (GVCR) 2017-2030, the multisectoral approach to the prevention and control of vector-borne diseases (2020), along with India's manual on integrated vector management. Several ministries have already begun implementing measures to address mosquito breeding. Successful case studies from Kenya, Maharashtra, and Gujarat demonstrate the effectiveness of such collaborative efforts in vector control. However, challenges remain, particularly in defining roles, securing funding and strengthening entomological infrastructure. Addressing these challenges through strong political commitment, clear accountability frameworks, and increased resources is crucial for achieving sustainable malaria elimination in India. Improving health outcomes should be a shared responsibility, breaking silos and aligning efforts across all sectors and sections of the society.

Keywords: Malaria, India, Mosquito, Vectors, Vector borne diseases

INTRODUCTION

Malaria remains a significant public health challenge in India, though its endemicity has notably declined in recent years. As part of a shift from malaria control to elimination, the Government of India has aligned with the Global Technical Strategy for Malaria 2016-2030 and the National Framework for Malaria Elimination 2016-2030, and designed the National Strategic Plan for Malaria Elimination (2023-2027).[1] It aims to have zero indigenous cases of malaria in India by 2027 and achieve complete malaria elimination by 2030. Five strategies have been proposed, of which optimization of vector control is a pivotal strategy, receiving 40% of the total budget. Key areas for action are entomological surveillance, insecticide resistance monitoring (IRM) and evidence-driven vector control.[1]

THE PROBLEM OF THE SILOED APPROACH IN VECTOR CONTROL

A siloed approach involves different entities working in isolation with minimal communication and disjointed work processes.[2] While silos can sometimes reduce complexity, they often result in inadequate outcomes due to fragmented efforts by different stakeholders, particularly in the context of vector control.[2,3]

In an urban slum, for example, intermittent water supply necessitates water storage in containers, creating breeding sites for mosquitoes.[4] While the local corporation may implement insecticide policies, to attain a significant decrease in the number of infective vectors, vector control operations need to be synchronised with the detection of cases and *Anopheles* breeding sites.[5] Additionally, the mosquito vectors may develop resistance to insecticides, reducing the effectiveness of this singular approach. Very few residents in the slums may use protective measures such as bed nets or repellents. Compounding the issue, the slums may have unsafe housing and stagnant water collection in inaccessible areas.

Consequently, we realise that malaria is a disease with various environmental, social, and behavioural determinants, requiring responses that are beyond the capacity of the health sector.[6] By focusing exclusively on health sector interventions, we overlook critical factors that contribute to mosquito breeding and malaria transmission.[3,6] This has been identified as an important gap area in the 2022 review of the malaria elimination programme in India, with multisectoral efforts for vector control in the country being mostly scattered and episodic.[6]

THE CONCEPT OF MULTISECTORAL COLLABORATION

Multisectoral coordination involves bringing together various actors and stakeholders for issues affecting health outcomes, in a way that is more effective, efficient and sustainable than could be achieved by the health sector alone.[6] Here, the term "multisectoral" is preferred over "intersectoral" to highlight that the collaboration can include more than two sectors.

Recognising the importance of such collaboration, the World Health Organization (WHO) developed the global vector control response (GVCR) 2017-2030 and the multisectoral approach to the prevention and control of vector-borne diseases (2020).[3,6] With the roll back malaria partnership, WHO also launched the "zero malaria starts with me" campaign to engage political leaders, private sector companies, and communities in vector control.[8] Additionally, the WHO supports a "high burden to high impact" (HBHI) approach for accelerating malaria control in its high-burden countries, with multisectoral response as a key element. It was adopted by India in May 2019.[8] Apart from the health sector, key sectors identified by the WHO for vector control are environment, agriculture and aquaculture, housing and infrastructure, water and sanitation and research, as illustrated in Figure 1.

These initiatives emphasize that effective vector control is linked not just with sustainable development goal 3 (good health and well-being), but also with – goal 1: no poverty, goal 6: clean water and sanitation, goal 11: sustainable cities and communities, goal 13: climate action, and goal 17: partnerships for the goals.

This highlights the importance of a multifaceted approach to vector control.

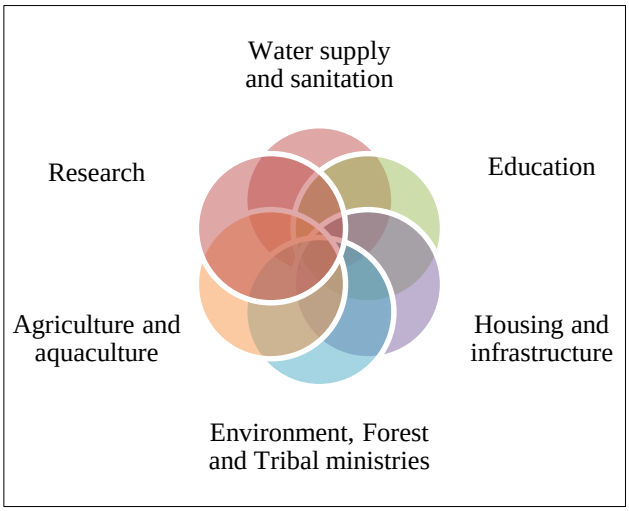

Figure 1: Sectors suggested for a multifaceted approach to vector control.

INDIA ON TACKLING VECTORS WITH MULTISECTORAL COLLABORATION

India's manual on integrated vector management emphasizes multisectoral coordination as a guiding principle.[5] The government has envisaged task forces with representation from various sectors to coordinate efforts, define roles, and establish platforms for data-sharing and impact assessment. However, while the National Task Force is established, its meetings and oversight are not fully functional and many state and district task forces have yet to be constituted or are not fully functional.[4]

The following opportunities are being explored in India for a multisectoral response to vector control.

Water supply and sanitation

Intermittent water supply is the norm in India, necessitating water storage practices.[9] Stored water can be conducive to mosquito breeding if not covered or maintained properly. To address the mosquito breeding linked to intermittent water supply and storage practices, the Ministry of Jal Shakti and the Ministry of Rural Development work closely to maintain pipelines and ensure a more reliable and consistent water supply.[5] Additionally, the Ministry of Rural Development and the Ministry of Panchayati Raj should consider the production of larvivorous fish in the water bodies falling under its jurisdiction.[12] Linking mosquito control activities with the Swachh Bharat Mission (SBM) is important for proper greywater management and waste disposal.[5,10,11] By aligning water supply improvements, waste management and natural mosquito control methods, the overall effectiveness of vector control efforts is enhanced.

Housing and infrastructure

The Ministry of Housing and Urban Affairs should mandatorily integrate health impact assessments into infrastructure projects (noted foci of malaria incidence) at the design phase itself. This would allow specific antimalarial recommendations such as improvement of housing design to prevent waterlogging and ensuring adequate access to overhead tanks along with mosquito-proofing of tanks.[4]

Environmental management

Accumulated waste, clogged drains, unlevelled roads, construction sites and potholes can hold water and become mosquito breeding sites. Hence, the public health engineers and the public works department should be aware of the role of timely waste collection, desilting of drains, levelling and other source reduction activities. Innovative strategies such as - the use of drones for the application of antilarval oil in inaccessible areas undertaken by the Municipal Corporation in Mumbai, need to be developed and assessed for their impact.[4]

Additionally, various ministries are responsible for keeping their areas mosquito-free: The Ministry of Home Affairs in office buildings, residential colonies, and *malkhanas* (a police warehouse for seized items)**;** The Ministry of Defence in cantonment areas and naval colonies**;** The Ministry of Education for school premises**;** The Ministry of Commerce and Industry for industrial establishments**;** The Ministry of Road Transport and Highways for tyre houses, godowns, roads and highways; and The Ministry of Railways for dump yards, tracks and staff quarters.[5]

Agriculture and aquaculture

Agricultural systems need to be modified appropriately to reduce potential breeding sites.[15] Methods like the alternate drying and wetting (AWD) irrigation systems are promoted by the Ministry of Agriculture and Farmers' Welfare but are not widespread.[5] The Ministry of Fisheries, Animal Husbandry and Dairying releases farmer-centric information for mass production of larvivorous fish and composite fish farming schemes.[12] It is important to accelerate its adoption as biological vector control is a crucial strategy to reach the last mile of elimination. The Ministry should also disseminate appropriate IEC to interrupt malaria transmission resulting from the co-habitation of cattle and humans.[1]

Education

The Ministry of Education is involved in encouraging school-based activities for vector control. Opportunities to be utilised for advocacy are World Malaria Day (25 April) and the anti-malaria month (June), just before the major transmission season.[4] Notable initiatives include Mortein's 2024 School Malaria curriculum in Bareilly, a malaria-endemic district in Uttar Pradesh, featuring quirky characters and materials to educate children on mosquito breeding and control and the 2017 Delhi Government advisory for schools on vector control education.[16,17]

Health education and advocacy

The Ministry of Women and Child Development should incorporate vector control activities in the curriculum of Anganwadi workers.[5] These workers have direct access to communities, especially in rural areas. Along with educating mothers and caregivers about health and nutrition, they should also sensitise them about the importance of keeping the environment clean, managing water sources and preventing mosquito breeding. It will also enable linkage with other public health initiatives that can optimise vector control, such as the Swachh Bharat Mission. The Ministry of Youth Affairs and Sports and the Ministry of Information and Broadcasting can be involved in advocacy on vector control.[1]

Research and innovation

The Ministry of Science and Technology is developing novel vector control tools and studying mosquito behaviour and resistance to insecticides. e.g. Insecticide susceptibility tests, and testing the larvicidal activity of novel plant extracts.[14,18] Efforts like this are important to develop evidence-based practices in vector control. Tools like GIS mapping for the identification of foci have been used in some states for microplanning vector control operations. Newer equipment such as hand compression pumps with constant flow valves (CFV) instead of the conventional stirrup pumps for chemical control and newer methods such as cold fogging instead of thermal fogging are being used in some states. It is important to build scalable and replicable models that can be adopted institutionally by other states.[4] Along with the ICMR, it is important to strengthen the involvement of academic institutions and medical colleges, which will require more funding. Delays in sharing the evidence generated through research can render the vector control activities irrelevant and hence, it is important to properly disseminate the findings of operational research with the concerned stakeholders, to allow appropriate modifications.[4] The Ministry of Environment, Forest and Climate Change works closely with the National Institute of Malaria Research to study the impact of changing vector dynamics and climate change on the transmission of malaria.[19]

Forests, tribal and border areas

Tribal communities bear about 60% of the malaria burden in the country.[1] Various vector-related factors contribute to this – such as triple insecticide resistance, multiple vector species, and unique practices that create breeding sites. For instance, a tribal group in Gujarat stores *tadi* – locally produced palm wine, in small earthen pots, which are left unused in the post-monsoon season, creating a breeding ground for mosquitoes. There is also an increased

man-vector contact due to residence in forest terrains and practices like "Jhum", a type of shifting cultivation practised in remote tribal areas.[4,20] Recognizing this, the NVBDCP has partnered with the Ministry of Tribal Affairs for a Joint Tribal Action Plan for Malaria Elimination, which aims for a multisectoral response to target these unique characteristics and challenges. Practices like mud plastering, common in tribal areas, are known to reduce the effectiveness of indoor residual spraying (IRS) due to the porous nature of the mud.[21]

Hence, a key strategy for vector control in tribal areas includes – planning the insecticide spraying operations in consultation with the tribal leaders, village headmen and the community at a time when the possibility of mud plastering is lowest in the next three months, to maintain the effectiveness of the insecticide sprayed.[1]

Additionally, the Ministry of Environment, Forest and Climate Change and the Ministry of Defence proactively participate in the effective implementation of vector control measures in areas under social forestry and border areas.[4] For instance, in the malaria endemic areas along the Tripura-Bangladesh border, foot patrolling by Border Security Forces in the forests increases their contact with malarial vectors. To manage this risk, the Ministry of Defence provides them with portable fumigators and netmasks for vector control. Additionally, they are quarantined for 10 days on returning to the headquarters to break the transmission chain of the vector.[22]

EXAMPLES OF SUCCESSFUL MULTISECTORAL COLLABORATION

Kenya

External evaluation of the implementation of Integrated Vector Management at two sites in Kenya – Malindi and Nyabondo between 2006 and 2011 revealed that IVM was more successfully implemented in Malindi, owing to community-driven larval source management (LSM) and better multisectoral engagement. Successful collaborations were observed with the Ministry of Fisheries for farming larvivorous fish, and the Ministry of Education for establishing "school health clubs". Schools were also involved in making objects using plastic waste collected from the environment as an attempt to reduce potential breeding sites. Health workers and NGO members were encouraged to work as "mosquito scouts" to survey mosquito densities in their designated areas. Community involvement was also promoted through various environmental modification and income-generation activities.[23]

Konkan railway construction project

A health impact assessment of the project was conducted, led by the National Institute of Malaria Research (NIMR), and supported by the Ministry of Railways. The survey team consisted of entomologists, engineers, draftsmen and field workers. This led to recommendations such as sloping the station tops and building concrete drains next to the tracks to prevent water stagnation, and installing soak pits and septic tanks at staff quarters for greywater management. Abandoned sleeper curing tanks (~ tanks that provide a controlled environment for concrete train sleepers to achieve their desired properties) were stocked with larvivorous fish that were supplied by hatcheries from the local primary health centres. As a result of this successful collaboration, no outbreaks of malaria were observed along the railway line or in the labour camps and nearby villages, during construction.[24]

Algarwadi, Maharashtra

Poor maintenance and recurrent choking of open drains, the only system available for greywater management in this village, created breeding spots for mosquitoes. The department of drinking water and Sanitation proposed the idea of soak pits for greywater management. They arranged for information and demonstrations from the Zilla Parishad of a neighbouring district (Nanded) where this was already successfully implemented. Funds were mobilised through the Gram Panchayat and the MNREGA scheme to construct 307 soak pits in 9 months. The extensive coverage of soak pits prevented water stagnation, breaking the reproduction cycle of the mosquitoes.[25]

Kheda district, Gujarat

Due to widespread mosquito resistance to insecticides in this area, the National Institute of Malaria Research decided to implement various bioenvironmental measures for vector control, with village *Panchayats* (administrative bodies) as nodal points and the village *Sarpanch* (head) as nodal persons. For larval source reduction, a team of 4-5 daily wage workers was appointed and the practice of *Shramdan* (voluntary contribution through labour) was promoted among the community members and through voluntary agencies like the *Mahila Mandal* (women groups), and national cadet corps (NCC).

The Fisheries Department developed hatcheries for larvivorous fish and promoted income-generating schemes for fish culture and social forestry, along with other departments such as the public works, irrigation and forest departments participating in mosquito control. Soakage pits were constructed with the help of the B.V. Polytechnic Institute, and voluntary donations from villagers were invested in vector control activities. IEC activities were done with the help of the Indian Space Research Organisation (ISRO) and *Doordarshan*. This led to a massive decrease in the malaria burden in the district.[4,25]

These successful vector control interventions reinforce the idea that malaria is not an exclusive priority of the health sector, but needs integration of efforts across various sectors to harness the complete potential of vector control.

CHALLENGES AND SOLUTIONS

Defining roles

While planning for multisectoral coordination, challenges can be faced in defining the roles and responsibilities of relevant stakeholders. Non-health sectors may not be fully aware of the benefits of malarial vector control. However, malaria has been proven to be associated with slower economic development and lesser GDP growth.[3] Vector control interventions against malaria are known to have the highest return on investment through reduction of disease burden and advancement of human and economic development.[3] Sensitising and educating them that malaria control not only improves the survival and quality of life but also helps countries achieve a just and equitable development is crucial.[15]

Funding

A well-established funding mechanism is crucial for the success of multisectoral collaboration. This needs a strong political commitment to ensure adequate external (e.g. World Bank, GFATM) and domestic funding. Additionally, funds can be mobilized through corporate social responsibility (CSR) partnerships, research institutes (e.g. ICMR) and other departments (e.g. funds mobilized through the Tribal Welfare Department in Gujarat).[4]

Monitoring and evaluation

Accountability mechanisms must be established to track the progress of actions taken by various stakeholders. Figure 2 illustrates an example based on the WHO's multisectoral accountability framework to end tuberculosis by 2030.[26] The framework should clearly define who is accountable, what commitments and actions they are accountable for, and how will they be held to account. The commitments by stakeholders should lead to concrete actions, with the progress tracked by monitoring and reporting. Results should be reviewed periodically, and recommendations made to drive new or improved actions.

Lack of an entomological infrastructure

Vacant posts of entomologists and insect collectors at the subnational levels render us unable to monitor the ongoing vector control activities through entomological parameters. For quality and evidence-based interventions, filling up all the entomological vacancies at the Central, State and District levels is necessary. The 2022 Malaria Programme Review in India recommends two insect collectors per entomologist and at all levels, at least until 2030. There is also a shortage of logistics such as bioassay kits and insecticide-impregnated papers, which are crucial for insecticide-resistance monitoring and management. This laboratory and logistical support needs to be strengthened at all levels.[4]

Increasing insecticide resistance

India has adopted "integrated pest management" in agriculture since 1985, aiming to promote biological, cultural, and mechanical methods for pest control and using chemical methods only when necessary.[13] Given the increasing resistance of the *Anopheles* mosquito to DDT, malathion and pyrethrum, the IRS compounds need to be used judiciously too, and bioenvironmental vector control should be promoted with a needs-based use of chemical methods.[8,14]

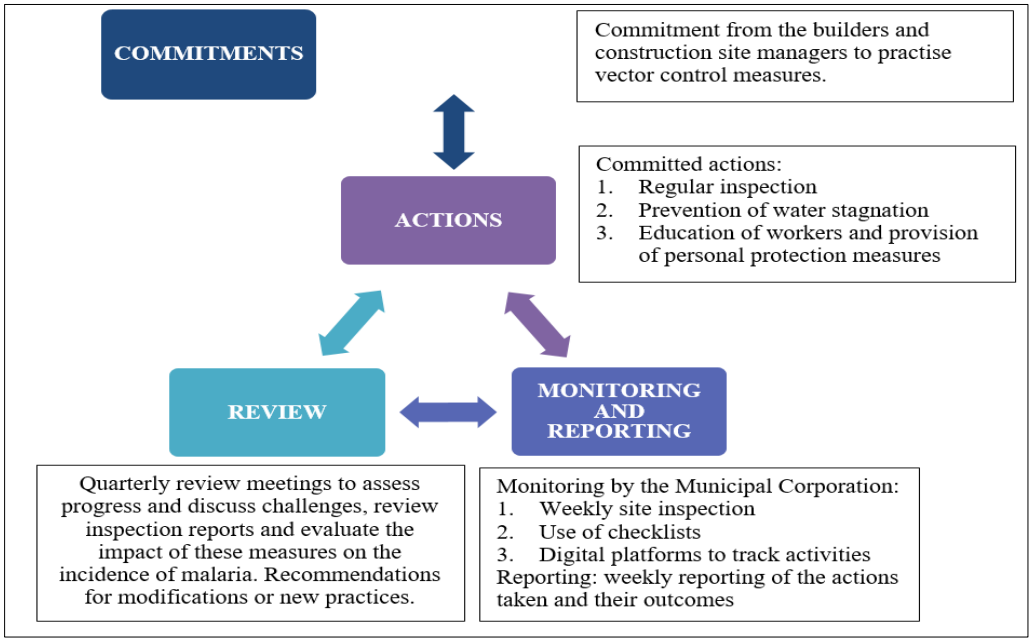

Figure 2: Suggested components of an accountability framework using the example of builders or construction site managers as the stakeholder.[25]

CONCLUSION

Improving health outcomes should be a shared responsibility, breaking silos and aligning efforts across all sectors and all sections of society. Effective collaboration supplements the efforts of the health ministry, making implementation easier and improving the sustainability of interventions. By doing so, we can demonstrate what is possible when the right strategies, policies and resources come together to eliminate malaria, contributing to global health goals and improving the well-being of our population.

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