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Integrated Mosquito Vector Management Strategies for Reducing Malaria Transmission Risk

Ying Fu, Fangya Chen, Xueyan Chen
Tropical Animal Resources Research Center, Hainan Institute of Tropical Agricultural Resources, Sanya, 572000, Hainan, China
Corresponding email: xueyan.chen@hitar.org
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Abstract This review examines integrated mosquito vector management (IVM) strategies for reducing malaria transmission risk. Malaria remains a major global public health burden, with transmission driven by Anopheles mosquitoes whose biological and ecological characteristics are shaped by environmental factors. The complex interactions among mosquito vectors, *Plasmodium parasite*s, and human hosts, together with climate change and human activities, influence transmission dynamics. Conventional control methods, including insecticide-treated nets and indoor residual spraying, have achieved significant success but face limitations such as insecticide resistance and behavioral adaptation. Emerging approaches, including plant-based insecticides, genetic technologies, and nanotechnology-based delivery systems, provide promising alternatives. IVM integrates multiple strategies, emphasizing ecological sustainability, community participation, and policy support. Evaluating safety, environmental impact, and cost-effectiveness is essential for long-term success. Future efforts should address resistance management, climate challenges, and implementation barriers to enhance malaria control outcomes.
Keywords Malaria; Mosquito vectors; Integrated vector management; Insecticide resistance; Control strategies

1 Introduction

Malaria remains a major global public health challenge, particularly in tropical and subtropical regions where it causes significant morbidity and mortality. Despite decades of control efforts, the disease continues to impose a heavy burden, with sub-Saharan Africa bearing the highest incidence and prevalence rates worldwide. Vulnerable populations such as children under five years old and pregnant women are disproportionately affected, contributing to substantial socio-economic impacts in endemic countries. The persistence of malaria is driven by complex interactions among biological, environmental, and socio-economic factors that sustain transmission cycles and complicate eradication efforts (Akowe et al., 2025; Kombate et al., 2025).

Central to malaria transmission are mosquito vectors, primarily Anopheles species, which serve as the biological agents facilitating parasite spread between humans. Vector behavior, ecology, and population dynamics critically influence transmission intensity and patterns. Traditional vector control methods such as insecticide-treated nets (ITNs) and indoor residual spraying (IRS) have significantly reduced malaria incidence but face challenges including insecticide resistance, outdoor biting behaviors, and ecological variability among vector populations. These factors limit the effectiveness of single interventions and underscore the need for comprehensive approaches that address both indoor and outdoor transmission risks while adapting to evolving vector behaviors (Benelli and Beier, 2017; Sougoufara et al., 2020).

Integrated Vector Management (IVM) has emerged as a strategic framework that combines multiple vector control tools tailored to local contexts to enhance malaria control outcomes sustainably. IVM integrates traditional methods like ITNs and IRS with novel interventions such as larviciding, environmental management, house screening, community education, and emerging biotechnologies including Wolbachia-based strategies. Evidence from diverse settings demonstrates that integrated approaches achieve greater reductions in malaria transmission indicators compared to single interventions alone. Moreover, IVM promotes multisectoral collaboration, continuous surveillance, and adaptive management to overcome challenges like insecticide resistance and residual