vectors with traditional methods shows promise but requires further evaluation under field conditions. Overall, integrated strategies represent a comprehensive framework capable of adapting to evolving transmission dynamics while maximizing public health benefits.

Resistance to insecticides among mosquito populations remains a major obstacle undermining the long-term efficacy of vector control programs. The widespread emergence of resistance mechanisms reduces the effectiveness of chemical-based interventions like ITNs and IRS, necessitating the development of new insecticides and resistance management strategies. Climate change further complicates malaria control by altering vector distribution, breeding patterns, and transmission seasons through rising temperatures and changing rainfall patterns. These environmental shifts expand malaria risk zones into previously unaffected areas, challenging existing control frameworks. Predictive models incorporating climate data are increasingly used to anticipate outbreaks but require integration into operational planning. Implementation barriers also hinder progress in many endemic countries. Weak health infrastructure, inadequate funding, fragmented policy coordination, and limited intersectoral collaboration reduce program efficiency. Studies from Kenya and Zambia highlight gaps between climate-resilient malaria policies and their execution due to misaligned stakeholder roles and insufficient monitoring systems. Social factors such as low community awareness, cultural barriers, and limited access to healthcare further impede intervention uptake. Addressing these multifaceted challenges demands strengthened governance, capacity building, and inclusive policy frameworks that integrate climate adaptation with malaria control.

Future research should prioritize filling critical knowledge gaps related to vector biology in diverse ecological settings, especially urban environments where transmission dynamics differ markedly from rural areas. Investigations into non-vector transmission pathways alongside vector control will provide a more comprehensive understanding of malaria epidemiology. The development of novel tools such as vaccines tailored to region-specific parasite strains and gene-drive technologies for vector population suppression warrants accelerated evaluation through rigorous field trials. Policy recommendations emphasize the need for multi-sectoral collaboration integrating public health, environmental management, climate science, and community stakeholders to design adaptive malaria control programs resilient to emerging threats. Strengthening surveillance systems with real-time data integration will enhance early warning capabilities for outbreaks driven by climatic variability. Additionally, sustainable financing mechanisms coupled with capacity building at local levels are essential for scaling up integrated approaches effectively. Emphasizing equity by addressing social determinants of health will improve intervention reach among vulnerable populations. Collectively, these efforts can advance toward durable malaria reduction aligned with global health goals amid changing environmental landscapes.

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Conflict of Interest Disclosure

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