MALARIA VECTOR CONTROL: CHALLENGES AND FUTURE STRATEGIES

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Abstract

The current demand for the eradication of malaria marks a new-fangled chapter in the antiquity of this illness. This has been brought about by the striking decreases in malaria caused by administration of efficient medications and vector control. However, the emergence of pesticide resistance poses a challenge to this approach. Alternative tools must be developed to continue supporting or potentially replace insecticide-based vector control methods. Long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) continue to be the mainstays of the majority of National Malaria Control Programs in Africa, despite the large number of promising control tools tested against mosquitoes. These strategies are not enough to successfully control malaria. While these techniques are successful in lowering malaria incidence, their overall effectiveness in lowering malaria prevalence is often limited. Additionally, efficiency of LLINs and IRS is threatened by the rising rates of pesticide resistance in the targeted mosquito populations. Thus, although larvicidal treatments can be beneficial, using them in rural regions is not advised. To enhance mosquito vector control efforts and improve their quality and delivery, it is important to focus on integrated approaches. Successful malaria eradication requires close collaboration between parasitologists and entomologists, along with a comprehensive evaluation of epidemiological impact of innovative mosquito vector control strategies. This review discusses current malaria vector control strategies and highlights challenges, and promising tools that are expected to contribute to malaria eradication.

Keywords: *Malaria, Vector Control, Current Challenges and Future Strategies.*

Introduction

Approximately 619 000 people still die from malaria each year, and 247 million new cases are reported in 84 different countries (WHO 2022). A 33% decrease in mortality associated with malaria has been recorded in Africa. This has been attributed to preventive measures that have been scaled up in attempt to achieve the Millennium Development Goals (MDGs) of reduced maternal and child mortality. This represents a significant improvement over the past ten years. A definite pointer for MDG 6 is malaria, which also supports MDGs for education, maternal health, child survival, and poverty (Hemingway 2014). The majority of malaria prevention efforts focus on reducing the mosquito vectors to human contact by encouraging people to sleep under treated mosquito nets and to apply indoor residual spraying (IRS).

Roughly 780 million individuals in Africa who are at risk of malaria would need access to long-lasting insecticidal nets (LLINs), and roughly 150 million bed nets would need to be supplied annually. This estimate makes the assumption that the nets are still functional after five years on average. However, only 66 million nets had been distributed by 2015, failing to meet the aim. Additionally, mounting data indicate that LLINs are unlikely to last the full 5-year timeframe (Mejia et al 2013, Wills et al 2013). The LLIN market is very price sensitive, and poorer quality, less durable nets have dominated. Because of this, the anticipated 5-year lifespan of these nets is greatly shortened and they start to fall apart rapidly. In 2011, 11% of the world's population was protected from malaria thanks to the use of indoor residual spraying (IRS), up from 5% in 2005. 77 million of those persons were in Africa. The President's Malaria Initiative (PMI) in 19 target African countries, where 30.3 million individuals were shielded by the IRS in 2012, is largely responsible for this surge.

It is crucial to significantly expand funding for disease control initiatives and operational actions if we are to maintain the gains made in disease control and go closer to regional and global eradication of malaria. Meeting the global malaria targets will require an estimated $5.1 billion annually from 2011 to 2020. However, in 2011, only $2.3 billion was available, less than half of the required amount. Recent years have seen some progress, with more pledges made for 2022, including over $12 billion that has already been pledged in comparison to the $15 billion required for 2014–2016 for the Global Fund PMI 2023.

Notably, it won't be enough to merely increase financial support, though. Thus, to preserve the long-term durability of the insecticides and medications used for prevention and treatment of malaria, improved stewardship of these resources is essential. Resistance will certainly reduce our ability to successfully prevent and manage malaria if we ignore this obligation. Because Malaria is an infectious disease spread by mosquitoes that affects millions of people worldwide, malaria vector control is essential in the fight against malaria transmission. There have been several methods used to manage malaria vectors, and research is always being done to create new ones. Here is a summary and review of the problems with and potential solutions for malaria vector control.

Present Vector Control Techniques

Insecticide-Treated Nets (ITNs): ITNs are among the widely used and effective vector control interventions. They provide a physical barrier between humans and mosquitoes while also delivering insecticide that kills or repels mosquitoes. ITNs have shown significant success in reducing malaria transmission, especially when used consistently and universally (Hill et al 2006, Lengler et al 2007).

IRS: Insecticides are sprayed on interior walls of homes to kill mosquitoes that come into contact with the treated surfaces. This strategy has been successful in limiting the spread of malaria, especially in regions with high vector densities and pesticide susceptibility (Protopopoff et al 2015, Okumu et al 2011). However, challenges such as insecticide resistance and logistical requirements limit its widespread implementation. Larval Source Management (LSM), targets mosquito breeding sites, such as stagnant water bodies, to reduce mosquito populations. It involves interventions like draining, larviciding, or modifying habitats to disrupt mosquito breeding. LSM can be an effective complementary approach to ITNs and IRS, particularly in areas with specific breeding sites or where mosquitoes have developed resistance to insecticides.

Biological Control: This strategy encompasses introduction of natural predators, such as fish or predatory insects, to reduce mosquito populations. While it has shown some promise in certain settings, biological control methods require careful consideration to avoid unintended ecological consequences and disruption of local ecosystems (Beneli et al 2016, Dahmana and Mediannikov 2020). Advances in genetic engineering have opened up possibilities for genetically modifying mosquitoes to reduce their ability to transmit malaria. One notable example is the development of genetically modified mosquitoes that carry genes that suppress the mosquito population or make them resistant to the malaria parasite (Raghavendra et al, 2011). This approach shows promise but raises ethical, regulatory, and safety concerns that need to be addressed. Integrated Vector Management (IVM) sums it all up as it involves combining multiple vector control strategies in a coordinated manner, considering local epidemiological and ecological factors (Benelli and Beier 2017). By integrating various interventions, such as ITNs, IRS, LSM, and others, IVM aims to achieve sustainable and effective vector control (Figure 1).

Challenges and future strategies

Malaria vector control faces several challenges that can hinder its effectiveness in reducing transmission. Understanding and addressing these challenges is crucial for the success of vector control interventions.

Insecticides used in vector control interventions, such as pyrethroids, might cause mosquito resistance which may in turn reduce the effectiveness of indoor residual spraying (IRS) and insecticide-treated nets (ITNs). Resistance develops and spreads as a result of over-reliance on a small number of insecticides and insufficient rotation of other pesticide classes (Takken and Kohls 2009, Corbel and N'Guessan 2013, Killen and Ranson 2018). Developing and deploying new insecticides, as well as implementing resistance management strategies, are necessary to combat this challenge.

Mosquitoes have consistently changed their behaviour in response to vector control interventions. For example, some mosquitoes may shift their feeding habits from indoors to outdoors or change their biting times to avoid contact with insecticide-treated surfaces. Such behavioural adaptations reduce the impact of interventions that primarily target indoor-biting mosquitoes, making it more challenging to control malaria transmission. Malaria is transmitted by various mosquito species, and their behaviour, ecology, and susceptibility to control interventions can vary. A one-size-fits-all approach may not effectively target all vector species in different regions (Raghavendra et al 2011, Massebo et al 2015). Understanding the local vector species composition and their behaviours is crucial for designing appropriate and targeted vector control strategies.

Achieving high coverage and sustained use of vector control interventions, such as ITNs and IRS, can be challenging in resource-limited settings. Thus, limited access to these interventions, financial constraints, and cultural factors can impede their widespread adoption. Ensuring equitable access to vector control tools and addressing barriers to their implementation is essential to achieving effective coverage Tizifa et al 2018. Vector control interventions require ongoing maintenance, monitoring, and replacement to remain effective. Challenges related to infrastructure, funding, supply chain management, and community engagement can hinder sustainability of interventions. Building robust systems for monitoring and evaluation, as well as strengthening health systems, is crucial to sustaining vector control efforts.

Climate change has greatly influenced the distribution, abundance, and behaviour of mosquito vectors. Rising temperatures, altered rainfall patterns, and changes in land use can impact mosquito populations and their ability to transmit malaria (Glunt et al 2013).

Adapting vector control strategies to account for climate change and considering environmental factors in intervention design is important for long-term effectiveness.

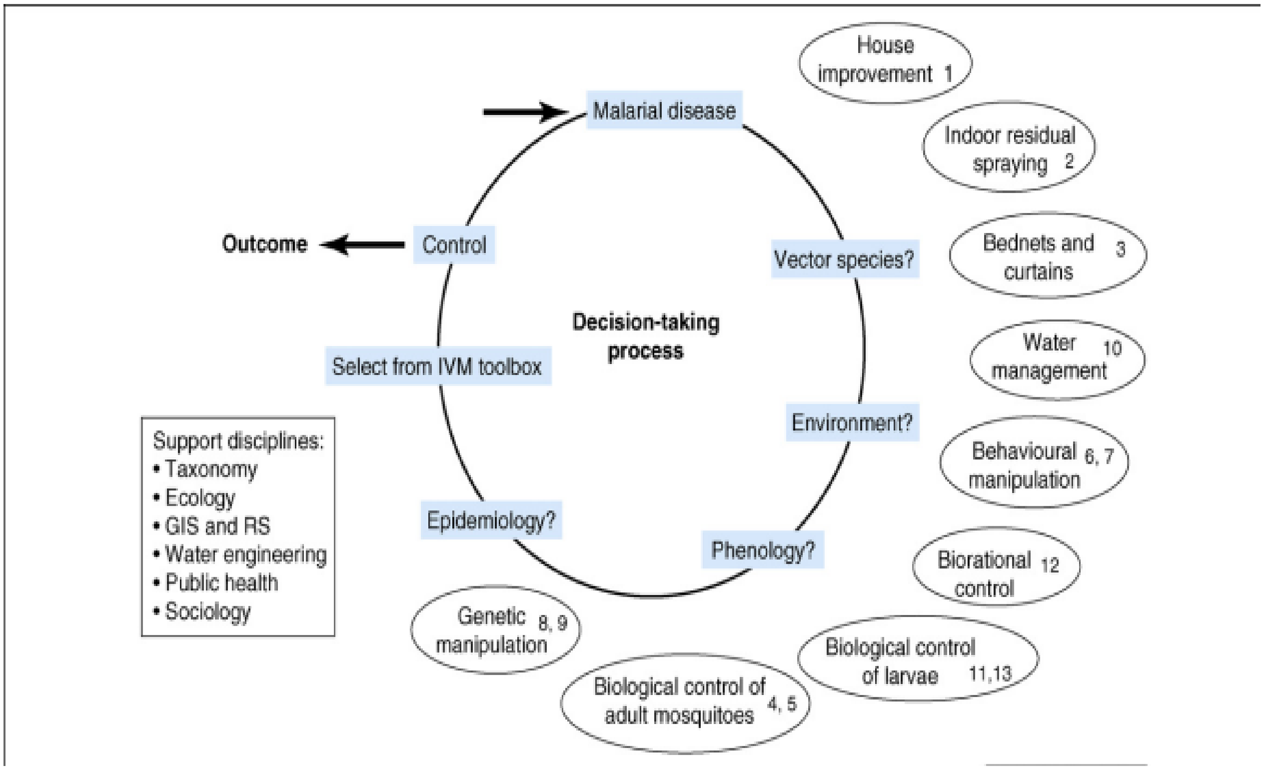

Figure 1. Integrated vector control interventions (Tekken and Knolls, 2009)

Future vector control strategies

Future strategies for malaria vector control are being explored and developed. These may include innovative repellents that deter mosquitoes from entering human living spaces.

Approaches such as new insecticides and formulations, developing and deploying alternative insecticides and formulations that overcome insecticide resistance and have improved safety profiles (Figure 2) have been considered. Spatial repellents: Creating long-lasting spatial conflict and instability. Malaria-endemic regions often face political instability, conflicts, and displacement of populations, which can disrupt or hinder vector control efforts. Inadequate infrastructure, limited resources, and population movements make it challenging to implement and sustain control interventions in these contexts. Coordinated efforts involving humanitarian agencies, governments, and international organizations are necessary to address vector control challenges in conflict-affected areas (Hemingway 2014).

Addressing these challenges requires a multi-faceted and integrated approach, including research and innovation, strengthening health systems, community engagement, and collaboration among stakeholders. Continuous monitoring, evaluation, and adaptation of strategies based on local contexts are crucial to improving the effectiveness and sustainability of malaria vector control efforts.

Attractive Toxic Sugar Baits (ATSB): Using sugar baits laced with toxic substances to attract and kill mosquitoes outside human dwellings. *Targeting outdoor transmission*: Developing interventions that specifically target outdoor biting and transmission, as some malaria vectors exhibit outdoor feeding behaviour. *Novel vector control tools*: Exploring new technologies, such as trapping systems, genetic control methods, and use of unmanned aerial vehicles (drones) for targeted delivery of interventions (Benelli and Beier 2017, Tizifa et al 2018, Echodu et al, 2020).

It's paramount to note that the success and success of these future strategies may vary contingent on the local context, including vector species, insecticide resistance patterns, and community engagement (Ranson 2017, Nasir et al 2020, Barreaux et al 2017, Sougoufara et al 2017). Continued research, collaboration, and investment in malaria vector control are essential to develop and implement sustainable strategies that can reduce the burden of malaria globally.

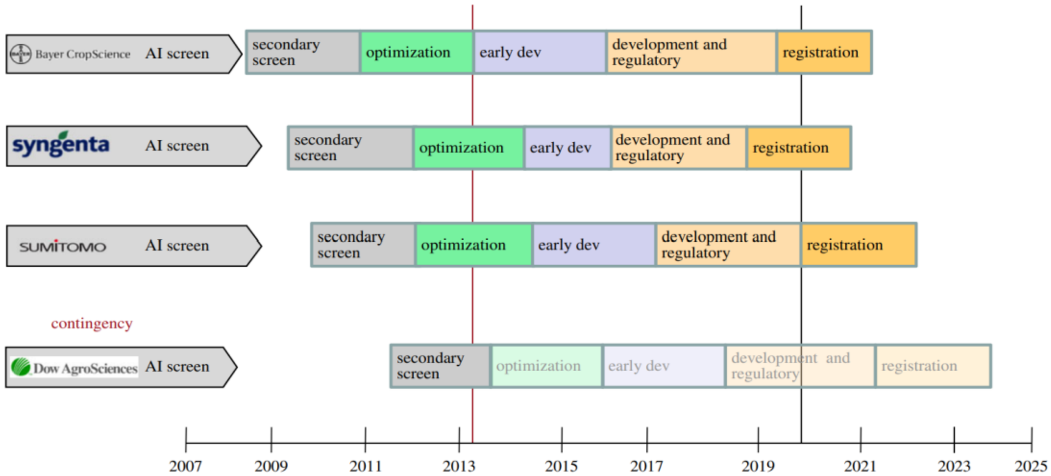

Figure 2. An overview of the market trends for new insecticides in the IVCC product line, together with the timelines for their introduction (Hemingway, 2014).

Conclusion

To enhance mosquito vector control efforts and improve their quality and delivery, it is important to focus on the following areas of research: Process and delivery approaches for vector control measures optimization. employing trusted methods to keep an eye on mosquito populations and biting activity. Creation of efficient and ecologically friendly instruments to lessen or possibly completely eradicate local cases of malaria and other diseases spread by mosquitoes thorough assessment of applicability and efficiency of new mosquito control methods in actual settings to show how they affect disease transmission. monitoring of environmental changes that might affect mosquito populations and spread of malaria. collaboration among numerous academic and research disciplines, including parasitology, tropical medicine, ecology, entomology, and ecotoxicology. This interdisciplinary approach must be kept up if we are to better understand the behavioral ecology of malaria vectors. The effectiveness of vector control strategies is hampered by a number of ecological issues. These include the diversity of vector species, interactions within the mosquito food web and competition, variations in mosquito behavior, emergence of insecticide resistance, propensity of mosquitoes to avoid specific control methods, knowledge gap regarding mosquito dispersal and mating behavior, and the influence of environmental changes on mosquito traits.

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REVIEW ON VARIATION IN GENETIC AND CHEMICAL CONSTITUENTS OF *Strychnos henningsii* POPULATIONS IN KENYA

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Abstract

Strychnos henningsii is an indigenous medicinal plant species widely used in tropical Africa. Studies have revealed that this plant has been used as a remedy for various ailments including rheumatism, gastrointestinal complications, abdominal pains, syphilis, snakebites, diabetes malaria, and arthritis amongst others. Phytochemical and pharmacological studies have identified various compounds such as alkaloids, anthraquinones, cardiac glycosides, chalcones, flavonoids, phenolics, proanthocyanidins, saponins, steroids, tannins and triterpenes from the crude extracts of S. henningsii. These chemical constituents exhibited analgesic, antibacterial, antidiabetic, anti-inflammatory, antioxidant, antiplasmodial, antiprotozoal, antispasmodic as well as cytotoxicity activities. Secondary metabolites are known to aid plants in coping with various environmental stresses. Environmental stress triggers expression of genes for the enzymes involved in biosynthesis of secondary metabolites, many of which have higher medicinal value despite being useful in plant defense mechanisms. This paper is a review on the chemical constituents, pharmacological properties and genetic variation of S henningsii across its geographical range.

Key Words: *Strychnos henningsii, chemical constituents, genetic, medicinal, variation.*