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EVIDENCE BRIEF

Potential Benefits and Risks of Gene Drive Mosquitoes for Malaria Burden Reduction and Elimination in Endemic Countries of Africa: A Rapid Review

Background

Malaria prevention and control has been a global public health priority, with nearly half the global population at risk of contracting the disease [1]. There were 247 million malaria cases and 619,000 deaths in 2021 [2]. In the past two decades, malaria control and prevention activities led to two billion cases and 11.7 million deaths averted globally [2]. The most at-risk populations for contracting malaria and developing severe disease are infants, children below five years of age and people with low immunity, especially pregnant women and persons living with HIV/AIDS in endemic transmission regions [1–3].

Gene drive mosquito technology is a new tool being developed for malaria control and elimination in Africa. The idea of releasing GDMs into the environment has led to several concerns, occasioned by the lack of information about potential environmental and human health impacts [4]. An evidence synthesis was conducted through a systematic rapid review to explore the benefits, risks and concerns associated with GDM use in sub-Saharan Africa.

Key Messages

- ☑ Gene drive mosquitoes promise potential human health benefits such as a reduction of malaria incidence and deaths.
- ☑ They hold promise as additional tools for integrated malaria vector control programs
- ☑ These mosquitoes have not been tested anywhere in the world and may present unforeseen problems if not cautiously tested and deployed.
- ☑ Thus, there is a need for improved surveillance systems to continuously monitor and address any unintended consequences posed by open releases of gene drive mosquitoes.

Methods

The rapid review searched for literature from the database's inception to January 2023. The articles were searched in Google Scholar and peer reviewed databases, including Cochrane and PubMed.

Results

Only 534 articles were screened out of 4,504 retrieved from databases, of which only 37 were included for the full review. From the included studies, the total number of studies conducted from sub-Saharan Africa was 10 (27%), while 27 (73%) were from other regions.

Potential benefits of gene drive mosquitoes

The potential benefits of using gene drive mosquitoes for malaria control and elimination in Africa fall under two protection goals, i.e., biodiversity and human health. The gene drives mosquito technology only targets the mosquito vector by passing 'beneficial genes' to suppress or eliminate populations of disease-carrying insects. The technology does not kill or alter other disease vectors and thereby has less environmental impact [5], [6].

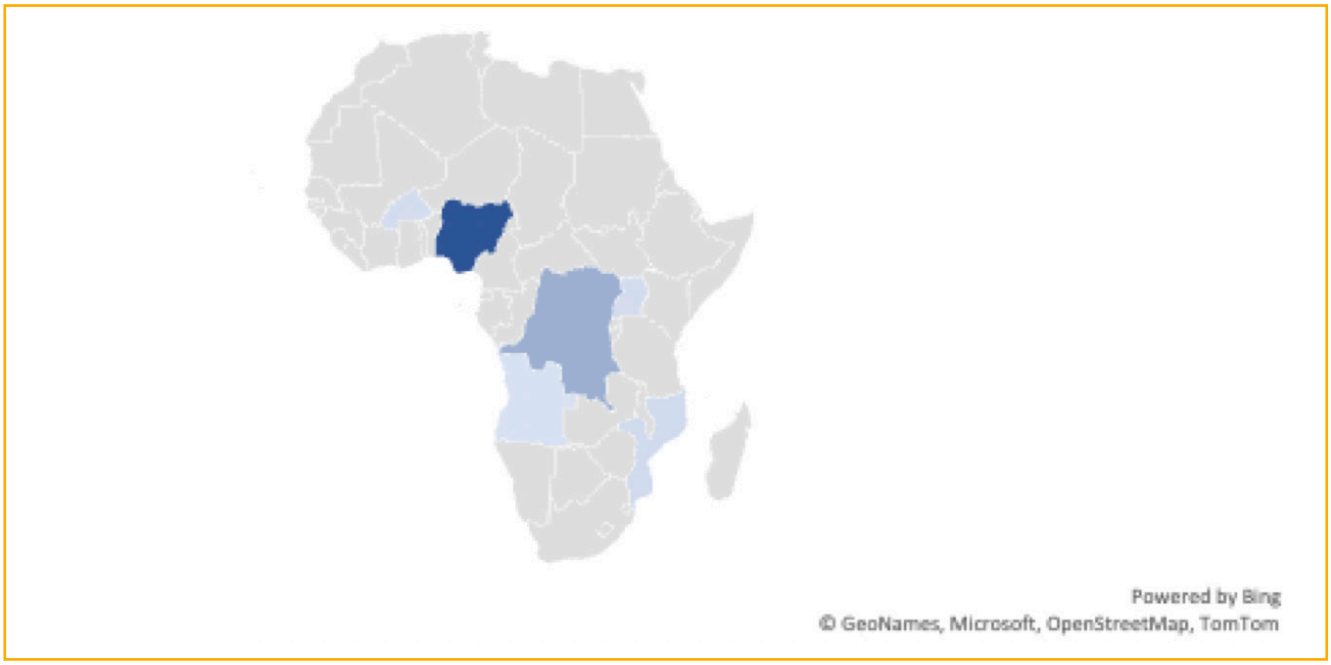
Additionally, there are three benefits to human health, including the elimination and/or reduction of malaria incidence, reduced deaths due to malaria, and prevention of the re-introduction of malaria in areas that have achieved elimination [4], [7], [8]. Overall, GDMs provide a possible additional tool for integrated malaria vector control and elimination in Africa [9].

Potential risks of gene drive mosquitoes

The biodiversity risks to non-target populations include horizontal gene transfers whereby genes of interest may inadvertently spread across populations of otherwise distinct species [10]. This could give rise to new genes or silence other genes, which could potentially eliminate other useful non-target populations in the ecosystem [11], [12]. Furthermore, GDMs could lead to the distortion of the biodiversity food chain, for example, eliminating the food source of another species or promoting the proliferation of its prey [8], [10], [13]–[19].

The other biodiversity risk is vertical gene transfers, where movement of genetic material is transferred from parents to offspring [10]. Consequently, eliminating a target organism instead of suppressing it or decreasing the fitness of the targeted mosquito species. This influences its survival, mating success, and fertility, compromising intended entomological and epidemiological outcomes [13], [14].

A documented consequence of GDMs to human health is that a 'super fit' mosquito could have an increased capacity to host pathogens and transmit malaria. For example an ability to carry Plasmodium variant it never had prior, making it more deadly [20].



Sub-Saharan African countries with highest malaria cases and deaths, World Malaria Report 2022

To mitigate the risk of susceptibility to new diseases, there is need to improve xeno-surveillance, thus quickly detecting and addressing any unintended consequences [21]

Discussion

This evidence synthesis explores the risks and benefits of gene drive mosquitoes for malaria control and elimination in Africa. There are immense concerns over potential environmental and health impacts centered around the unpredicted adverse effects of the release of gene drive mosquitoes. These bring to the fore the need for more elaborate gene drive research to assess the highlighted concerns and develop risk mitigation measures.

Overall, the highlighted benefits under the human health protection goal [4], [6], [8], [22] through the provision of a viable tool for integrated malaria vector control [4], [8], [9], [23] offer the potential for a lifesaving innovation. Furthermore, cost-related reasons that have eluded people experiencing poverty in the hard-to-reach populations within the malaria endemic regions now have the potential realization of malaria elimination through the gene drive mosquito technology [5], [8], [24].

There are immense concerns over potential environment and health impacts centred around the unpredicted adverse effects of the release of gene drive mosquitoes.

Conclusion

The future use of GDMs as a vector control approach will broaden the integrated strategies for malaria control and elimination efforts once fully developed. Therefore, the anticipated limitations should not, in isolation, provide a reason for rejecting GDMs. Rather, the benefits should be examined against the potential risks and modifications adopted based on the risk levels for the different products under development alongside stakeholder engagements as a gateway for it to acquire a social license.

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