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Application of Genetically Based Vector Control Technologies to Control Infectious Diseases in Africa

Policy Brief

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Key Messages

- Genetically based vector control (GBVC) technologies involve manipulating the genes of disease-transmitting vectors, such as mosquitoes, to reduce their ability to transmit diseases.
- GBVC technologies can specifically target and significantly reduce the populations of vectors responsible for diseases and are therefore crucial to effective disease management in regions heavily burdened by vector-borne illnesses.
- These technologies offer long-term vector control, reducing reliance on chemical insecticides and providing a sustainable alternative to traditional insecticide methods. This minimises the environmental and health risks associated with pesticide use, and enhances resilience to insecticide resistance, a growing concern in vector management.
- GBVC technologies can be precisely designed to target specific vectors, significantly lowering collateral damage to non-target species and ecosystems. They can also be adapted to local contexts, providing tailored solutions that address regional challenges posed by different vector species and disease dynamics.
- Regulatory and governance frameworks for the development and use of these technologies are essential to minimise or eliminate any harmful impacts.

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Context

Genetically Based Vector Control (GBVC) technologies present a promising solution to combat vector-borne diseases such as malaria, dengue fever, and Zika virus in Africa where these illnesses pose significant public health challenges. Recent advances and field trials have shown that GBVC technologies have great potential in reducing the population of disease vectors or their ability to transmit disease. However, their implementation faces several hurdles, such as public perceptions especially for approaches that involve genetically modified organisms, ethical concerns, and complex regulatory frameworks. Additionally, there are suspicions of ecological risks associated with unintended consequences, such as disruption of ecosystems and potential loss of biodiversity. Ensuring long-term sustainability and equitable access to these technologies is crucial for their successful application in African countries.

Methodology

This brief is based on information drawn from a review of existing literature on GBVC and emerging technologies. The authors reviewed relevant scholarly articles, conference papers, books, reports, newspapers, and other sources to identify opportunities and challenges of using the technologies for the control of infectious diseases in Africa, and to make recommendations for their wider application. The brief was further enriched with information gathered during meetings with experts on emerging technologies convened by the African Institute for Development Policy (AFIDEP) and the African Union Development Agency (AUDA-NEPAD) in August, September and October 2024. The meetings included the emerging health technologies expert meeting, biannual statutory meeting for the African Union High Level Panel on Emerging Technologies (APET) and a Regional Dialogue on Leveraging Emerging Technologies to Improve Healthcare Delivery Systems in Africa.

Findings

GBVC encompasses various innovative technologies aimed at combatting vector-borne diseases in Africa, which collectively promise substantial reductions in targeted vector populations. The technologies include:

(i) Sterile Insect Technique (SIT), which involves releasing sterile insects into the wild to decrease the populations of those that carry diseases.

(ii) Incompatible Insect Technique (IIT), which leverages Wolbachia-infected insects to create reproductive incompatibility among wild insect populations, thereby reducing disease transmission rates.

(iii) Gene drive technology, which allows desirable genetic traits to spread quickly through populations, potentially altering disease dynamics.

Other methodologies, such as Ribonucleic Acid Interference (RNAi) and CRISPR/Cas9 , enable direct manipulation of vector genomes to silence specific genes, effectively lowering disease transmission.

The advantages of using GBVC technologies in addressing public health challenges in Africa are significant. Studies and field trials have shown that they are effective at controlling disease-carrying vectors, such as mosquitoes, which spread diseases such as malaria, dengue fever, and Zika virus. For instance, in Burkina Faso, studies are underway to prepare for testing genetically modified mosquitoes that have potential to inhibit their ability to transmit malaria and dengue. The precision targeting capabilities of GBVC technologies diminish the risks associated with broad-spectrum insecticides on non-target species and ecosystems. They can also curb environmental damage and public health risks associated with reliance on pesticides, making them highly advantageous in the battle against vector-borne diseases. Furthermore, these genetic interventions hold potential for long-term effectiveness and sustainability, reducing the need for repeated applications as with traditional methods.

While the prospects of GBVC are bright, several social and ethical considerations must be addressed for their successful deployment. For instance, their social acceptability hinges on considerations of the local cultural beliefs and practices, underscoring the importance of community involvement in decision-making. It is important to engage local communities in the informed consent processes for trials and implementation, so that they are aware of the potential risks and benefits associated with such technologies.

Concerns regarding equity should also be considered. It is crucial that all community members, particularly marginalised populations, benefit from these interventions without exacerbating existing health disparities. Comprehensive regulatory frameworks are also necessary to manage potential environmental impacts, ensuring that GBVC technologies are both safe and effective.

Continuing research is critical to help countries navigate the challenges related to the implementation of GBVC technologies. Research can contribute to understanding the biology and genetics of vector species, vector-host interactions, and exploring the ecological impacts of deploying gene drive systems. Additionally, social science research can illuminate community perspectives and inform strategies for effective public engagement. Capacity building through training and regional collaborations will help to strengthen research capabilities and surveillance systems necessary for effective vector control. These efforts will help ensure that GBVC technologies are developed responsibly and contribute to improved public health outcomes in Africa.

Policy Recommendations

Some of the policy actions that can promote the effective application of GBVC technologies for controlling infectious diseases in Africa include the following:

1. Prioritise investment in research and development to enhance the efficacy and safety of genetically based vector control technologies. This includes funding studies on genetic modifications, vector behaviour, and ecosystem impacts.

2. Promote an integrated approach to vector control that combines genetically based strategies with other interventions such as insecticide-treated bed nets, indoor residual spraying, and environmental management. This comprehensive approach maximises effectiveness while minimising environmental impact and the risk of insecticide resistance.

3. Develop robust regulatory frameworks to govern the deployment of genetically modified organisms (GMOs) for vector control. These include frameworks for risk assessment protocols, monitoring systems, and mechanisms for public consultation and participation in decision-making processes.

4. Build local capacity for research, monitoring, and evaluation of vector control programmes. These include providing training for scientists, healthcare workers, and community leaders, as well as investing in infrastructure and laboratory facilities.

5. Implement comprehensive community engagement and education programmes to ensure public awareness and acceptance of genetically based vector control technologies. This should involve consultation with local communities, addressing concerns, and providing accurate information about the benefits and risks.

6. Ensure that the deployment of genetically based vector control technologies adheres to ethical principles, including respect for human rights, informed consent, and social equity.

7. Develop strategies for the sustainable implementation of genetically based vector control technologies, including mechanisms for long-term funding, capacity maintenance, and adaptive management in response to emerging challenges and opportunities.

8. Establish robust monitoring and evaluation mechanisms to assess the impact of genetically based vector control interventions on vector populations, disease transmission, and public health outcomes. These include regular surveillance for insecticide resistance and other indicators of programme effectiveness.

9. Foster collaborations between governments, research institutions, non-governmental organisations,and international agencies to share knowledge, resources, and expertise in implementing vector control strategies.

10. Advocate for policy support at the national, regional, and international levels to prioritise investment in genetically based vector control technologies as part of broader efforts to combat vector-borne diseases in Africa.

Conclusion

GBVC technologies represent a transformative approach to combating vector-borne diseases in Africa, promising significant public health benefits. Their precision targeting and potential for long-term sustainability make them valuable alternatives to traditional insecticide-based methods, particularly in addressing the challenges posed by insecticide resistance. However, successful implementation requires careful consideration of social, ethical, and ecological factors, necessitating community engagement and robust regulatory frameworks to ensure safety and efficacy. Continuing research and collaboration across the continent will be crucial for harnessing the full potential of GBVC technologies, improving health outcomes and reducing the burden of infectious diseases in African populations.

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For More Information, Contact:

Africa Institute for Development Policy (AFIDEP)
Malawi Office: 3rd Floor, Public Service Pension Fund Building, P.O. Box 31024, Lilongwe 3
Kenya Office: 6th Floor (Block A), Westcom Point Building, Mahiga Mairu Avenue, Off Waiyaki Way, Westlands
P.O. Box 14688-00800, Nairobi, Kenya | info@afidep.org
www.afidep.org

African Union Development Agency (AUDA-NEPAD)
230 15th Road, Midrand,
Johannesburg, South Africa
info@nepad.org
www.nepad.org

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