U.S. President's Malaria Initiative

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# Susceptibility Testing of *Anopheles* Malaria Vectors with the Neonicotinoid Insecticide Clothianidin: Results from 16 African Countries, in Preparation for Indoor Residual Spraying with New Insecticide Formulations


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## Background

- New IRS formulations, SumiShield™ 50WG and Fludora Fusion™ WP-SB, became WHO prequalified vector control products in 2017 and 2018 respectively.
- Both formulations contain the neonicotinoid active ingredient, clothianidin.
- In preparation for rollout of clothianidin formulations as part of national IRS rotation strategies, baseline susceptibility testing was conducted in 16 countries in sub-Saharan Africa.

## Methods

- There is currently no WHO guidance regarding clothianidin susceptibility procedures or diagnostic concentrations.
- A protocol was developed for impregnating filter papers with 2% SumiShield™ 50WG dissolved in distilled water that were subsequently tested in WHO tubes.
- Susceptibility tests were conducted using insectary-reared reference *Anopheles* and wild collected malaria vector species. Mortality was recorded daily for 7 days, due to the slow-acting nature of clothianidin against mosquitoes

**Figure 1.Locations where clothianidin susceptibility testing was conducted in 2016-17**

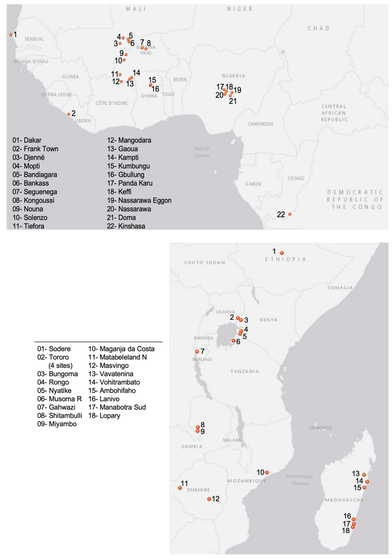



**Figure 2. Larval collections of *An. gambiae* s.l. larvae and bioassays in WHO tubes**

## Results

One-hundred percent mortality was reached with 11/12 susceptible insectary strains.

**Figure 3. Percentage mortality of insectary reared susceptible *An. gambiae*, *An. coluzzii*, and *An. arabiensis* following 60 mins exposure to clothianidin treated filter papers in WHO tubes in 12 countries**

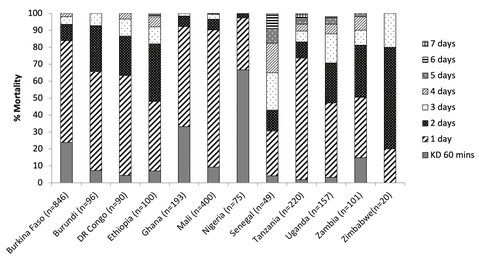



**Figure 4. Percentage mortality of wild F1 *An. gambiae* s.l. from sites in West and Central Africa following 60 mins exposure to clothianidin treated filter papers in WHO tubes**

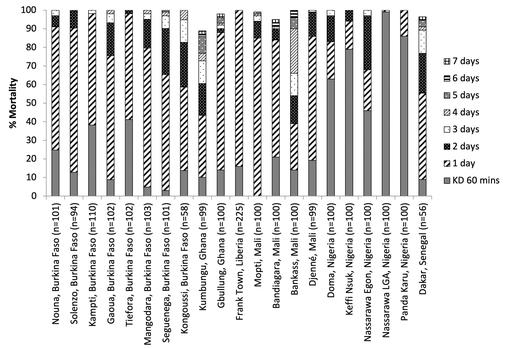
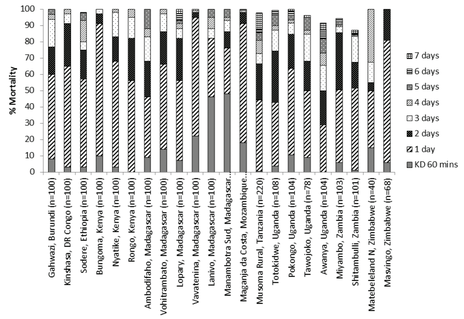



**Figure 5. Percentage mortality of wild F0 *An. funestus* s.l. (Mozambique and Zambia) and F1 *An. gambiae* s.l. from sites in East and Southern Africa following 60 mins exposure to clothianidin treated filter papers in WHO tubes**




- Tests in at least one location from 5 countries produced mortality below 98% (Fig. 4 & 5).
- While this could potentially be a sign of clothianidin resistance, it is more likely that the diagnostic dose or protocol requires further optimization

**Figure 6. Probit analysis to estimate the holding time expected to result in 25, 50, 70, 80, 90 and 95% mortality after 60 exposure to 2% clothianidin**

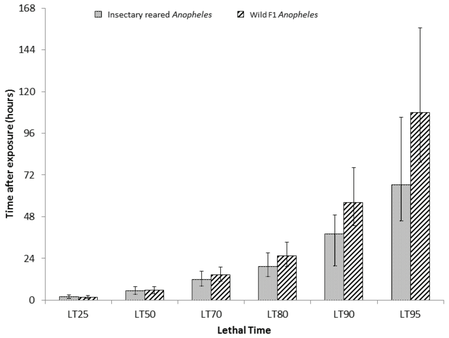
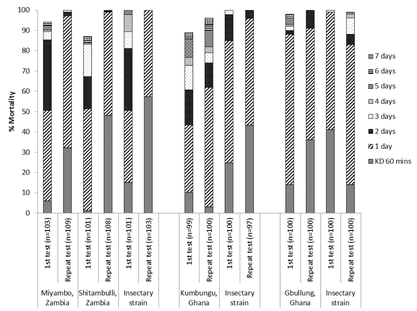



**Figure 7. Percentage mortality of wild F1 *An. gambiae* s.l. from repeated tests for sites in Zambia and Ghana**




- Probit analysis for wild collected *Anopheles* and insectary reared susceptible mosquitoes produced similar results, showing that the majority of mortality occurred within the first 24h and 90% of mortality was estimated to take place 72h after exposure (Fig. 6).
- Repeat testing in 3 sites in Ghana and Zambia, where possible resistance was detected, subsequently produced 100% mortality (Fig 7).
- Results showed susceptibility to clothianidin in 38 of the 43 sites in sub-Saharan Africa, including malaria vectors with multiple resistance mechanisms to other insecticides.

## Conclusion

- This study provides an interim diagnostic dose of 2% clothianidin on filter papers which can be utilized by national malaria control programs and research organizations until WHO concludes multi-center studies and provides further guidance

Abt ASSOCIATES