Insecticide resistance in *Anopheles arabiensis*, the primary malaria vector in Sudan

Mr. Ayman Ahmed, M.Sc.
Research Fellow at Institute of Endemic Diseases, University of Khartoum, Sudan
Wellcome Trust Master’s Fellow at the Liverpool School of Tropical Medicine (LSTM), UK
ayman.ame.ahmed@gmail.com
Malaria in Sudan:

• Sudan is considered a high-burden and high-risk country for malaria.

• 1.5 million estimated cases of malaria and about 3,885 deaths.

• Sudan’s contributing by 35% of the estimated malaria cases within EMRO in 2017.

• Control program rely heavily on IR and ITNs.
IR in Sudan:

Study conducted in 2012 showed that resistance of the Khartoum population of *Anopheles arabiensis* to the four class of insecticides used for IRS.

What is our question?

• We had two concerns in mind:

1) The public health use of insecticide is not the only source for IR.

2) Organophosphates and carbamates are the main option for IRS in Sudan.
Scale of the study:

- We investigated the carbamate and organophosphate resistance in *An. arabiensis*.

- 2725 and 2825 samples were tested for Bendiocarb 0.1% and Malathion 5% resistance respectively.

- Countrywide across the three ecological zones of the country (transmission varies per zone).
Major findings: Sites of the desert/semi desert region

- **Zeidab**
  - Peri-urban sites:
    - Malathion 5%
    - Bendiocarb 0.1%
  - Urban sites:
    - Malathion 5%
    - Bendiocarb 0.1%

- **Makabrab**
  - Urban sites:
    - Malathion 5%
    - Bendiocarb 0.1%

- **Red Sea state**
  - Urban sites:
    - Malathion 5%
    - Bendiocarb 0.1%

- **River Nile state**
  - Urban sites:
    - Malathion 5%
  - Peri-urban sites:
    - Bendiocarb 0.1%
  - Peri-urban sites:
    - Malathion 5%
Sites of the poor Savanna region:

- **Gedaref state**
  - Alseit: Malathion 5%, Bendiocarb 0.1%
  - Rashid:
    - Urban sites: Malathion 5%
    - Peri-urban sites: Bendiocarb 0.1%

- **Khartoum state**
  - Urban sites
    - Maygoma: Malathion 5%, Bendiocarb 0.1%
    - Soba: Malathion 5%, Bendiocarb 0.1%
Sites of the rich Savanna region:

- **Hajabdalla**
  - Peri-urban sites: Malathion 5%
  - Peri-urban sites: Bendiocarb 0.1%
- **Keriba**
  - Urban sites: Malathion 5%
  - Urban sites: Bendiocarb 0.1%
- **Om el Khair**
  - Peri-urban sites: Malathion 5%
  - Peri-urban sites: Bendiocarb 0.1%
- **Sennar**
  - Urban sites: Malathion 5%
  - Urban sites: Bendiocarb 0.1%
Bendiocarb is significantly associated with Peri-Urban sites.

\[ X^2 = 121.46, \text{ df } = 2, \ P < 0.00001 \]

An effect size = 21\%, 95\% C.I. (17\% - 25\%)

Malathion is not:

\[ X^2 = 0.13, \text{ df } = 2, \ P = 0.722939 \]
Conclusion:

• We confirmed the absence of Ace-1 mutation in the population of *An. arabiensis* across all states.

• IR of the Sudanese population of *An. arabiensis* is heterogeneous. Possibly, due to the barriers of the harsh environment.

• We are working on validating the genes associated with resistance.

• Our morphological and molecular investigation suggesting the possible involvement of cuticle resistance (Melanic form).
Recommendations:

• We recommend investigating the temporal and spatial variation of IR in the mosquito population at small distance and time frequency.

• Investigating the role of cuticle resistance as well as barriers for the genes follow.

• The coordination between the ministry of health and ministry of agriculture for the early detection of resistance among pests, better use of insecticides, and improve the management of IR.
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Insecticide resistance in the main malaria vector in Sudan