Why mosquitoes matter

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19/02/2017, Keystone
Why mosquitoes matter

- They transmit infectious diseases
- Vector control is an important component in the overall strategy to control and ultimately eliminate malaria
Key concepts entomology

1. Resistance to insecticides
2. Residual transmission
3. Surveillance

Double R crisis

Tools
Why are mosquitoes so successful?

*r-strategists*

live in unstable environments and produce many offspring with a low survival rate

Their great numbers...
How do we fight the bite

Frontline tools: Universal coverage with LLINs and/or IRS

LLIN: Long-Lasting Insecticidal Nets
IRS: Indoor Residual Spraying
Our front-line tools are very successful

Contribution of interventions:
- ITN  insecticide-treated nets
- ACT  artemisinin-based combination therapy
- IRS  indoor residual spraying

Predicted $PfPR_{2-10}$
- Actual
- Counterfactual (no interventions)

Bhatt Nature 2015
Our front-line tools are very successful

Enormous pressure → Resistance
How can they counteract so rapidly?

r-strategists
more likely to have 1 mosquito with a mutation

1/100,000
How can they counteract so rapidly?
Resistance to pyrethroids

They counteract rapidly - Mozambique

Nearly fixed...
Resistance to pyrethroids as a result of the \textit{kdr mutation} (2-3-fold increase) may not have an operational impact, but the > 1000-fold increases due to \textit{P450}-based metabolic resistance likely has (Hemingway 2014)
Intensity of resistance - Mozambique

An. funestus
PermaNet 2.0
They counteract rapidly

“Today there is no country in Africa where the vectors remain fully susceptible to pyrethroids”

pyrethroids  

They counteract rapidly

New insecticides for public health >2022  

organophosphates  

DDT  

carbamates
Key concepts entomology

- Resistance to insecticides (R)
- Residual transmission (S)
- Surveillance (T)

Double R crisis

Tools
Why are mosquitoes so successful?

**r-strategists**

live in unstable environments and produce many offspring with a low survival rate

More than great numbers alone...
Why are mosquitoes so successful?
Why are mosquitoes so successful?

>100 species
Different ecology
Different behavior
What should entomologists measure?

That what really matters:

Vector-human contact

*When and where does malaria transmission occur?*
Vector-human contact - key concepts
Vector-human contact - key concepts
Vector-human contact - key concepts
Vector-human contact - key concepts
Vector-human contact - key concepts

Exophagic Feeding
Exophilic Resting

Endophagic Endophilic
Feeding Resting
Vector-human contact - key concepts
Vector-human contact - key concepts

zoophagic

anthropophagic
Vector-human contact - key concepts

- zoophagic
- opportunistic
- anthropophagic
Vector-human contact - complex
Persistence of transmission after good coverage has been achieved with high quality vector control interventions to which local vectors are fully susceptible

*Let’s look at some hypothetical examples*
Vector-human contact
Vector-human contact
Vector-human contact

Resting outdoors
Vector-human contact

Feeding before bedtime
Vector-human contact

Resistant...
Vector-human contact
Vector-human contact
Vector-human contact
Vector-human contact
Vector-human contact - complexities
Vector-human contact - complexities
Vector-human contact - complexities
Vector-human contact - complexities
Vector-human contact - complexities
Both human and vector behaviour is responsible for such residual transmission, such as people staying outdoors at night or local mosquito vector species displaying behaviour that allows them to avoid core interventions.
Linking human & mosquito behaviors
Linking human & mosquito behaviors

Protective gap
How to capture all this?
How to capture all this?

Various surveillance tools

- Human Landing Catch (HLC)
- Pyrethrum Spray Catch (PSC)
- Odor-baited traps
- Tent traps
- Window exit traps
How to capture all this?

HLC

PSC

WHO

Biogents

limn.it/nature.com
But be aware!

Different tools → different behaviors
host seeking, resting, ovipositing

Selection depends on your question
Pyrethrum Spray Catch (PSC)

Resting @ 6am
Impact of IRS
Pyrethrum Spray Catch (PSC)
Pyrethrum Spray Catch (PSC)
Key concepts entomology

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Double R crisis

Tools

CISM - Centro de Investigação em Saúde de Manhiça
ISGlobal - Barcelona Institute for Global Health
IR - Smarter with insecticides

- Rotation of insecticides
- Mixtures

A: 1/100.000, B: 1/100.000, AB: 1/10.000.000.000

- Mosaic spraying
IR - New insecticides

• 3 new Active Ingredients (AI)>2020

• Nets with synergist
• Nets with 2 insecticides
We need to look beyond insecticides

Multiple vector species, biting several hosts, various habitats
Vector control pipeline

2014

Chlorfenapyr indoor residual spraying (IRS)

2015

Chlorfenapyr/pyrethroid long-lasting insecticide-treated net (LLIN)

2016

Chlorfenapyr long lasting IRS (LLIRS)

2017

Re-purposed crop protection development compound

2018

New active ingredients from library screens of agrochemical industry partners (Syngenta, Bayer, Sumitomo, Dow)

2019

Biologically modified mosquitoes

2020

Spatial repellents (e.g., airborne chemicals)

2021

Pyriproxyfen/pyrethroid LLIN

2022

Re-purposed active ingredients from crop protection for LLIRS and LLINs

2023

Eave tubes, toxic durable wall liners (as replacement for IRS), insecticidal paint

2024

Attractive toxic sugar baits, outdoor barrier sprays, toxic barrier screens, larvicides

2025

More work is clearly needed

Ivermectin/endectocides
Odor-baited traps
Effective vector control can be complex and difficult... Regular and adequate surveillance is key