



April 2024

Development of a prioritized *An. stephensi* research agenda

Anopheles stephensi: a growing threat



Anopheles stephensi



Detected in: Djibouti (2012), Ethiopia (2016), Sri Lanka (2017), Republic of Sudan (2016), Puntland (2019), Nigeria (2020), Somaliland (2020), Eritrea and Yemen (2021), Kenya and Ghana (2022)

An. stephensi: the challenge

- Thrives in container habitat, often shared with *Aedes aegypti*, but also identified in natural habitats
- Effective adult trapping tools lacking, making evaluation of control tools on transmission a challenge
- Potential misidentification as other *Anopheles*
- Growing evidence of contribution to malaria transmission
- Genomics indicate multiple introductions/re-introductions
- Impact on malaria and implications for control costs
- How the species was introduced and is spreading remains unknown





What knowledge gaps exist and what research questions should be prioritized to guide research efforts and inform decision making?

What do we hope to achieve?

- Identify gaps in knowledge
- Provide a guiding resource for funders and researchers
- Accelerate action and create collaboration opportunities
- Disseminate prioritization outputs



How did this activity take place?

- Convening leading researchers and program managers virtually
- Five topic area working groups:
 1. Surveillance - entomological and epidemiological
 2. Control
 3. Genomics
 4. Modelling - mathematical and geospatial
 5. Human behaviour
- 12-15 participants per group, 2 leads
- 2-3 meetings for discussion
- Presentation of ranked prioritization with all participants
- Consensus summary document developed
- Survey to endemic country representatives
- VCWG feedback to be solicited





Surveillance (Entomological & Epidemiological)

Meshesha Managido, Yaw Afrane, Eric Ochomo, Hmooda Toto Kafy, Samira Al Eryanis, Michael Macdonald, Alia Zayed, Diana Iyaloo, Tovi Lehmann, Hiwot Teka, Said Ali, Ashwaq Madani Alnazawi, Mihirini Hewavitharane, Solomon Yared, Ahmadali Enayati, Sarah Zohdy, Melissa Yoshimizu, Anne Wilson





1. Larval habitat characteristics, productivity, and new methods for immature surveillance
2. Optimization of adult trapping methods
3. *An. stephensi* biology and bionomics
4. Evaluation of vectorial capacity and how it differs by location/time/baseline malaria burden
5. Identification of mode of entry (egg/adult) and routes of dispersion (e.g., transport, wind, etc.) and factors influencing establishment
6. New approaches for surveillance including defining optimal timing, frequency and location of sampling (scale), tools for rapid identification (e.g., use of AI tools), and community-based/devolved surveillance

Entomological Surveillance



Audience participation

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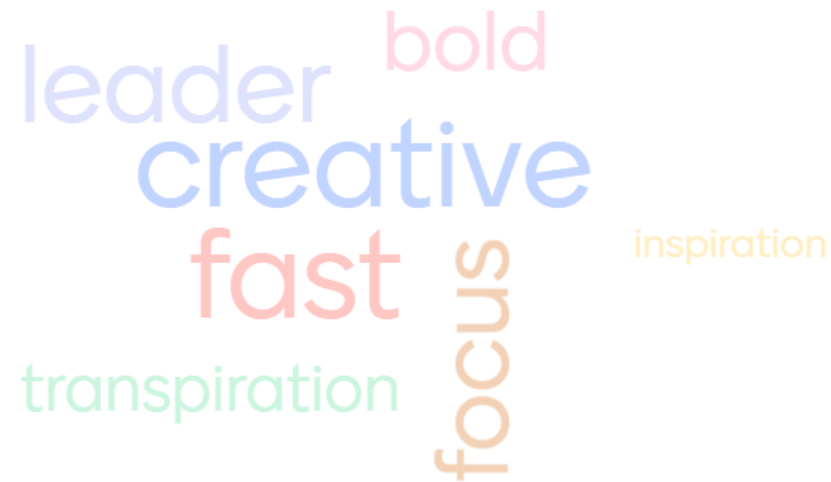
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 Mentimeter

In maximum 2 words, what should be a research priority for entomological surveillance of *An. stephensi*?



A word cloud of responses to the survey question. The words are: leader (blue), bold (pink), creative (blue), fast (red), focus (orange), transpiration (green), and inspiration (yellow).

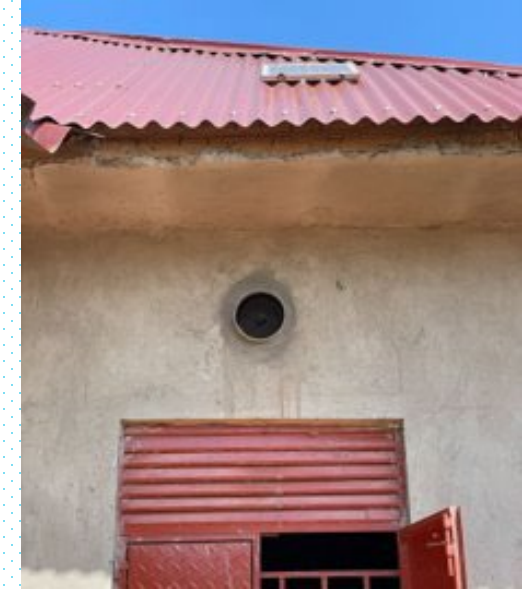




Epidemiological Surveillance



1. Role of *An. stephensi* vs. native vector species in malaria transmission including integrating entomological data with other data sources (travel history, rainfall, bednet use, etc.) to identify the impact of *An. stephensi* on cases
2. The study of malaria cases and vector surveillance in sentinel, vulnerable populations (e.g., pastoralist/migrant worker/IDP/construction workers)
3. Evaluation of the role of *An. stephensi* in *P. falciparum* and *P. vivax* transmission and in transmission of drug and diagnostic resistant malaria parasites
4. Development of early warning systems including determination of malaria case thresholds and arboviral outbreaks as triggers for enhanced malaria case surveillance



Control

Anne Wilson, Silas Majambere, Gonzalo Vazquez-Prokopec, Delenasaw Yewhalaw, Prosper Chaki, Pablo Manrique Saide, Jason Richardson, Dave Malone, Helen Jamet, Abdullah Awash, Mohammed Alzahrani Antonio Nkondjo, Charles Mbogo, Rishinta Premaratne, Hiwot Solomon, Bouh Abdi, Fatemeh Nikpoor, Ayman Ahmed, Susanta Kumar Ghosh





Control

1. Evaluation and optimization of existing control approaches (LSM, ITN, IRS, etc.), including assessment of effectiveness and cost effectiveness
2. Development and optimization of novel control approaches (ATSBs, spatial and topical repellents, genetically modified mosquitoes, animal-based interventions, etc.) including assessment of effectiveness and cost effectiveness
3. Identify and optimize mechanisms for sustained engagement of different sectors (health, environment, housing, infrastructure, agriculture, etc.) in control
4. Evaluation of integrated vector control interventions targeting both *An. stephensi* and *Ae. aegypti*

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What vector control approaches should be prioritised for *An. stephensi* research?



LSM

ITNs

IRS

Space
spraying

ATSBs

Spatial
repellents

GM
mosquitoes

Housing
modifications

Mass
trapping

Animal-
focused
interventions





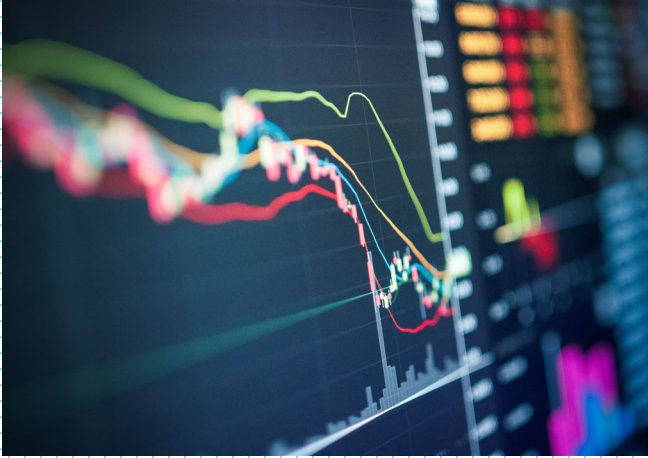
Genomics

Tamar Carter, Charles Wondji, Bhavna Gupta, Bryan Greenhouse, Farah Ishtiaq, Laura Norris, Neil Lobo, Susana Campino, Sinnathamby Noble Surendran, Tristen Dennis, Fitsum G. Tadesse, Martin Donnelly, David Weetman, Louisa Messenger, Chaitali Ghosh

Genomics

1. Usage of genomic variation data to improve control
2. Development and implementation of rapid genomic surveillance approaches in invasive range
3. Temporal dynamics of *An. stephensi* genomic diversity and how it has changed since establishment in Africa
4. Development and implementation of genomic data management platform for collaboration and dissemination to policy makers





Modelling - Mathematical and Geospatial

**Thomas Churcher, Prashanth Selvaraj, Simon Kiware, Sadie Ryan,
Courtney Murdock, Nick Golding, Anne Wilson, Melissa Yoshimizu, Caitlin
Beaver, Sarah Zohdy, Rachel Lowe, Shannon Stanfill, Luigi Sedda,
Marianne Sinka, Hannah Slater, Charles Whittaker, Arran Hamlet**

Modelling

1. Optimization of spatiotemporal surveillance including geospatial models to identify sampling strategy and risk factors for detection

2. Development of statistical and mechanistic environmental niche models for predictive maps, assessments of rate of invasion and routes of invasion, and interaction with other mosquito species

3. Development of statistical analysis and mechanistic transmission-dynamic models to understand impact of *An. stephensi* on malaria transmission

4. Development of mechanistic transmission-dynamic models of *An. stephensi* and malaria to identify most cost-effective vector control given programme objective (mitigation/elimination), including synergies with *Aedes* control



Human Behaviour

Anne Wilson, Gabrielle Hunter, Elli Leontsini, Linda Lloyd, April Monroe, Shelby Cash, Andy Tompsett, Daraje Galata, Abraham Mnzava, Valerie Paz-Soldan, Fatou Jaiteh, Christina Liew, Richard Allen, Guda Alemayehu, Desta Kebede, Kaci McCoy

Human Behaviour

1. What socio-ecological factors influence malaria risk in the context of *An. stephensi*? How do risk factors vary across contexts?
2. What factors/design elements might increase acceptability of *An. stephensi* program components? How do these factors vary across contexts?
3. What are the primary challenges to fostering and sustaining multi-sectoral engagement in the context of *An. stephensi*? What strategies have been effective in overcoming barriers?
4. What are examples of effective social and behaviour change programs/interventions in the context of *An. stephensi*? What factors contributed to their success?

Key cross cutting themes identified:

- Basic biology, ecology, and evolution of *An. stephensi*
- Consider IVM - combinations of tools/approaches with co-benefits on *Anopheles*, *Culex*, and *Aedes* vectors
- Standardizing sampling methods and effort, and optimizing spatiotemporal surveillance at the appropriate scale (household, community, seaport, region, country etc.)
- What level of sampling effort constitutes a negative site and reporting negatives?
- Rapid field deployable approaches for genomic surveillance

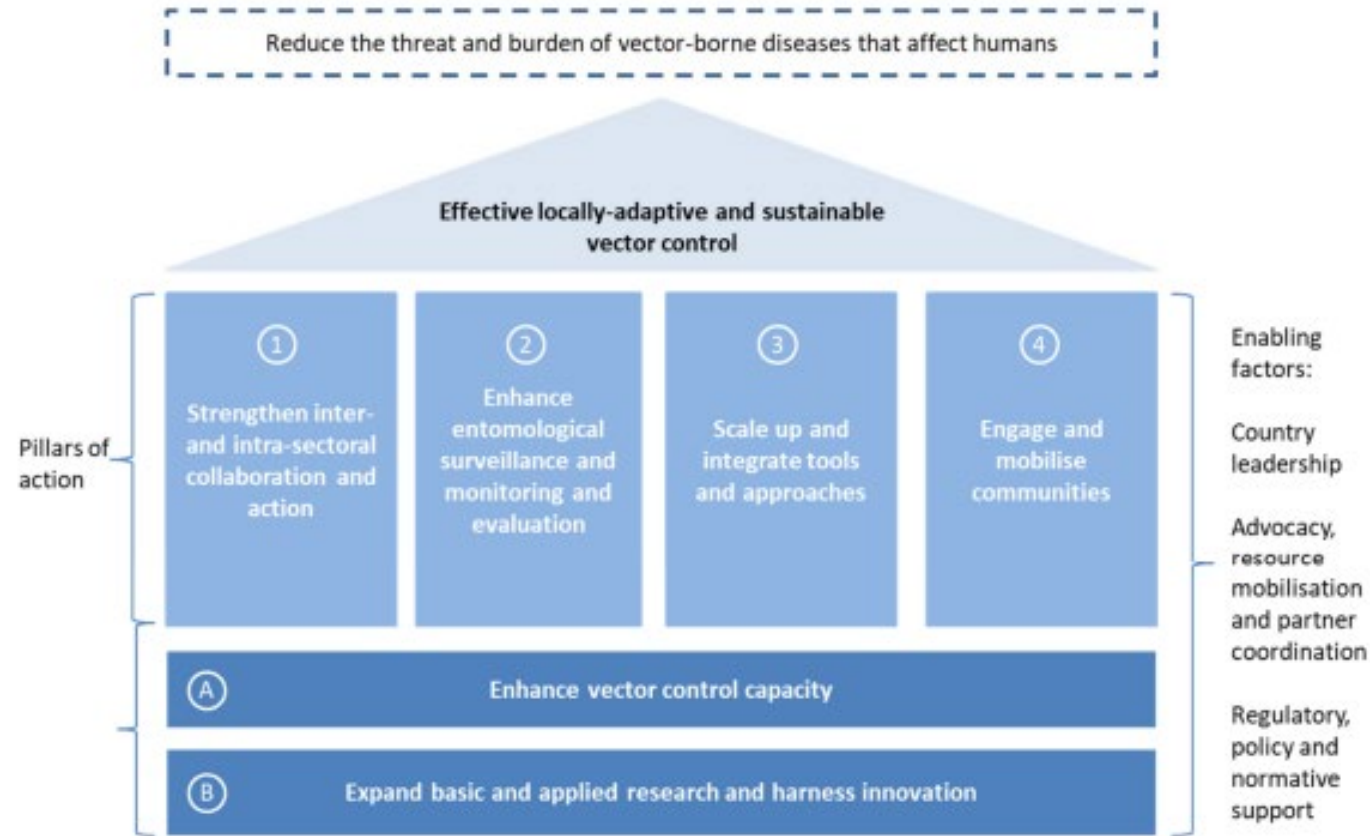


Key cross cutting themes identified (cont.):

- Characterise insecticide resistance frequency/intensity/mechanisms in *An. stephensi* populations in Africa
- Tailoring response to settings based on introduction/level of transmission
- Cross-border and multisectoral collaboration with local governments, municipalities, communities, ministries, etc., to enhance sustainability of activities and leverage existing platforms and resources
- Encourage use of data sharing platforms (e.g. data, code, protocols etc)



Multisectoral engagement opportunities identified:



Country priorities

- Open comment period to gather perspectives and priorities of countries
- Responses so far from: Sri Lanka, Sudan, Nigeria, Saudi Arabia, Ethiopia, MENA region
- More feedback welcome!



Country priorities so far

Surveillance

- Key larval habitat characteristics and productivity

Control

- LSM and upstream interventions (animal-based interventions and autodissemination)

Genomics

- Best approaches to translate genomic sequencing data to rapid surveillance approaches

Modelling

- What will be the impact of *An. stephensi* on malaria transmission?

Human behaviour

- What socio-ecological factors influence malaria risk in the context of *An. stephensi*?

← Cross-cutting: Considerations for integrated vector management →

Research prioritization summary document



MESA malaria tracker

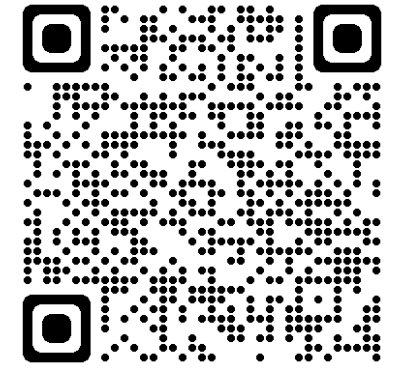


MESA Track

The malaria projects database

ADD YOUR MALARIA PROJECT

Increase the visibility of your malaria research and connect with other researchers in your field by adding your project to this open database.



- [An. stephensi Deep Dive](#)
- [Urban malaria Deep Dive](#)
- [Larval source management Deep Dive](#)



VCWG participant input


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What do you feel may be missing from the research agenda prioritization activity?

All responses to your question will be shown here

Each response can be up to 200 characters long

Turn on voting in Interactivity to let participants vote for their favorites



Thank you on behalf of the *An. stephensi* Task Team and all the contributors to this activity!