
Partners convening: a regional response to the invasion of *Anopheles stephensi* in Africa

Meeting report
8–10 March 2023

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ABBREVIATIONS

AHRI	Armauer Hansen Research Institute
IRS	indoor residual spraying
ITN	insecticide-treated net
LSM	larval source management
LSTM	Liverpool School of Tropical Medicine
PBO	piperonyl butoxide
PMI	United States President's Malaria Initiative
WHO	World Health Organization

1. BACKGROUND

The Vector Control and Insecticide Resistance Unit of the World Health Organization (WHO) Global Malaria Programme, jointly with the WHO Regional Office for Africa and the WHO Regional Office for the Eastern Mediterranean, convened a partnership meeting on a regional response to the invasion of *Anopheles stephensi* in Africa. The convening was held at the Hilton Hotel in Addis Ababa from 8 to 10 March 2023.

1.1 Rationale

Anopheles stephensi is a malaria vector that was first reported on the African continent in Djibouti in 2012. It has since been reported in seven other countries: Ethiopia (2016), Sudan (2016), Somalia (2019), Nigeria (2020), Eritrea (2022), Ghana (2022) and Kenya (2022). The full extent of its distribution in Africa is not known, although it is likely to be present in additional countries.

The presence of *An. stephensi* has been associated with increases in the number of malaria cases in Djibouti and Ethiopia. However, there is still considerable uncertainty around the current and potential contribution of *An. stephensi* to malaria transmission.

Nevertheless, WHO considers the spread of *An. stephensi* to be a threat to malaria control and elimination. In September 2022, the *WHO initiative to stop the spread of An. stephensi in Africa (1)* was launched. This initiative aims to: (i) improve information exchange; (ii) increase collaboration; (iii) strengthen surveillance; (iv) prioritize research; and (v) develop guidance. The partnership convening was devised to support the aims of this initiative.

1.2 Purpose, objective and expected outcomes

The purpose of the convening was to provide a forum for exchange of information and for the prioritization and coordination of *An. stephensi* surveillance and control activities. The objective was that, by the end of the convening, participants would be aware of the surveillance, research, control and policy activities relating to *An. stephensi* being conducted in Africa. It was expected that the communication encouraged by this convening would enhance regional collaboration for the improved control of malaria transmitted by *An. stephensi*.

1.3 Structure and content

The convening included plenary presentations (day 1), a field visit (day 2) and breakout group discussions (day 3). Topics covered during the plenary sessions included: national updates on vector distribution, malaria trends and national strategies related to *An. stephensi*; funding updates; introduction to the WHO regional initiative; and research updates. The breakout group discussions were on research prioritization. The agenda of the convening is included as Annex 1. All sessions were open to attendance by all participants, while adhering to any exceptions indicated by WHO during the Declaration of Interest assessment (Annex 2). The convening was chaired by Dr Dorothy Achu (Tropical and Vector Borne Diseases Team Lead, WHO Regional Office for Africa) on day 1 and by Dr Eric Ochomo (Kenya Medical Research Institute) on day 3; there was no chair on day 2 due to the field visit.

1.4 Attendance

A total of 94 participants from 23 countries attended the partnership convening (Annex 3). Participants included personnel from Ministries of Health, academic and research institutes, and funding and technical partner organizations, including WHO staff from headquarters and regional and country offices.

1.5 Declarations of interest

Prior to the convening, all participants submitted a Declaration of Interest form. Dr Seth Irish (WHO Global Malaria Programme Vector Control and Insecticide Resistance Unit) assessed each submission and identified 23 declared interests relevant to the convening. The interests and their management by WHO are outlined in Annex 2.

2. PROCEEDINGS OF THE CONVENING

2.1 Opening

Dr Jan Kolaczinski, Head of the Global Malaria Programme Vector Control and Insecticide Resistance Unit, welcomed participants and opened the meeting. He then reminded participants of the procedures governing WHO's assessment of conflicts of interest and read out the declarations (see Annex 2).

2.2 Welcome messages

The first welcome message was presented by Dr Nonhlanhla Dlamini, acting WHO Representative to Ethiopia. Dr Dlamini welcomed the participants to Ethiopia and noted the importance of the convening for understanding the spread of *An. stephensi* on the African continent and its relevance for malaria control.

The second welcome message was provided by Dr Hiwot Solomon, Director of the Disease Prevention and Control Directorate, Ethiopian Federal Ministry of Health. Dr Solomon noted the efforts that had been made in Ethiopia to determine the distribution of *An. stephensi* and to understand its impact on malaria transmission. These efforts have included the development of a strategy targeting *An. stephensi*. She encouraged participants to continue this important work and to identify opportunities to expand this work throughout Africa.

3. PLENARY SESSIONS

3.1 Country presentations

Thirteen countries provided updates on key areas of their work on malaria and *An. stephensi*: Chad, Djibouti, Eritrea, Ethiopia, Ghana, Kenya, Mauritius, Nigeria, Somalia, South Sudan, Sudan, United Republic of Tanzania, and Yemen. Each country presented surveillance and research findings on *An. stephensi*, as well as control interventions undertaken and policies or strategies developed.

Chad: It was reported that *An. stephensi* has not yet been found in Chad, including in an entomological surveillance campaign in 2022. During that campaign, major vectors were identified and susceptibility to insecticides was measured. It was noted that, in 2022, there was an increase in malaria cases due to flooding. As pyrethroid resistance was detected in *Anopheles* vectors at sentinel sites, pyrethroid-piperonyl butoxide (PBO) insecticide-treated nets (ITNs) were planned for the mass distribution in 2023.

Djibouti: *Anopheles stephensi* was first detected in 2012 and has become the main vector in the country. This has corresponded with an increase in the number of confirmed malaria cases – from fewer than 500 per year before 2013 to a peak of 73 535 in 2020. The national malaria control programme has eight surveillance sites, with adult and ovitrap collections reported weekly. Surveillance is being scaled up, and an evaluation of indoor residual spraying (IRS) in 2022 and early 2023 showed that *An. stephensi* populations were present throughout the year. Epidemiological surveillance continues through the routine health system, with the highest numbers of cases in those aged 25 to 34 years. Most cases were in Djibouti City, with 90% in the commune of Boul'aos. About two thirds of cases were due to *Plasmodium falciparum*, with the remaining due to *P. vivax*. IRS was conducted in 2020 (4945 households protected), 2021 (5825 households protected) and 2022 (8385 households protected). Larviciding was also done in Djibouti City and ITNs were distributed. Resistance was detected to some insecticides (organochlorines, pyrethroids, organophosphates and carbamates). The aim of the national malaria control programme is to reduce the number of malaria cases by 50% from the 2019 level by the end of 2024, strengthen surveillance (entomological, parasitological and epidemiological) and continue to fine-tune the vector control response.

Eritrea: *Anopheles arabiensis* is considered the primary malaria vector. However, *An. stephensi* was found in two zones (Anseba, Gash Barka) out of four surveyed from September to December 2022. There is limited ongoing entomological surveillance, with resistance monitoring and bionomics monitoring planned for 2023. Epidemiological surveillance is ongoing, and a malaria indicator survey is planned for September 2023. Important challenges and limitations include logistics, lack of technical assistance and Internet connectivity. Vector control activities are ongoing, with ITNs being distributed through mass campaigns and routine distribution. IRS is conducted in selected areas. Environmental management and larviciding are also conducted in nearly all areas. Health education activities are also under way. There is no specific *An. stephensi* strategy, but there is a desire to increase surveillance, health promotion and integration with other vector-borne disease control efforts. These priorities feed into the National Strategic Plan, which aims at reducing malaria annual parasite incidence to five per 1000 population and achieving zero malaria deaths by 2026. The strategy also aims at achieving zero local malaria transmission in 15 sub-zobas by 2026 and maintaining zero transmission in another seven sub-zobas.

Ethiopia: *Anopheles stephensi* was detected in Ethiopia in 2016 and has since been found in 51 sites throughout the country. Malaria cases have been increasing over the last three years, and the reasons for this increase are being studied. Entomological surveillance is under way in areas where *An. stephensi* has not yet been found, and *An. stephensi* and *Aedes aegypti* abundance and insecticide susceptibility are also being monitored. Eight towns are implementing larval source management (LSM) in response to the *An. stephensi* invasion. Other interventions are under consideration, including by-laws to regulate water storage, construction and solid waste management. The action plan for the integrated surveillance of *An. stephensi* and *Ae. aegypti* (2022–2026) is being implemented. A draft national social and behaviour change guide for the elimination of *An. stephensi* has also been prepared.

Ghana: A study was conducted in 2022 to monitor mosquito species diversity, insecticide resistance and bionomics of malaria vectors in and around Accra. This study showed that *Anopheles* mosquitoes have adapted to breeding in dirty and polluted water. Phenotypic resistance of *Anopheles* to several insecticides (pyrethroids, organophosphates) was also noted. Some mosquito samples that did not amplify with polymerase chain reaction were then sequenced to determine the species. *Anopheles stephensi* was identified in samples collected in Tuba and Dansoman. Further work will include a retrospective analysis of mosquitoes collected from other zones and from additional larval sites.

Kenya: *Anopheles stephensi* was detected in 2022 in Marsabit County. The species has since been found in Turkana County as well. Additional *An. stephensi* adults were collected in February 2023 in other sites in Marsabit. Routine entomological surveillance is ongoing in 13 counties, with support of the Global Fund to Fight AIDS, Tuberculosis and Malaria, and in eight counties, with support of the United States President's Malaria Initiative (PMI). *Anopheles stephensi* mosquitoes were collected as larvae and as adults in ultraviolet light trap collections. ITNs are being distributed in 27 counties through mass campaigns and in 36 counties through routine distribution in antenatal care and child welfare clinics. IRS is conducted in two high-burden counties (Migori and Homa Bay). LSM is being conducted in eight counties through a community-based approach. The Ministry of Health has been briefed on the situation and a task force has been established. The plan is to build capacity in a critical mass of health workers in border counties and major cities.

Mauritius: Mauritius does not have locally acquired malaria cases; however, the country still has imported cases, which are primarily detected through an active disease surveillance system at points of entry. Malaria cases are treated exclusively by public health doctors, free of cost, and there is follow-up for at least one year. In addition, prophylaxis is provided free of charge to Mauritians travelling to endemic countries. Vector surveillance is conducted at eight sentinel sites monthly. Additional surveys are conducted at seaports through monthly inspection of potential larval sites and weekly surveillance of sentinel larval sites. In addition, in collaboration with veterinary services, human landing collections and Biogents traps (baited with dry ice and BG-Lure) have been set at animal sites. To date, no *An. stephensi* mosquitoes have been collected and identified in Mauritius. If a case of malaria is detected, reactive IRS and occasional fogging are conducted, as well as larviciding and LSM, and sensitization of the local population. Dengue is another important vector-borne disease in the country. Vector-borne disease control is conducted in a multisectoral way, and existing plans to address malaria and dengue/chikungunya can be adapted for *An. stephensi*. Future work is needed to evaluate new vector control tools, strengthen monitoring, procure equipment, develop response strategies and work with other countries in the region.

Nigeria: *Anopheles stephensi* was first detected in Gombe State in 2020. This species was collected as part of routine entomological surveillance conducted in 174 locations throughout Nigeria. No control activities have been put in place, but further investigations are under way in 10 states to understand the spread of the vector and its role in malaria transmission. Morphological training is being done to ensure that *An. stephensi* is identified correctly, and the national Vector Control Needs Assessment has been updated to include *An. stephensi* and its control.

Somalia: *Anopheles stephensi* was first found in Boosaaso in 2019 and in Berbera, Hargeysa and Lawyacado in 2020. It was then detected in Burco and Borama in 2022. Three different *An. stephensi* haplotypes have been identified in Somalia. The *kdr* L1014F mutation, which is associated with pyrethroid resistance, has been detected

in *An. stephensi*. Over the past 10 years, the number of malaria cases in Somalia has decreased steadily. Entomological surveillance has been conducted in sentinel sites, with both adults and larvae being collected. Vector composition, bionomics and insecticide resistance are monitored. Control activities implemented include ITN distribution, IRS and LSM. Several strategies inform the surveillance and control of *An. stephensi*, including the National Malaria Strategic Plan (2021–2025), the National Integrated Vector Management Strategic Plan (2022–2026) and the Insecticide Resistance Monitoring and Management Plan (2020–2023). Targets for future work include gaining an understanding of the distribution of *An. stephensi* in the country, its coexistence with *Ae. aegypti*, its insecticide resistance and bionomics, and its role in malaria transmission. Opportunities include a strong political commitment, existence of strategies and technical support from WHO and Baylor University, and funding from the Global Fund for entomological surveillance. Challenges include droughts and flooding, insecticide resistance, a lack of expertise and capacity, lack of multisectoral and international cooperation, and a lack of funding.

South Sudan: *Anopheles stephensi* has not been found in South Sudan. However, no entomological surveillance has been specifically conducted to find *An. stephensi*, despite its presence in neighbouring countries. No vector distribution studies have been conducted since 2011. The last insecticide susceptibility study was conducted in 2020. The study detected *An. gambiae*, *An. arabiensis* and *An. funestus* and found resistance to all insecticides tested in six states of the country. There is a national vector surveillance project planned for 2023. Routine epidemiological data are collected through the DHIS2 system, with established sentinel sites and quarterly data quality assessments. A malaria indicator survey is planned for 2023. ITNs are distributed through mass and routine distribution. IRS is conducted in camps for internally displaced persons and refugees. LSM is also conducted in internally displaced person and refugee camps, where sites are few and findable. While there is no specific *An. stephensi* strategy, there is a National Strategic Plan with specific integrated vector management guidelines.

Sudan: The number of malaria cases has been increasing over the past few years in Sudan. While the link with the spread of *An. stephensi* is uncertain, Sudan was the first country in the region to develop a national strategy targeting this vector, with the stated aim “to develop surveillance and control system to contain and prevent further spread of *An. stephensi* in Sudan between 2021 and 2025 and eliminate this invasive vector from the country by 2030”. This strategy aims at intensifying entomological surveillance to detect *An. stephensi* throughout the country, building capacity of entomological teams, integrating molecular and genomic methods, and understanding the contribution of *An. stephensi* to malaria transmission. To this end, Sudan aims at integrating epidemiological surveillance with vector surveillance. It also aims at better understanding *An. stephensi* bionomics, implementing the International Health Regulations (2005) and developing vector control strategies for integrated vector management that includes *Aedes* vectors. Sudan is also working to evaluate new vector control products, including space spraying and larviciding for the control of *An. stephensi*. Over 120 national vector surveillance and control officers from all 18 states of the country have been trained in vector collection and identification. Insectaries have been established or refurbished, and a nationwide survey to determine the distribution of *An. stephensi* has been carried out. Communities have been engaged in the implementation of LSM, and surveillance and control teams have been provided with the necessary equipment and vehicles. As a result of this extensive work, by early 2023, *An. stephensi* had been detected in 14 of 18 states. Finally, population genetics have helped to understand the history of introduction of *An. stephensi* to Sudan. Sudan continues to collaborate with neighbouring countries by sharing information and actionable plans.

United Republic of Tanzania: *Anopheles stephensi* has not been reported in mainland Tanzania, but entomological surveillance is ongoing. The high-risk areas where surveillance is being conducted include urban areas, areas along the coast of the Indian Ocean, international points of entry and locations along major transportation highways. Entomological surveillance has been conducted in 32 sentinel sites since 2015, and exploratory surveys focused on detecting *An. stephensi* are planned to be conducted in Tanga, Dar es Salaam and Arusha. Epidemiological surveillance of cases is also being conducted across the different epidemiological strata. In terms of vector control, ITNs are distributed, and larviciding is conducted at a small scale using *Bacillus thuringiensis* subspecies *israelensis* and *Bacillus sphaericus*. There is no specific national strategy for *An. stephensi*, but there is a National Malaria Control Strategy (2021–2025) that addresses vector control, surveillance, case management, and social and behaviour change communication, a National Strategy for Vector Control (2019–2024), and Integrated Vector Management Guidelines and standard operating procedures.

Anopheles stephensi has also not been reported in the islands of Zanzibar. Entomological surveillance for *An. stephensi* is planned that will involve sampling larvae on a weekly basis on two of the four islands. This sampling will be supplemented by monthly outdoor collections. Staff will be trained on morphological identification. In addition, 10 established sentinel sites sampled for routine vector surveillance will also be included. Furthermore, epidemiological surveillance detects and investigates malaria at the household level and is supported by entomological foci investigations. Pyrethroid-PBO ITNs have been distributed through mass and routine distribution. Reactive focal IRS is conducted. There is also the possibility of focal larviciding, although funds are not yet available for this purpose. The fifth national strategic plan for Zanzibar has been developed, which includes entomological monitoring, improved vector control and malaria case surveillance.

Yemen: *Anopheles stephensi* was identified in northern Yemen in Ad Dahi in 2021 and in Zabid in 2022. It was subsequently detected in an additional four districts in Tihamah. Samples were molecularly confirmed at Baylor University, where two haplotypes were identified. One of the haplotypes was the same as that found in the Horn of Africa, while another was unique to Yemen. Resistance to bendiocarb and deltamethrin was found in local *An. stephensi*. Epidemiological surveillance is under way, and malaria incidence decreased between 2018 and 2022. The main malaria control interventions are ITN distribution and IRS, with some larviciding and larval source reduction. Entomological surveillance, LSM campaigns, community engagement, involvement of students and a reactivation of the vector control steering committee are planned to improve the response to *An. stephensi*.

Anopheles stephensi was first detected in southern Yemen in 2021 during entomological monitoring in internally displaced person camps and host communities in Aden city. Twelve samples were investigated and confirmed by the Liverpool School of Tropical Medicine (LSTM). Since then, additional surveillance has been conducted, including in two urban sites (Aden, Mukalla) with support from WHO. Since January 2023, monthly surveillance has been undertaken in three governorates in collaboration with the Naval Medical Research Unit 3. All samples collected are analysed at Baylor University, with samples from recent collections currently being processed. Epidemiological surveillance is also under way, with weekly case data reported. The vector control activities under way include IRS and ITN distribution, implementation of IRS in the most endemic districts, and LSM and health education campaigns in the case of outbreaks. The National Malaria Strategic Plan (2020–2024) is currently under review, and technical assistance and capacity-building for addressing *An. stephensi* will be considered when developing the updated strategy.

3.2 Funder presentations

Representatives from four funding agencies presented the activities currently being funded and priorities for future funding related to *An. stephensi*.

Ms Kelsey Barrett from Unitaid presented the organization's malaria programmatic priorities for 2023–2027 to optimize the use of prevention tools and improve access to quality case management. Building on investments in the development of vector control tools, Unitaid plans to launch a new Call for Proposals on vector control delivery strategies, including for settings where *An. stephensi* is a growing concern.

Dr Laura Norris provided a recorded presentation on research funded by the Bill & Melinda Gates Foundation. This research includes the development of self-limiting mosquito strains, the evaluation of attractive targeted sugar baits, development of data resources such as the Malaria Vector Atlas project, and projects to improve mosquito analysis.

Dr Sarah Zohdy and Dr Melissa Yoshimizu from PMI presented the current PMI *An. stephensi* action plan, as well as an overview of PMI-supported activities that are ongoing in Ethiopia, Nigeria and Kenya. A social and behaviour change guidance document, developed with PMI support, was also shared. Activities of the U.S. Centers for Disease Control and Prevention were also presented, including surveillance and identification training with the West African Aedes Surveillance Network, funding for the Pan-African Mosquito Control Association training and malaria response in Djibouti, funding for population genetics work, and a broad agency announcement call for further population genomics, surveillance and control innovation.

Dr Patrick Okello from the Global Fund presented on the Global Fund's activities, which are aligned with WHO guidance. He also indicated that the Global Fund is currently supporting a thematic review led by the Swiss Tropical and Public Health Institute, entitled "An assessment of surveillance systems for *An. stephensi* in affected and at-risk countries in Africa". Dr Okello also noted that the Global Fund proactively encourages countries to enhance entomological surveillance in general and response efforts to *An. stephensi* in particular.

3.3 Researcher presentations

Seven researchers presented their work on *An. stephensi*, covering a range of research areas.

Dr Fitsum Tadesse from the Armauer Hansen Research Institute (AHRI) presented findings from a case–control study done in Dire Dawa, Ethiopia. These findings indicate that *An. stephensi* has played a role in the recent increase in urban malaria cases.

Dr Anne Wilson from LSTM presented an update on the Wellcome Trust-funded interdisciplinary Controlling Emergent *Anopheles stephensi* in Sudan and Ethiopia research project. Activities include longitudinal entomological sampling in 26 sites in Ethiopia and 61 sites in Sudan. LSTM and partners are also collecting data on vector behaviour and population genetics, and are conducting case–control studies to assess the role of *An. stephensi* in malaria transmission. Vector control pilot studies will also be undertaken to determine the best way to control *An. stephensi*. Social science studies are being conducted to identify social and ecological factors that could constrain or

enhance multisectoral vector control. Lastly, transmission dynamic models are being developed to understand the public health impact of *An. stephensi* invasions and to identify optimal control strategies.

Dr Matt Thomas from the University of Florida presented work on invasion biology and *An. stephensi*. He noted that *An. stephensi* was different from other African vectors in terms of its ecology, and highlighted how this has an effect on its role as a vector and on how amenable it is to control. His key messages were that it is very difficult to eliminate malaria transmission by a zoophilic vector by implementing vector control that targets human dwellings alone. Additional targeting of livestock and livestock shelters might allow for a higher level of control. He further emphasized the potential value of taking a regional perspective to slow the spread and ultimately work towards the goal of elimination of *An. stephensi*. Low-density founder populations are more amenable to elimination, and the most cost-effective way of dealing with an invasive species is to hit it early or stop its arrival. The urgency of action was emphasized.

Dr Meshesha Balkew from PMI VectorLink provided an update on PMI-supported monitoring of *An. stephensi* in Ethiopia. VectorLink has been conducting surveillance on *An. stephensi* in Ethiopia since 2018 to map its distribution, understand its bionomics and document its resistance to insecticides. PMI VectorLink found that *An. stephensi* was collected almost year-round, with animal shelters and valve pits the key adult resting sites. Natural infections of *P. vivax* were found in *An. stephensi*, and resistance was detected to insecticides commonly used in ITNs and IRS, with the exception of clothianidin and chlorfenapyr.

Dr Tamar Carter from Baylor University provided a presentation on the population genetics of *An. stephensi*. She spoke about the growing ability of cytochrome c oxidase subunit I loci data and how these data can improve the understanding of the origin of invasive *An. stephensi*. She also highlighted how genomic analysis provides information on connectivity between different populations, and can identify well established hubs of *An. stephensi* and associations with a reported outbreak of malaria.

Dr Charlie Whittaker from Imperial College London presented on the seasonal dynamics of *An. stephensi*. Rainfall seasonality and densities of *An. stephensi* were assessed, with no clear relationship detected. However, correlations between mosquito densities and land use and temperature were shown. The implications for vector control were discussed.

Dr Gonzalo Vazquez Prokopec from Emory University provided lessons from *Ae. aegypti* control. Lessons learned included that: (i) *Ae. aegypti* elimination and interruption of Aedes-borne viruses are not feasible using existing methods and knowledge; (ii) the heterogeneity of dengue transmission ecology limits the efficacy of reactive interventions; (iii) designing Phase III clinical trials for urban vectors is much more complex than for vectors in rural areas; (iv) routine entomological indices underestimate vector density and pathogen risk; and (v) given all those complexities (that is, biological environmental, political), a single “magic bullet” will not be effective in terms of impacting transmission in meaningful ways. He also indicated that integration of vector control tools is essential.

4. FIELD VISIT

On the second day of the convening, participants went on a field visit to Adama, approximately 90 km from Addis Ababa. The first visit was to the Malaria and NTD Research and Training Center of AHRI, a former WHO collaborating centre. The group was welcomed by Ms Hinsene Mohamed, Deputy Mayor of Adama, who emphasized that *An. stephensi* poses a threat to the malaria situation in the city and surrounding areas. Dr Alemseged Abdissa then presented the history of AHRI and its current activities. Dr Fitsum Tadesse detailed recent work on *An. stephensi* to determine its distribution, bionomics and transmission of *Plasmodium spp.* The AHRI team then led participants to three different field sites, where they were able to observe the aquatic habitats of *An. stephensi* and conduct larval sampling.

5. BREAKOUT SESSIONS ON IMPLEMENTATION AND RESEARCH PRIORITIZATION

On the final day of the convening, a preliminary research prioritization exercise was conducted. Four breakout groups were convened to discuss one each of four topics as they relate to *An. stephensi* and its incursion into Africa: (i) vector control; (ii) vector surveillance; (iii) strategy and policy; and (iv) human social and behaviour change. Results from the individual groups were presented in a plenary session for consideration and discussion by all participants. A summary of each discussion is presented below. The intention was for these initial discussions to provide a starting point for future research prioritization exercises.

5.1 Vector control

The key areas identified as priorities for research during the discussion on vector control included exploring: (i) links with *Ae. aegypti* control and surveillance; (ii) clear definition and use of entomological end-points for intervention evaluation; (iii) *An. stephensi* bionomics; (iv) effects of climate change, outdoor transmission and human behaviour on vector control effectiveness; and (v) how to increase information sharing, guidance and funding.

5.2 Surveillance

The discussion of the surveillance breakout group focused on three types of surveillance: entomological, epidemiological and genetic. The group acknowledged that entomological surveillance activities need to be tailored to each country based on the level of introduction of *An. stephensi* and the public health goals. For entomological surveillance, improved methods for adult collection and molecular techniques are needed. For epidemiological surveillance, key factors including routine data analysis, documentation of other factors, integration of entomological data, and the attribution of malaria cases to transmission by *An. stephensi* require further research attention.

5.3 Integration of *An. stephensi* activities into national strategic plans

Participants recognized the importance of ensuring that activities for the surveillance and control of *An. stephensi* are adequately reflected in Ministry of Health strategic planning processes. Implications for national strategic plans and for funding

proposals to the Global Fund and other development partners were discussed, as well as opportunities for funding new activities through established or novel funding mechanisms. The WHO Regional Office for Africa has developed a framework document to guide strategic planning that will soon be shared with Member States.

It was clarified that while there is no additional Global Fund funding stream for *An. stephensi*-specific activities, it remains essential to include all relevant activities for malaria vector surveillance and control in national strategic plans. These should include activities listed in the recent update to the WHO vector alert on *An. stephensi* invasion and spread (2), especially increasing surveillance, larviciding where justified and ensuring multisectoral engagement drawing on the One Health approach. It is important to consider strategic communications, and examples from other health topics should be considered. It is also important to consider the role of community health workers.

5.4 Social and behaviour change

Several aspects of *An. stephensi* control related to social and behaviour change were discussed. Much of the discussion revolved around the appropriate implementation of vector control and involvement of communities and individuals in that process. This is especially important for *An. stephensi*, given that the most common vector control approach used is LSM, which involves coordination of Ministries of Health with local administrations, urban planners, religious and other community leaders, and potentially also education institutions.

Implementing legislation or enforcing by-laws will also require community comprehension, acceptance and compliance. Furthermore, effective approaches for promoting social and behaviour change are likely to vary between rural and urban settings, and depend on other factors.

The group acknowledged the critical need for a multisectoral approach. They noted that it is also important to consider the most appropriate approaches through mixed methods, interdisciplinary and participatory research. Gathering best practices from other settings was noted as a useful approach.

6. CLOSING

Dr Achu provided the closing statement. She reiterated the importance of continued work on *An. stephensi* in Africa and noted that the convening was a good opportunity for those interested in the topic to build connections to further this work. She acknowledged the quality of the scientific presentations and the contributions of different groups, and highlighted the potential for these discussions to inform future research. Participants were encouraged to push forward with their activities to support continued progress towards malaria elimination in Africa.

References

1. WHO initiative to stop the spread of *Anopheles stephensi* in Africa. Geneva: World Health Organization; 2022 (<https://apps.who.int/iris/handle/10665/363318>, accessed 8 June 2023).
2. Vector alert: *Anopheles stephensi* invasion and spread in Africa and Sri Lanka. Geneva: World Health Organization; 2022 (<https://apps.who.int/iris/handle/10665/365710>, accessed 8 June 2023).

ANNEX 1. AGENDA

DAY 1 - WEDNESDAY, MARCH 8, 2023		
Part I: Welcome and national updates		
8:30-8:40	Welcome and declarations of interest	Jan Kolaczinski
9:00-9:10	Welcome message	Nonhlanhla Dlamini
9:10-9:30	Welcome by the Minister of Health of Ethiopia	H.E. Dr Dereje Duguma
9:30-9:45	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (Sudan)	TBD
9:45-10:00	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (Djibouti)	Bouh Abdi Khaireh
10:00-10:15	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (Somalia)	Said Ali
10:35-10:50	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (Ethiopia)	Gudissa Assefa
10:50-11:05	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (Nigeria)	Adeogun Adedapo
11:05-11:20	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (Kenya)	Lenson Kariuki
11:20-11:35	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (United Republic of Tanzania)	Charles Dismas Mwalimu & Zamzam Juma Pandu
11:35-11:50	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (South Sudan)	Constantino Doggale
12:05-12:20	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (Chad)	Israël Kodindo
12:20-12:35	Updates on distribution, malaria trends, and national strategy of <i>An. stephensi</i> (Eritrea)	Selam Mihreteab
12:35-1:00	Questions and discussion	All presenters
Part II: Funding updates, introduction to the regional initiative and research updates		
14:30-14:40	UNITAID funding for <i>An. stephensi</i> surveillance/control	Kelsey Barrett
14:40-14:50	BMGF funding for <i>An. stephensi</i> surveillance/control	Laura Norris
14:50-15:00	PMI funding for <i>An. stephensi</i> surveillance/control	Sarah Zohdy/Melissa Yoshimizu
15:00-15:10	GF funding for <i>An. stephensi</i> surveillance/control	Patrick Okello
15:10-15:20	Introduction to WHO initiative against <i>An. stephensi</i>	Seth Irish
15:20-15:30	Questions and discussion	
16:00-16:15	Case control study in Dire Dawa	Fitsum Tadesse

DAY 1 - WEDNESDAY, MARCH 8, 2023

16:15-16:30	"Controlling emergent <i>Anopheles stephensi</i> in Sudan and Ethiopia" (CEASE) project update	Anne Wilson
16:30-16:45	<i>Anopheles stephensi</i> invasion biology	Matt Thomas
16:45-17:00	Vectorlink updates, 2022	Meshesha Balkew
17:00-17:15	<i>Anopheles stephensi</i> population genetics	Tamar Carter
17:15-17:30	Seasonal dynamics of <i>Anopheles stephensi</i>	Charlie Whittaker
17:30-17:45	Urban control of <i>Aedes aegypti</i> , lessons for <i>An. stephensi</i>	Gonzalo Vazquez-Prokopec

DAY 2 - THURSDAY, MARCH 9, 2023**Part III:** Field visit to observe *An. stephensi*

8:30-9:10	Welcome and presentation of the Malaria Training and Research Centre in Adama	TBD
9:10-10:30	Division into groups and guided visit to insectary/ laboratory	Led by AHRI staff
10:30-12:30	Visit to larval sites (Adama/Modjo/Bishoftu)	Led by AHRI staff

DAY 3 - FRIDAY, 10 MARCH, 2023**Part IV:** Research prioritization

9:00-9:15	Introduction to research prioritization discussion session	TBD
9:15-10:30	Breakout groups 1) Vector control 2) Surveillance 3) Strategy / integration of <i>An. stephensi</i> activities into national malaria programmes 4) Social and behavior change	TBD
10:45-12:30	Presentation of group priorities	Group leaders
12:30-13:00	Synthesis and next steps	TBD
13:15-13:30	Closing remarks	Dorothy Achu

ANNEX 2. DECLARATIONS OF INTEREST

Ninety-four experts were invited to participate in the *An. stephensi* meeting. All experts were considered to be participants in the meeting and there were no observers. All participants duly completed and submitted their Declaration of Interest (DOI) and their Confidentiality Undertaking forms. Interests declared on the DOIs were reviewed by the Vector Control and Insecticide Resistance Unit under the Global Malaria Programme and a due diligence Internet and publication search was completed. All potential conflicts of interest are summarized below, along with the conclusions of the review.

Travel was reported to be paid by employers of 14 participants, without any conflict of interest. Research funding for projects related to *An. stephensi*, entomological monitoring or malaria research was noted by 11 participants, without any conflict of interest. **Anne Wilson** (LSTM) noted funding from the Deployed Warfighter Protection Program, supported by the U.S. Department of Defense, to evaluate vector control for *An. stephensi* (US\$ 600 000) from September 2022 to August 2024. As this may represent a potential conflict of interest, Dr Wilson was excluded from participating in the “Vector Control” group discussion of the research prioritization exercise (part IV).

Employment by an organization with an interest in the work was reported by five participants, without any conflict of interest. Consulting for an organization with an interest in the work was reported by four participants, without any conflict of interest. **Fitsum Tadesse** (AHRI) reported brief consulting work for Oxitec. While not especially recent, nor financially significant, the consulting fee from Oxitec might represent a conflict of interest in the research prioritization exercise. Therefore, it was recommended that Dr Tadesse not participate in the “Vector Control” group discussion of the research prioritization exercise (part IV). **Delenasaw Yewhalaw** (Jimma University) reported consulting fees from Sumitomo Chemical for the evaluation of larvicides against *An. stephensi* in Ethiopia to the amount of US\$ 78 000. The funding for consultation on the evaluation of one method of vector control represents a potential conflict of interest. For this reason, it was recommended that Dr Yewhalaw not participate in the “Vector Control” group discussion of the research prioritization exercise (part IV). Non-monetary support from an organization with an interest was reported by two participants, without any conflict of interest.

ANNEX 3. LIST OF PARTICIPANTS

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