EvidenceSpotlight

Anopheles stephensi: Emerging evidence and implications for malaria control

Summary

Invasive *Anopheles stephensi* mosquitoes pose a growing threat to malaria control and elimination efforts in Africa by increasing malaria risk in urban areas that have historically experienced lower transmission. The species not only thrives in urban environments but also predominantly bites indoors, with the highest biting risk occurring in the early evening, creating additional challenges for malaria prevention. Expanding access to effective vector control tools will be essential as programmes respond to changing patterns of malaria transmission. New evidence is improving our understanding of the spread of *An. stephensi* and the challenges it poses for malaria control, helping to inform surveillance and response strategies.

An invasive malaria vector that thrives in urban areas

An. stephensi is an invasive mosquito species capable of transmitting both *Plasmodium falciparum* and *P. vivax* malaria parasites.[1,2] Unlike Africa's main malaria vectors, which are most common in rural and peri-urban settings, *An. stephensi* is highly adapted to urban environments.[1,2] Originally native to South Asia and the Arabian Peninsula, *An. stephensi* has since been detected across Africa, introducing malaria transmission to previously low-risk areas.[1,2] Its preference for breeding in artificial water storage containers means it can survive during dry seasons and distinguishes it from other Anopheles species, which typically breed in natural water bodies.[2,3] Furthermore, biting commonly occurs during early evening before people are sleeping, as well as throughout the night.[1,4,5] Together, these characteristics make *An. stephensi* a growing threat to global malaria control and elimination. Although *An. stephensi* can also thrive in rural conditions in Asia, there is currently little evidence of this in Africa.[4]

Since its first detection in Djibouti in 2012, *An. stephensi* has spread rapidly across parts of the continent. First establishing itself within the Horn of Africa, likely following its maritime introduction from coastal South Asia, the species has now been confirmed in at least nine African countries, extending well beyond its original foothold into West Africa.[6–8] In both Djibouti and Ethiopia, the species has been linked to major malaria outbreaks, highlighting the public health threat posed by its continued spread.[9,10] Although its contribution to local malaria transmission in other African countries remains less well defined, *An. stephensi* is recognized as an emerging threat to malaria control across the continent.[11]

The potential impact of *Anopheles stephensi* on malaria transmission in Africa

Much of Africa's malaria burden has traditionally been concentrated in rural areas during the wet season.[1,8] However, *An. stephensi* has the potential to alter the geography and timing of transmission due to its preference for breeding in artificial containers throughout the year.[4,12] One modelling study estimates that if left unchecked, *An. stephensi* could put an additional 126 million people at risk of malaria in cities across Africa.[1] Another modelling study indicates that P. falciparum malaria cases could increase by 50% in Ethiopia if *An. stephensi* establishes itself across the country, in the absence of additional vector control interventions.[9] Djibouti illustrates this impact clearly: just 7 years after the first detection of *An. stephensi* in the country, annual malaria cases jumped from less than 3,000 to more than 49,000 in 2019.[9] Overall, the spread of *An. stephensi* into urban areas of Africa where malaria has previously been low or absent presents a serious public health threat, particularly for populations with lower levels of immunity to malaria.[12]

Impact of *Anopheles stephensi* on vector control strategies

The distinctive behaviour and biology of *An. stephensi* present unique challenges for existing malaria vector control strategies. In addition to thriving in urban environments, the species primarily bites indoors in the early in the evening, with studies observing that biting risk is greatest between 6 pm and 10 pm.[1,4,5] Lower levels of activity are observed throughout the night until early morning, with little activity during daylight hours.[5] Therefore, whilst ITNs still provide critical protection during sleeping hours, people may be exposed to mosquito bites outside the periods when they are typically protected by an ITN. This highlights the importance of complementary vector control measures alongside high net coverage and usage. As *An. stephensi* continues to spread, vector control strategies that address both urban malaria transmission and changing mosquito behaviour will be essential.

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Insecticide resistance and *An. stephensi* biology

An. stephensi has demonstrated resistance to the pyrethroids (deltamethrin, permethrin, and alpha-cypermethrin), carbamates (bendiocarb and propoxur), and organophosphates (pirimiphos-methyl).[2,13] These insecticides are used in ITNs and indoor residual spraying – two of the main vector control strategies for malaria.[2,13] However, evidence from Ethiopia indicates that *An. stephensi* remains fully susceptible to the newer insecticides such as chlorfenapyr – commonly used in dual-active ingredient ITNs – and broflanilide and clothianidin.[13]

Recent genomic evidence suggests that *An. stephensi* resistance is likely induced through metabolic detoxification genes (i.e. genes that help the mosquito metabolise the insecticide into something harmless) rather than arising from new, locally evolved target-site mutations.[8] The study suggests that this resistance was introduced with the invading mosquito populations from Asia, rather than evolving independently after the species arrived in Africa.[8] This genomic resource is now being made available to help guide surveillance and resistance management as *An. stephensi* continues to spread.[8]

In areas where *An. stephensi* is found, the World Health Organization recommends that countries deploy targeted control measures, including strengthening the use of ITNs and indoor residual spraying.[11] Ensuring high coverage and usage with pyrethroid-chlorfenapyr ITNs will be vital in light of growing insecticide resistance.[13] Due to *An. stephensi*'s preference for biting in the early evening, complementary approaches such as larval source management, spatial emanators, environmental management and housing adaptations (e.g. window and door screens) are also recommended to reduce malaria transmission.[11,14] Recent WHO guidance has also highlighted the potential role of container and waste management due to the tendency of *An. stephensi* to breed in artificial urban containers.[15] Scaling up these integrated strategies will be essential to protect populations across Africa from the growing threat posed by invasive *An. stephensi* and native malaria vectors.

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