Insecticide-treated nets (ITNs) have contributed to impressive gains in malaria control, by protecting people when they are most vulnerable – in the middle of the night, at peak mosquito biting time – but they are not expected to protect against 100% of bites. Because many people spend much of their evenings outdoors socializing, working or sleeping to escape the heat, some malaria transmission still occurs even when people have access to and use ITNs or have well-implemented indoor residual spraying (IRS) \(^1\). Also known as residual malaria transmission (RMT), this ongoing transmission can pose a challenge in both high- and low-transmission settings. Understanding gaps in malaria prevention that remain after we achieve good coverage of our best tools, and how those gaps occur, is important to eliminating malaria.

1. **Residual malaria transmission can be an issue anywhere.** Whether in Zanzibar, where malaria prevalence is <1%, or in higher transmission contexts—such as northern Ghana (25%)—understanding what is contributing to the remaining transmission is key to targeting malaria prevention interventions and sustaining progress \(^1\,^2\,^3\).

Studies with rural populations in Ghana, Zanzibar, and Uganda found that people spend a good deal of time outdoors at night doing routine household chores and socializing in the evenings and early mornings. They also attend large-scale events, such as funerals and weddings, which can last all night. Social norms—particularly fear of being seen as too proud—and logistical barriers (such as where to hang the net) may deter people from using nets, particularly when they spend the night away from home \(^3\,^2\,^5\). And, in some settings, people may simply choose to sleep outdoors because of the heat \(^2\). For some people, often men, their livelihood may require them to work or sleep outside for jobs that include security or fishing in parts of sub-Saharan Africa, forest work in the Mekong, and illegal mining in South America \(^3\,^2\,^6\,^7\,^8\,^9\,^10\).
2. **Combine human and vector data to understand and target residual malaria transmission.** Because ongoing transmission results from human and mosquito behavior, it is important to have data on both for a more complete picture of malaria risk. But, a review of more than 3,000 papers found that only 26 included any information on where people spent time at night or what activities they were participating in during those times. Less than a dozen papers combined human and mosquito behavior data, and method descriptions varied, making it difficult to compare findings across settings [6].

Critical data include the percentage of the population that is outdoors versus indoors, the percentage that are sleeping or trying to sleep, the percentage that are using a net, as well as the indoor and outdoor mosquito biting rates at every hour of the evening. These data can improve estimates of real-world exposure to malaria mosquitoes, including the proportion of exposure to malaria mosquitoes prevented by ITN use and when (time of night) and where (indoors versus outdoors) the remaining exposure is occurring. Such data increases malaria control programs’ ability to identify and test appropriate tools, as well as monitor the effectiveness of nets and other vector control methods, over time [6].

3. **While imperfect, ways to reduce residual malaria transmission do exist.** To sustain progress, we can get the most out of nets by ensuring high levels of access and use and then maintaining their effectiveness. As noted earlier, barriers to consistent net use can be social and logistical. In areas where outdoor sleeping is widespread, it might be worth promoting ways to make outdoor net use possible, such as setting up posts from which nets can be hung or showing examples of households using nets as they sleep under porches and other areas within their compound. Leveraging community-driven solutions may increase access and use of preventive and treatment measures for hard-to-reach populations, as well as change social expectations around when nets can be used [3, 11]. It will also be important to encourage net care to help ensure nets last as long as possible [12].

To ensure elimination in many settings, nets alone are not enough. Although World Health Organization (WHO) does not recommend the large-scale deployment of alternative tools, WHO states that countries should prioritize the implementation of current tools, while novel tools, such as repellents, insecticide-treated clothing, and screens, as well as toxic sugar baits, outdoor traps, and insecticides for livestock—are assessed for their practicality, effectiveness, and affordability [1]. It will be increasingly important to identify and provide protection to high risk groups; occupation-based vector control interventions could be useful, particularly in elimination contexts [8]. Operational research can help the global community better understand where and how to deploy other tools for maximum impact [13].
While countries correctly focus on increasing and sustaining net access and use, well-planned programs also consider the limitations of current interventions. While we generally know the types of situations where people cannot be protected by nets, it is useful to understand when and where people remain at risk and to identify high-risk activities and groups within any given context. Bringing together human, mosquito, and epidemiological data can give us a better idea of where gaps in protection remain and help us target our efforts accordingly. Finally, when considering interventions, it is important to remember to make the most of existing tools while assessing the promise of new ones.