



HAL
open science

Reply to Wagman et al.: Data-driven assessments should establish the landscape of what is “within reach” of malaria transmission control

Carlo Costantini, Fabrice Chandre, Vincent Corbel, Nicolas Moiroux, Frédéric Simard, Claire Sangbakembi-Ngounou, Diego Ayala

► To cite this version:

Carlo Costantini, Fabrice Chandre, Vincent Corbel, Nicolas Moiroux, Frédéric Simard, et al.. Reply to Wagman et al.: Data-driven assessments should establish the landscape of what is “within reach” of malaria transmission control. *Proceedings of the National Academy of Sciences of the United States of America*, 2022, 119 (38), 10.1073/pnas.2211931119 . hal-03775827

HAL Id: hal-03775827

<https://hal.science/hal-03775827>

Submitted on 2 Jun 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



Reply to Wagman et al.: Data-driven assessments should establish the landscape of what is “within reach” of malaria transmission control

Carlo Costantini^{a,b}, Fabrice Chandre^a, Vincent Corbel^{a,c}, Nicolas Moiroux^a, Frédéric Simard^a, Claire Sangbakembi-Ngounou^d, and Diego Ayala^{a,e,1}

Commenting on results of Sangbakembi-Ngounou et al. (1), who showed extensive diurnal and outdoor biting by three of the most important Afrotropical malaria mosquitoes, Wagman et al. (2) aptly warn against the misconception that insecticide treated nets (ITNs) and indoor residual spraying (IRS)—currently the most efficient malaria vector control tools—are redundant, making the case for rethinking single intervention approaches in the face of budget constraints. The argument that indoor insecticidal interventions like IRS can be effective regardless of location or timing of mosquito blood-feeding is grounded on the resting behavior of malaria vectors: Reductions in transmission may be achieved despite diurnal or outdoor biting, provided that a significant fraction of the mosquito population rests on surfaces treated with effective insecticides (1, 2).

Sangbakembi-Ngounou et al. (1), however, further bring to attention dangers arising from ascertainment biases in mosquito biting behavior. Indeed, the unexpected finding of substantial diurnal biting resulted from their modification of conventional practices in malaria transmission assessment. Ascertainment biases in malaria vector resting behavior are potentially equally likely. For example, resolving uncertainties about the size (3) or nonuniform nature (4)—and, consequently, nonuniform exposure to indoor insecticides (5)—of the vector population resting outdoors, as well as filling data deficiencies about mosquito biting and resting in structures where people occur mostly during daytime (e.g., schools, offices, or public buildings—structures that are generally not covered by either IRS or ITNs), could help throw light on IRS variable control outcomes and, accordingly, on the limitations of IRS efficacy or cost-effectiveness under some circumstances, either deployed on its own (6) or in association with ITNs (7).

Other potential explanatory sources of variability arise from additional uncertainties: Despite efforts to investigate the preprandial behavior of indoor-biting malaria vectors, there are still uncertainties whether mosquitoes, once inside domestic households, rest on treated surfaces before coming to the host and biting, or the extent and

impact of postprandial exposure to insecticides. Similarly, some insecticidal formulations deter to variable degrees mosquitoes from entering into or remaining inside treated structures, inhibit blood-feeding, or induce them to escape outdoors, but the precise role and consequences of these effects upon malaria transmission are scantily appreciated (8). Furthermore, we are just beginning to understand how genetic polymorphisms and insecticide resistances (i.e., physiological or behavioral) and their interactions with environmental modulators influence mosquito biting and resting and their effects on transmission (9).

Importantly, extrapolation of findings from individual studies aimed at setting continent-wide control policies may also lead to unpredictable outcomes in the face of heterogeneities due to, *inter alia*, the genetically much diversified (10) and constantly evolving (5, 11) communities of vectors. Thus, undogmatic, data-driven, unbiased quantitative empirical approaches, informed by and feeding back into theoretical models (8), are necessary to assess the consequences of epidemiologically relevant behaviors of local vector communities, to understand the heterogeneous and volatile landscape of what may be “out of control” or otherwise “within reach” of current interventions, with the goal of sustainable control of residual malaria transmission by complementary tools whenever needed.

Author affiliations: ^aMIVEGEC (Maladies infectieuses et vecteurs : écologie, génétique, évolution et contrôle), Université de Montpellier, CNRS, Institut de Recherche pour le Développement, Montpellier 34394, France; ^bInstitut Pasteur de Dakar, BP 220 Dakar, Senegal; ^cOswaldo Cruz Foundation, Rio de Janeiro 21040-900, Brazil; ^dMedical Entomology Laboratory, Institut Pasteur de Bangui, BP 923 Bangui, Central African Republic; and ^eMedical Entomology Unit, Institut Pasteur de Madagascar, BP 1274, 101 Antananarivo, Madagascar

Author contributions: C.C., F.C., V.C., N.M., F.S., C.S.-N., and D.A. wrote the paper.

The authors declare no competing interest.

Copyright © 2022 the Author(s). Published by PNAS. This article is distributed under Creative Commons Attribution License 4.0 (CC BY).

¹To whom correspondence may be addressed. Email: diego.ayala@ird.fr.

Published September 12, 2022.

1. C. Sangbakembi-Ngounou et al., Diurnal biting of malaria mosquitoes in the Central African Republic indicates residual transmission may be “out of control”. *Proc. Natl. Acad. Sci. U.S.A.* **119**, e2104282119 (2022).
2. J. Wagman, et al., Some residual malaria transmission may be “out of control” but “within reach” of current tools. *Proc. Natl. Acad. Sci. U.S.A.* **119**, 10.1073/pnas.2210568119 (2022).
3. C. Costantini et al., Density, survival and dispersal of *Anopheles gambiae* complex mosquitoes in a West African Sudan savanna village. *Med. Vet. Entomol.* **10**, 203–219 (1996).
4. W. M. Guelbeogo, N. Sagnon, F. Liu, N. J. Besansky, C. Costantini, Behavioural divergence of sympatric *Anopheles funestus* populations in Burkina Faso. *Malar. J.* **13**, 65 (2014).
5. L. Dumez, M. Coosemans, “Residual transmission of malaria: An old issue for new approaches” in *Anopheles Mosquitoes—New Insights into Malaria Vectors*, S. Manguin, Ed. (InTech Open Books, 2013), pp. 671–704.
6. B. Pluess, F. C. Tanser, C. Lengeler, B. L. Sharp, Indoor residual spraying for preventing malaria. *Cochrane Database Syst. Rev.* **4**, CD006657 (2010).
7. J. Pryce, N. Medley, L. Choi, Indoor residual spraying for preventing malaria in communities using insecticide-treated nets. *Cochrane Database Syst. Rev.* **1**, CD012688 (2022).
8. E. Sherrard-Smith et al., Systematic review of indoor residual spray efficacy and effectiveness against *Plasmodium falciparum* in Africa. *Nat. Commun.* **9**, 4982 (2018).
9. D. Carrasco et al., Behavioural adaptations of mosquito vectors to insecticide control. *Curr. Opin. Insect Sci.* **34**, 48–54 (2019).
10. The *Anopheles gambiae* 1000 Genomes Consortium, Genetic diversity of the African malaria vector *Anopheles gambiae*. *Nature* **552**, 96–100 (2017).
11. M. E. Sinka et al., A new malaria vector in Africa: Predicting the expansion range of *Anopheles stephensi* and identifying the urban populations at risk. *Proc. Natl. Acad. Sci. U.S.A.* **117**, 24900–24908 (2020).