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Unlocking the human factor to increase effectiveness and sustainability of vector control tools

April Monroe, PhD

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VCWG Annual Meeting

Expanding the Vector Control Toolbox Workstream

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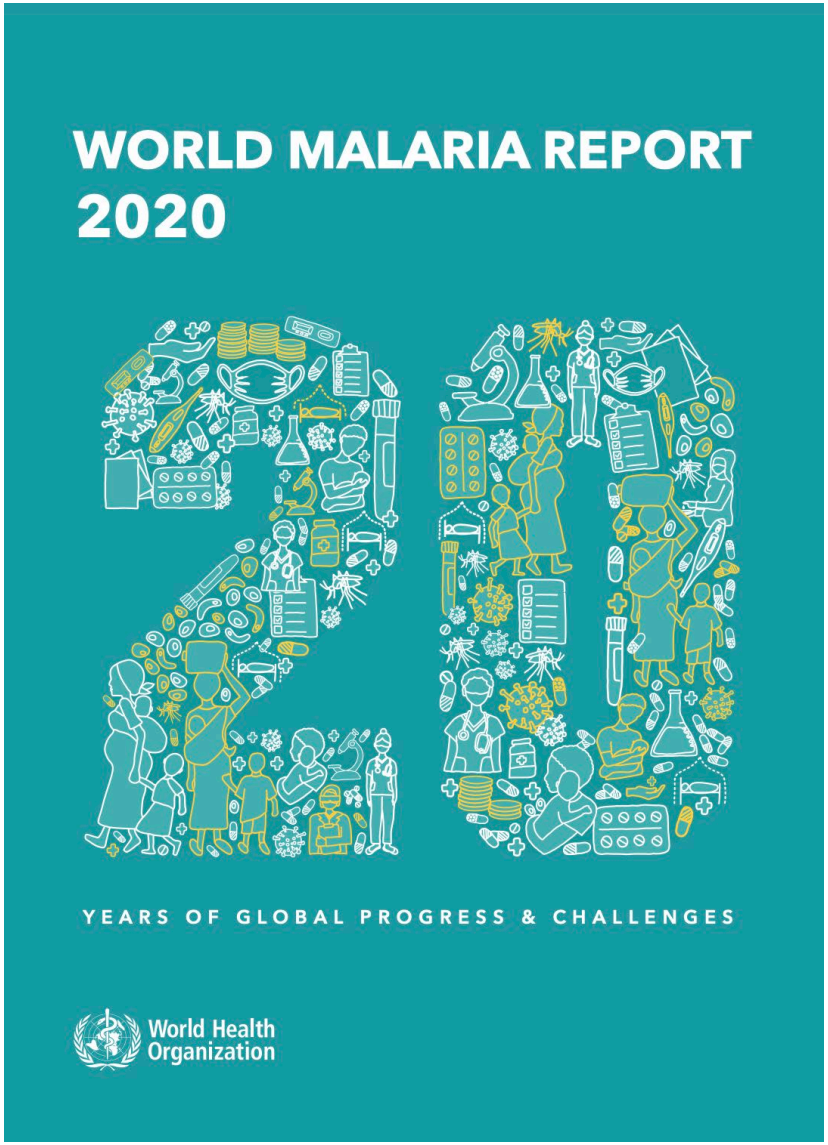
Background

- Despite gains, progress has stalled
- New tools provide cause for optimism
- **People** will be key to their success



01

Increase impact of core interventions

02

Identify and characterize gaps in protection

03

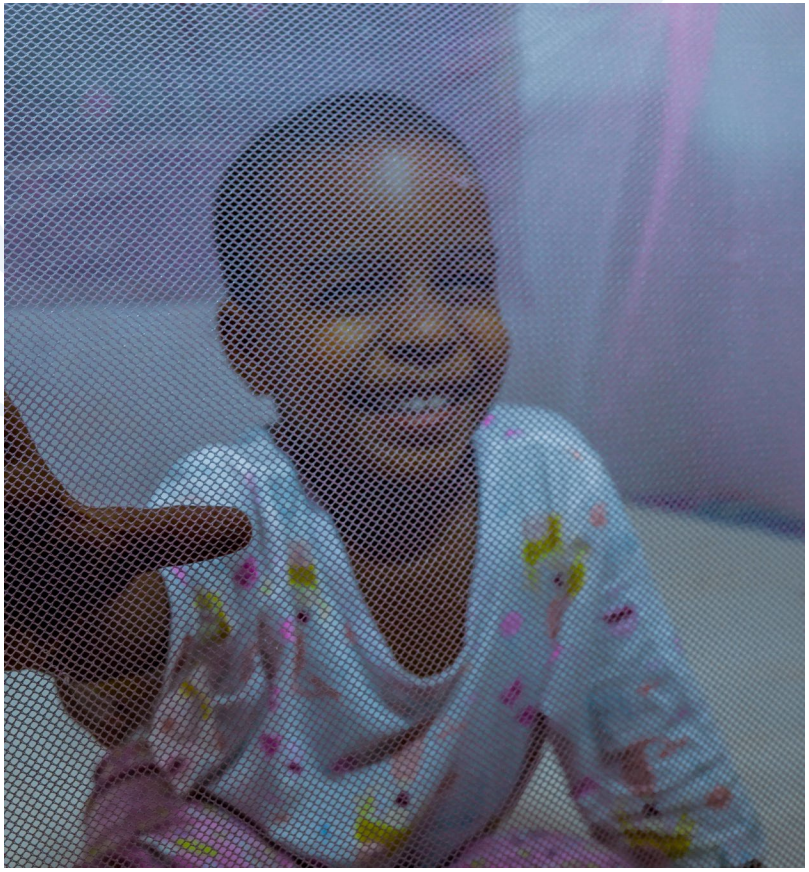
Integrate social and behavioral research in evaluation of new tools

04

Build resilience to sustain gains

01: INCREASE IMPACT OF CORE INTERVENTIONS

Examples of behaviors that can increase effectiveness of core interventions



ITNs

1. Access through available channels
2. Use consistently
3. Care for appropriately

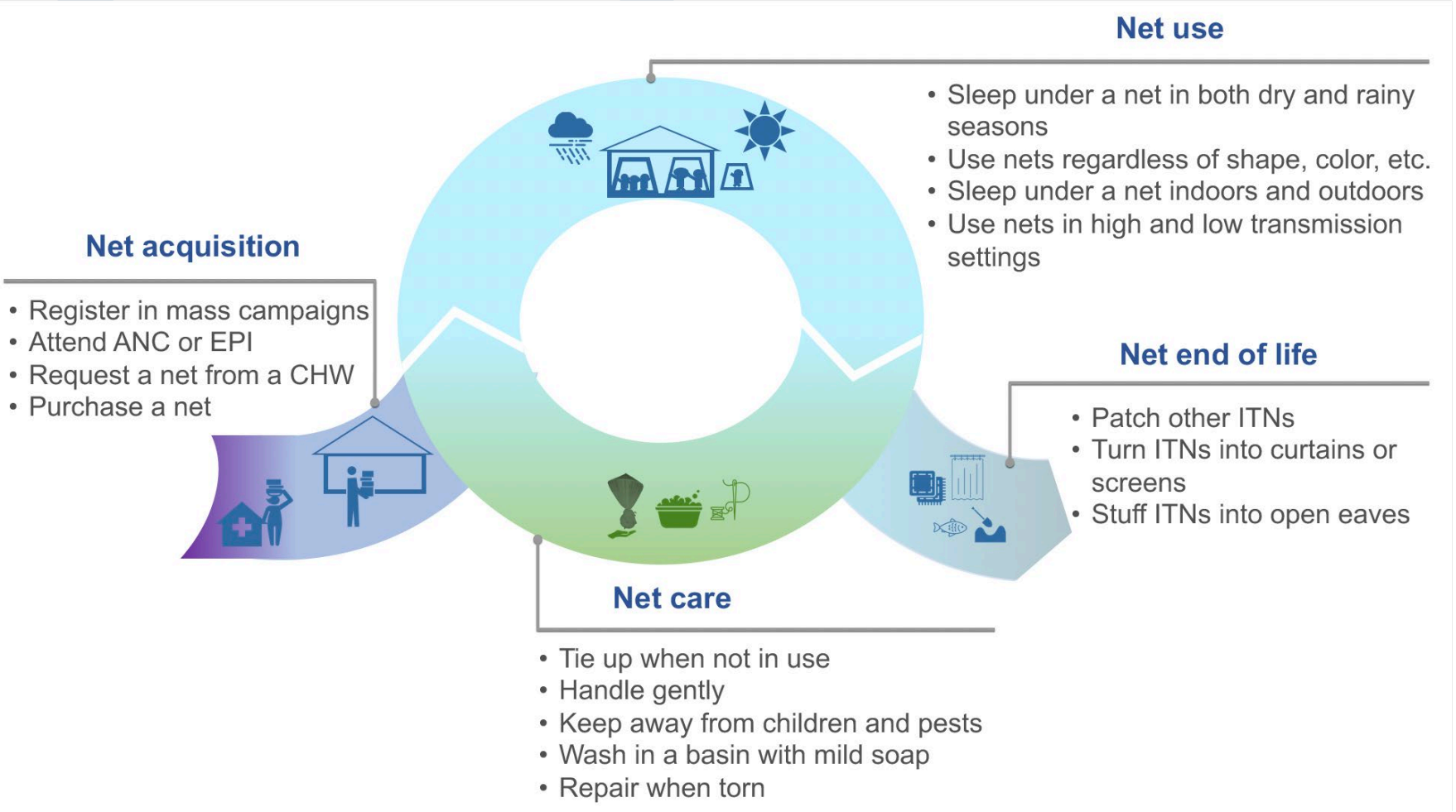
IRS

1. Accept sprayers in home
2. Consent to remove household possessions
3. Avoid post-spray wall modifications

Photo: Miss Lilibet Msangi courtesy of Mr. Joseph Madata

References: 1- Mboma et al. 2020. The Consequences of Declining Population Access to Insecticide Treated Nets (ITNs) on Net Use Patterns and Physical Degradation of Nets after 22 Months of Ownership.
2- Koenker et al. 2015. Impact of a behaviour change intervention on long-lasting insecticidal net care and repair behaviour and net condition in Nasarawa State, Nigeria.
3- Opiyo et al, 2020. 'We spray and walk away': wall modifications decrease the impact of indoor residual spray campaigns through reductions in post-spray coverage.

Example: Social and Behavior Change for ITNs



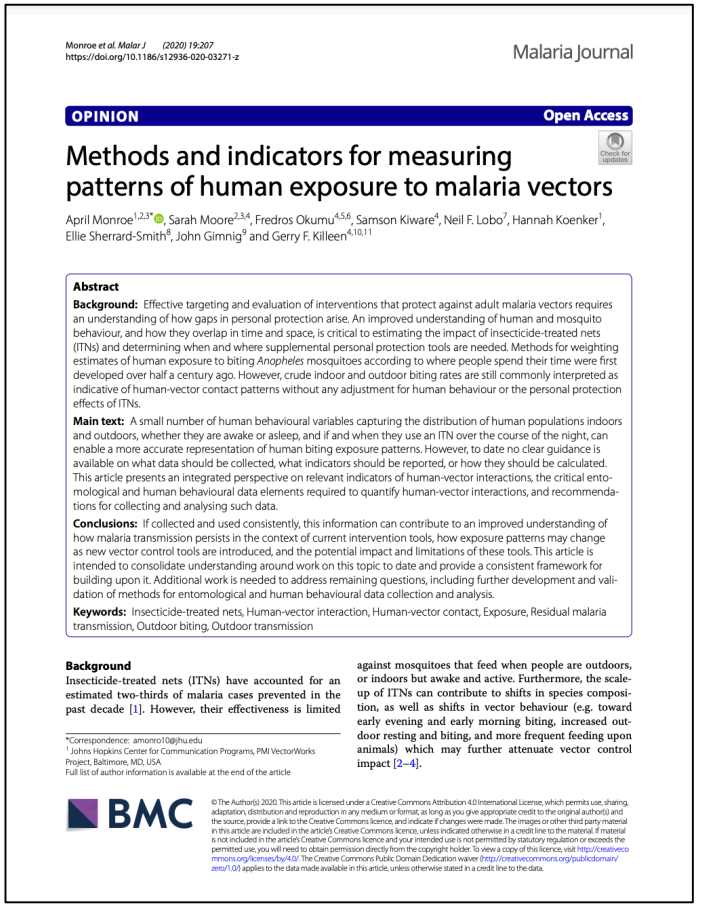
Reference: Social and behavior change for insecticide-treated nets. 2019. https://www.pmi.gov/docs/default-source/default-document-library/tools-curricula/pmi-vectorworks-social-and-behavior-change-for-insecticide-treated-nets-2019-toolkit.pdf

https://malariabehaviorsurvey.org/

02: IDENTIFY AND CHARACTERIZE GAPS IN PROTECTION

A small set of human behavioral data can improve understanding of *when* and *where* gaps in protection occur

- Indoor and outdoor biting rates alone often used to estimate human-vector contact
- Risk depends on overlap with human behavior and intervention use over the course of the night e.g.
  - home versus away
  - indoors versus outdoors
  - awake versus asleep
  - using an ITN/personal protection or not



Monroe *et al. Malar J* (2020) 19:207
https://doi.org/10.1186/s12936-020-03271-z

Malaria Journal

OPINION Open Access

Methods and indicators for measuring patterns of human exposure to malaria vectors

April Monroe[1,2,3*], Sarah Moore[2,3,4], Fredros Okumu[4,5,6], Samson Kiware[4], Neil F. Lobo[7], Hannah Koenker[1], Ellie Sherrard-Smith[8], John Gimnig[9] and Gerry F. Killeen[4,10,11]

Abstract

Background: Effective targeting and evaluation of interventions that protect against adult malaria vectors requires an understanding of how gaps in personal protection arise. An improved understanding of human and mosquito behaviour, and how they overlap in time and space, is critical to estimating the impact of insecticide-treated nets (ITNs) and determining when and where supplemental personal protection tools are needed. Methods for weighting estimates of human exposure to biting *Anopheles* mosquitoes according to where people spend their time were first developed over half a century ago. However, crude indoor and outdoor biting rates are still commonly interpreted as indicative of human-vector contact patterns without any adjustment for human behaviour or the personal protection effects of ITNs.

Main text: A small number of human behavioural variables capturing the distribution of human populations indoors and outdoors, whether they are awake or asleep, and if and when they use an ITN over the course of the night, can enable a more accurate representation of human biting exposure patterns. However, to date no clear guidance is available on what data should be collected, what indicators should be reported, or how they should be calculated. This article presents an integrated perspective on relevant indicators of human-vector interactions, the critical entomological and human behavioural data elements required to quantify human-vector interactions, and recommendations for collecting and analysing such data.

Conclusions: If collected and used consistently, this information can contribute to an improved understanding of how malaria transmission persists in the context of current intervention tools, how exposure patterns may change as new vector control tools are introduced, and the potential impact and limitations of these tools. This article is intended to consolidate understanding around work on this topic to date and provide a consistent framework for building upon it. Additional work is needed to address remaining questions, including further development and validation of methods for entomological and human behavioural data collection and analysis.

Keywords: Insecticide-treated nets, Human-vector interaction, Human-vector contact, Exposure, Residual malaria transmission, Outdoor biting, Outdoor transmission

Background

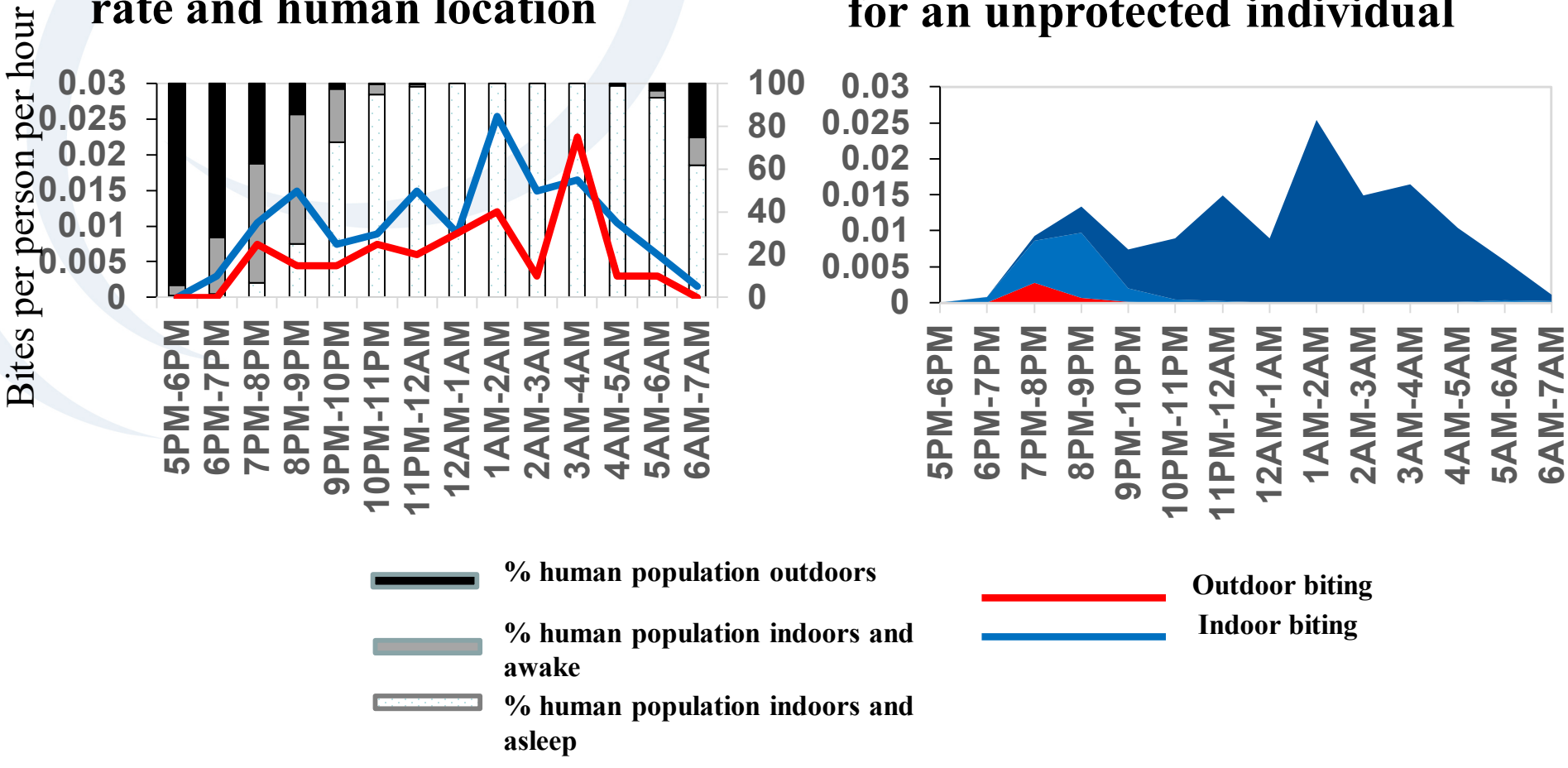
Insecticide-treated nets (ITNs) have accounted for an estimated two-thirds of malaria cases prevented in the past decade [1]. However, their effectiveness is limited against mosquitoes that feed when people are outdoors, or indoors but awake and active. Furthermore, the scale-up of ITNs can contribute to shifts in species composition, as well as shifts in vector behaviour (e.g. toward early evening and early morning biting, increased outdoor resting and biting, and more frequent feeding upon animals) which may further attenuate vector control impact [2–4].

*Correspondence: amonro10@jhu.edu
[1] Johns Hopkins Center for Communication Programs, PMI VectorWorks Project, Baltimore, MD, USA
Full list of author information is available at the end of the article

https://malariajournal.biomedcentral.com/articles/10.1186/s12936-020-03271-z

A. Directly measured biting rate and human location

B. Behavior-adjusted biting rate for an unprotected individual



Reference: Monroe et al. 2020. Methods and indicators for measuring patterns of human exposure to malaria vectors.
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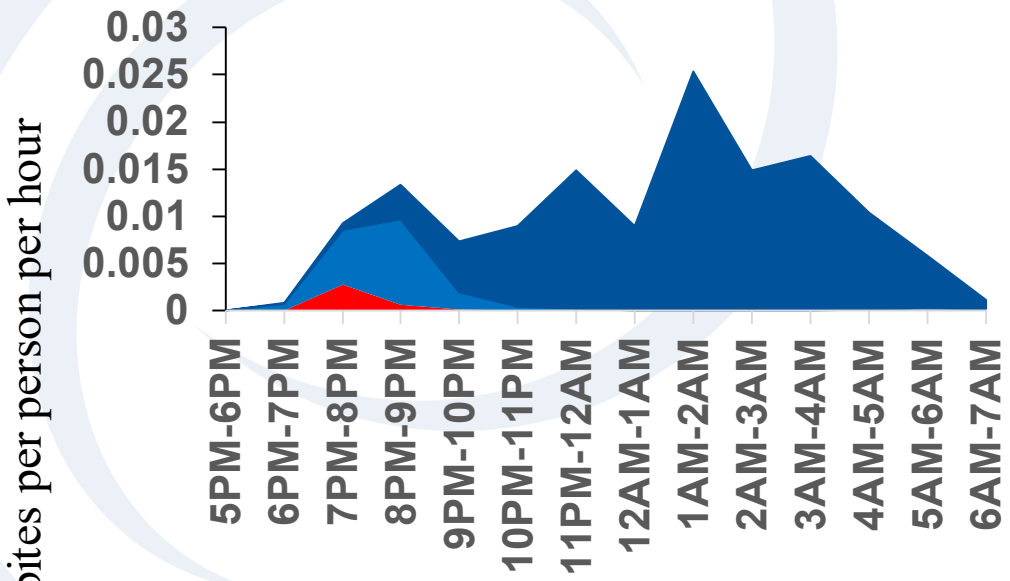
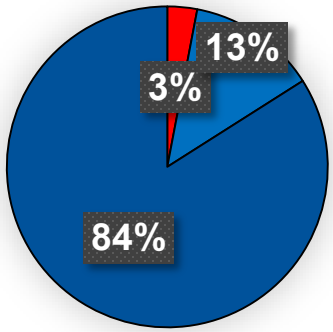
A. Unprotected individual





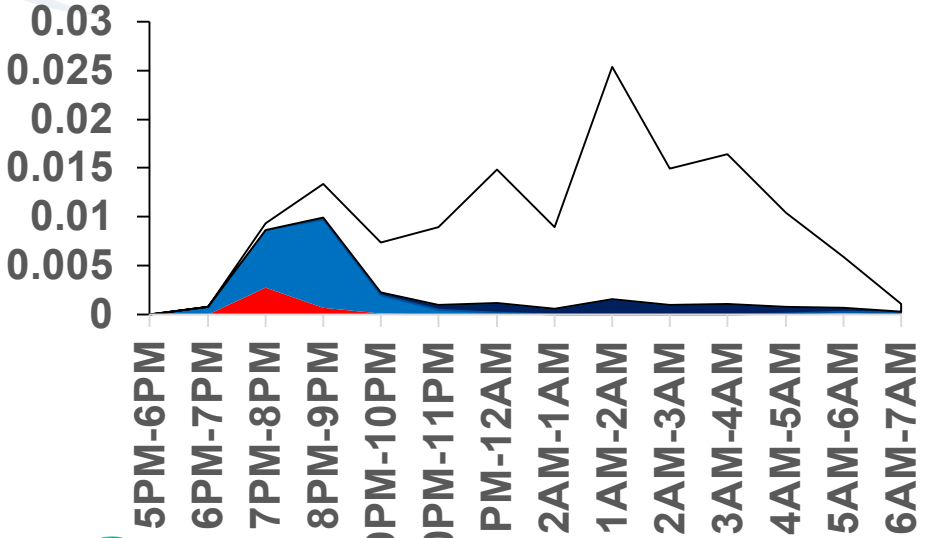
$\pi_{I,u} = 97\%$

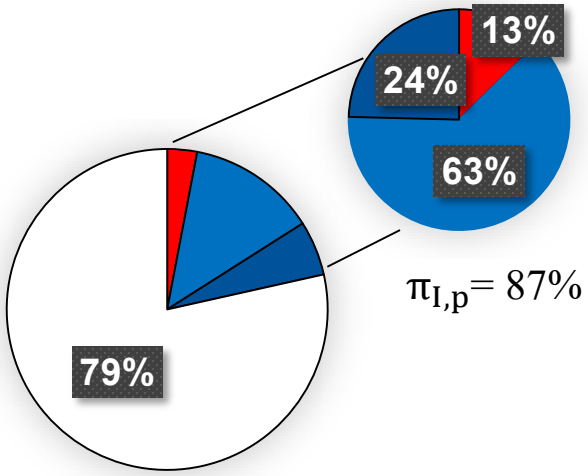
$\pi_{S,u} = 84\%$

Legend

- Behavior-adjusted vector bites occurring outdoors
- Behavior-adjusted vector bites occurring indoors while awake
- Behavior-adjusted vector bites occurring indoors while sleeping
- Bites prevented by using an ITN

B. ITN user





$\pi_{I,p} = 87\%$

$P_S^* = 79\%$

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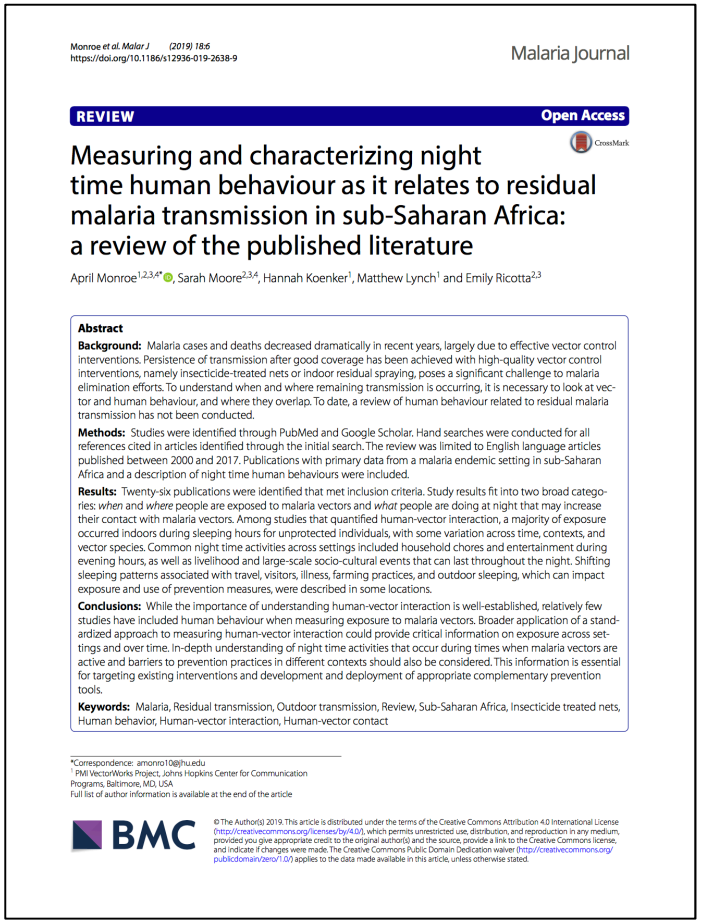
Characterize *who* is at risk and *what* they're doing during those times to determine *how* to improve protection

- Small but growing number of studies on nighttime human behavior
- Common activity categories
  - Routine activities
  - Special events
- Higher-risk groups
  - Mobile populations
  - Night time occupations
  - Internally displaced persons and refugees



Monroe *et al. Malar J* (2019) 18:6
https://doi.org/10.1186/s12936-019-2638-9

Malaria Journal

REVIEW Open Access

Measuring and characterizing night time human behaviour as it relates to residual malaria transmission in sub-Saharan Africa: a review of the published literature

April Monroe[1,2,3,4*], Sarah Moore[2,3,4], Hannah Koenker[1], Matthew Lynch[1] and Emily Ricotta[2,3]

Abstract

Background: Malaria cases and deaths decreased dramatically in recent years, largely due to effective vector control interventions. Persistence of transmission after good coverage has been achieved with high-quality vector control interventions, namely insecticide-treated nets or indoor residual spraying, poses a significant challenge to malaria elimination efforts. To understand when and where remaining transmission is occurring, it is necessary to look at vector and human behaviour, and where they overlap. To date, a review of human behaviour related to residual malaria transmission has not been conducted.

Methods: Studies were identified through PubMed and Google Scholar. Hand searches were conducted for all references cited in articles identified through the initial search. The review was limited to English language articles published between 2000 and 2017. Publications with primary data from a malaria endemic setting in sub-Saharan Africa and a description of night time human behaviours were included.

Results: Twenty-six publications were identified that met inclusion criteria. Study results fit into two broad categories: *when* and *where* people are exposed to malaria vectors and *what* people are doing at night that may increase their contact with malaria vectors. Among studies that quantified human-vector interaction, a majority of exposure occurred indoors during sleeping hours for unprotected individuals, with some variation across time, contexts, and vector species. Common night time activities across settings included household chores and entertainment during evening hours, as well as livelihood and large-scale socio-cultural events that can last throughout the night. Shifting sleeping patterns associated with travel, visitors, illness, farming practices, and outdoor sleeping, which can impact exposure and use of prevention measures, were described in some locations.

Conclusions: While the importance of understanding human-vector interaction is well-established, relatively few studies have included human behaviour when measuring exposure to malaria vectors. Broader application of a standardized approach to measuring human-vector interaction could provide critical information on exposure across settings and over time. In-depth understanding of night time activities that occur during times when malaria vectors are active and barriers to prevention practices in different contexts should also be considered. This information is essential for targeting existing interventions and development and deployment of appropriate complementary prevention tools.

Keywords: Malaria, Residual transmission, Outdoor transmission, Review, Sub-Saharan Africa, Insecticide treated nets, Human behavior, Human-vector interaction, Human-vector contact

*Correspondence: amonro10@jhu.edu
[1] PMI VectorWorks Project, Johns Hopkins Center for Communication Programs, Baltimore, MD, USA
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BMC

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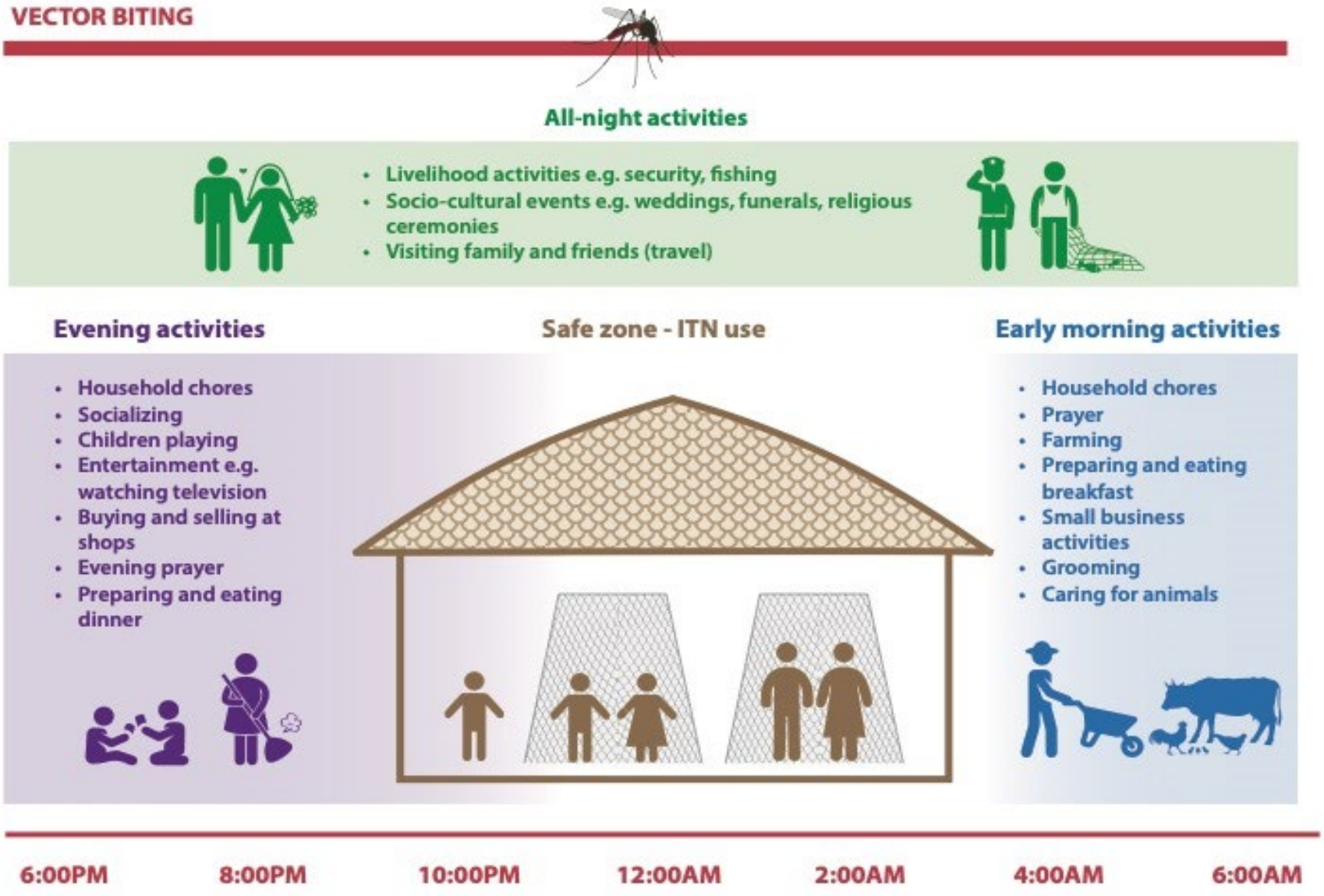


Reference: Monroe et al. 2019. Human behaviour and residual malaria transmission in Zanzibar: findings from in-depth interviews and direct observation of community events. https://malariajournal.biomedcentral.com/articles/10.1186/s12936-019-2855-2

03: INTEGRATE SOCIAL AND BEHAVIORAL RESEARCH IN EVALUATION OF NEW TOOLS

Complementary tools will depend on end-users to be successful

- Improved housing
- Larval source management
- Mosquito release technologies
- Topical repellents
- Insecticide-treated clothing
- Insecticide-treated hammocks
- Spatial repellents
- Push-pull systems
- Eave tubes and eave baffles
- Attractive targeted sugar baits
- Anti-parasitic drugs e.g. Ivermectin

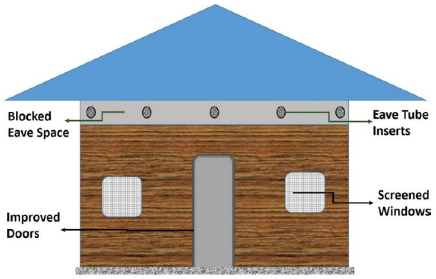


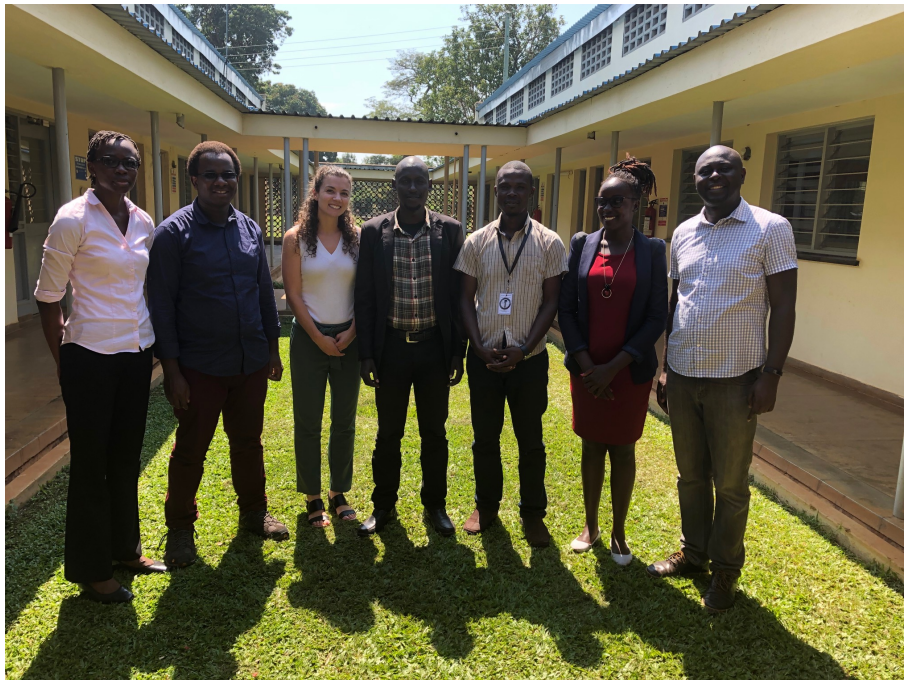
Photo credits (clockwise): 1 – ATSB: Hebrew University of Jerusalem; 2 – Spatial repellent: SCJohnson.com; 3-4 – Improved housing and LSM : Ifakara Health Institute

Vector control intervention	Example end-user behaviors
Larval source management (LSM)	Accept LSM in community
	Participate in activities to treat and/or eliminate breeding sites
Housing Improvements	Accept/embrace mosquito-proof housing designs
	Purchase materials and labor needed to make housing improvements
Mosquito release technologies	Accept to have mosquitoes released
	Assist in release of mosquitoes
	Host and monitor mosquito traps
	Participate in local progress monitoring committees
Insecticide-treated hammocks	Seek out hammock from employer or other source
	Carry hammock when spending night away from home
	Use hammock when sleeping outdoors
Topical repellents and insecticide treated clothing	Purchase topical repellent/IT clothing (or seek out if distributed)
	Use consistently when not under an ITN
Spatial repellents	Purchase spatial repellent (or seek out if distributed)
	Install spatial repellent according to specifications
	Replace spatial repellent regularly according to specifications
Attractive Targeted Sugar Baits (ATSB)	Accept ATSB in home (or seek out if distributed)
	Replace ATSB regularly according to specifications
Anti-parasitic drugs e.g., Ivermectin	Accept to have cattle treated (or treat cattle according to specifications)
	Accept to take drug
	Take drug according to specifications

Reference: Monroe et al. Under Review. Unlocking the human factor to increase effectiveness and sustainability of malaria control and elimination efforts.

Include social and behavioral research when evaluating new tools

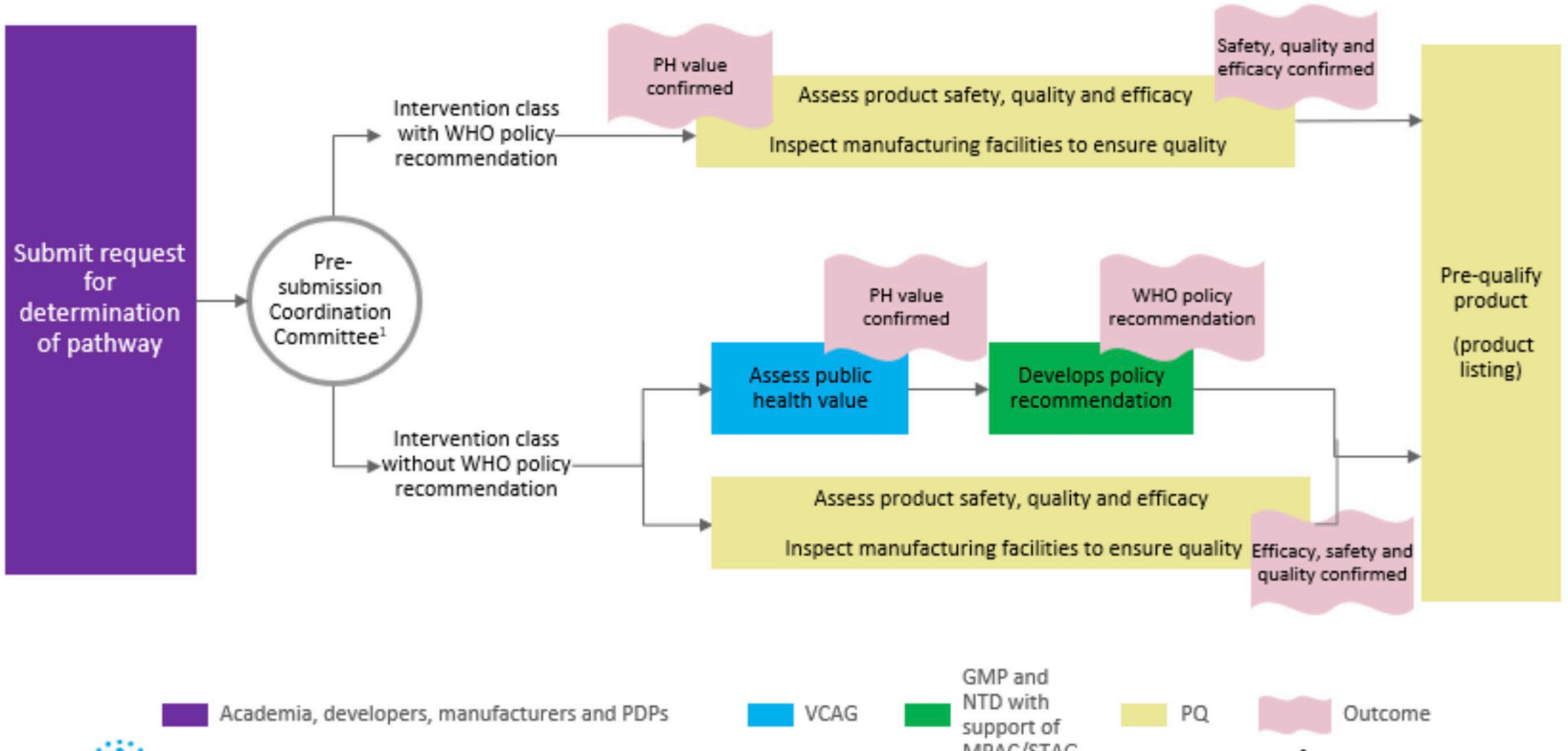
- How are people currently protecting themselves and what are the gaps?
- How does this new approach fit into people's lives?
- What are the factors that could make it easier or harder to use?
- How might patterns of exposure change with this intervention in place?
- What are the considerations for large-scale implementation?



Advancing Evidence for Global Implementation of Spatial Repellents (AEGIS)
Social science team training

Elevate role of human behavior in policy review process

+ key human behavioral factors?



Vector Control Advisory Group

1. Consisting of staff from PQT, GMP and NTD

04: BUILD RESILIENCE TO SUSTAIN GAINS

Expand use of human-centered design to develop and scale-up new solutions in vector control

- Engages end-users in co-creation process
- Empathetic research methods to uncover insights
- Rapid idea generation, prototyping, and testing of promising solutions

Photo: Private Sector Malaria Prevention project, Ghana. ITN outfitted with features identified as most important to end-users through a human-centered design process.

Human-centered design examples

- Improving malaria outcomes in mining communities in Guyana
- Improving water storage in Jamaica to reduce *Aedes* breeding sites
- Encouraging health providers in Nigeria to test for malaria and only treat those with positive tests

https://breakthroughactionandresearch.org/sbc-flow-chart/

Build resilience to sustain gains

Behavioral Resilience

Build habits around prevention behaviors; address barriers to engagement; integrate health education for disease control in school and community programs

Structural and Environmental Resilience

Improve homes and environments to sustainably suppress mosquitoes

Economic Resilience

Ensure households have resources to meet basic needs; increase domestic financing for health

Health Systems Resilience

Functional services and interventions within reach of all; ownership and use of data at the local level

Potential Workstream Opportunities

- Bring together groups working on this topic
- Produce recommendations for human behavior in vector control development, evaluation, and implementation
- Identify entry points for considering human behavior in policy review and guidelines
- Develop research agenda and case studies for human centered design in vector control

Thank you!

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Johns Hopkins Center for Communication Programs
amonro10@jh.edu

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