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EDITORIAL OPEN ACCESS

Malaria Research Priorities in Yemen: Paving the Way for Malaria Elimination

Rashad Abdul-Ghani[1,2,*]

[1] *Department of Parasitology, Faculty of Medicine and Health Sciences, Sana'a University, Sana'a, Yemen*
[2] *Tropical Disease Research Center, University of Science and Technology, Sana'a, Yemen*

ABSTRACT

Malaria represents a major health problem in Yemen, and it appears that the efforts devoted to its control and elimination only tackle the tip of malaria iceberg. There is an evident gap between research activities and control efforts reflected by the fact that efforts and funding allocation are mainly directed to control activities. Research on basic, clinical and epidemiological aspects of the disease, which could serve elimination efforts, is rather ignored. This can simply be observed by searching online scientific databases, where the majority of published articles are of researchers and post-graduate students. Therefore, organized and collaborative research activities intended to serve the efforts to eliminate the disease are urgently needed, with a fair allocation of funds between research and control activities. The present editorial highlights research priorities needed to pave the way for malaria elimination and the need for bridging the existing gap between research and control strategies.

Keywords: Malaria, Research, Elimination, Yemen

* **Corresponding author:** R. Abdul-Ghani (rashadqb@yahoo.com)

Research and control: need for bridging the gap

Despite continuing efforts to control and eliminate malaria and the support by regional and international organizations, malaria continues to be a major public health problem in Yemen. According to the World Malaria Report (2014), more than a half of the population is exposed to the risk of infection, with about 99% of microscopy-confirmed cases being due to *Plasmodium falciparum* (1). In Yemen, limited resources for research necessitate prioritizing research activities on malaria for better optimization of health benefits to the community to seal the tangible gap between malaria control efforts and research activities. Although malaria control efforts are adopted by the National Malaria Control Program (NMCP), research activities are of more individual concern; being undertaken by individual researchers and postgraduate students. In addition, those conducted for the sake of serving disease control are limited and most of them remain unpublished. In a parallel fashion, the majority of funding received from regional and international agencies is allocated for field control activities such as insecticide spraying and distribution of insecticide-treated nets (ITNs), with a negligible portion being really devoted to scientific research on basic, clinical and epidemiological aspects of malaria.

The basic research related to parasite and vector biology as well as host immunity is almost ignored. For instance, there is a need to understand how malaria parasites interact with the immune system of selected high-risk population groups in endemic areas. Basic research is also required to study and determine the factors that could possibly affect the transmissibility of parasites from humans to vectors and facilitate the emergence of drug resistance among parasite populations. This is because malaria transmission and drug resistance are the two key points of paramount importance for paving the way for malaria elimination. A research priority should also be given to uncover the possible biological processes associated with the pathogenesis and complications of malaria among high-risk groups. If evidence-based control is to be achieved, there is a real need to revise the policy adopted in funding allocation to include malaria research activities for augmenting malaria control and elimination efforts. Therefore, malaria research activities should be prioritized in a way that bridges the gap between research and control needs.

Research priorities in epidemiology

In the framework of the general orientation of our country to eliminate malaria, research agenda priorities should be directed to tackle the epidemiological aspects that could effectively contribute to the efforts of the NMCP. In this regard, comprehensive statistics on malaria indicators at the national level are yet to be elucidated. Only a single study about the prevalence of malaria at the national level has been carried out by the NMCP in 2009, where microscopy-confirmed malaria rate was estimated to be 1.5% of the total population (2). The initiative of Malaria Indicators Surveys (MIS) was developed by the Monitoring and Evaluation Working Group of Roll Back Malaria to provide key malaria indicators based on nationally representative surveys (more details are found at the MIS website: http://www.malariasurveys.org/). These MIS statistics are publicly available for several malaria-endemic countries; however, no statistics are presented about Yemen.

Because of the sparse and limited nature of epidemiological studies on malaria, there is a need to re-assess main malaria indicators, including disease incidence and prevalence, within the context of a comprehensive system for the evaluation of the effectiveness of ongoing control and elimination efforts. Malaria indicators have to be surveyed and publicly published on national and international databases. This will certainly guide both researchers to choose areas of high priority for research and agencies to select proposals suitable for funding. Epidemiological surveys should also focus on the population groups at high risk of the disease such as pregnant women and under five-year-old children because published studies on these groups are very few.

On the other hand, there is a lack of studies on the knowledge, attitudes and practices (KAP) of local communities residing in malaria-

endemic areas where control efforts are being implemented. Consequently, a considerable ambiguity exists in the role of misconceptions and wrong behaviors in hindering the control and elimination efforts. This, in turn, ignores the positive contribution that local communities could play in the success of such efforts if these misconceptions and behaviors were studied and accordingly corrected. KAP studies to determine the role of concepts and behaviors in the epidemiology of the disease in different endemic areas of the country should be carried out. Awareness-raising campaigns articulated on the findings of these studies can then be launched to promote the effectiveness of control measures against malaria and other vector-borne diseases.

Although submicroscopic parasitemia represents a major reservoir of infection that contributes to malaria transmission and drug resistance spread, and that such masked or hidden human infectious reservoir is much greater than that detected by microscopy (3–5), research on the role of this hidden reservoir in the epidemiology of malaria and drug resistance is neglected. This could be attributed to the fact that malaria in Yemen is mostly detected by microscopy and rapid diagnostic tests. It is important to establish molecular facilities in malaria control units in certain sentinel sites to regularly detect and monitor the trends in the burden of submicroscopic reservoir of infection and its role in maintaining malaria transmission and drug resistance. Successful control and elimination depend largely on limiting the role played by the hidden submicroscopic reservoir of apparently asymptomatic individuals in malaria epidemiology and drug resistance. Searching main databases revealed no published studies in this concern in endemic areas in Yemen, highlighting an urgent need to assess the submicroscopic infectious reservoir in a way that could promote the ongoing elimination efforts. Epidemiologically, there is a need to map the distribution of submicroscopic infections in different endemic settings to enable the adoption of transmission-blocking strategies using gametocytocidal drugs such as primaquine.

Research priorities in vector control

Vector control should be highly prioritized in the research agenda of malaria in Yemen as this also reflects on the incidence of other vector-borne diseases. Despite the great efforts to combat malaria by targeting vector mosquitoes through the distribution of ITNs, the effectiveness of this approach is evaluated in a narrow limit. Therefore, it is essential to conduct evaluation studies in targeted populations before and after future campaigns to explore the effectiveness of these interventions and the possible factors interfering with their success. In addition, there is a necessity for mapping potential vector mosquitoes in different endemic settings of the country according to their vectorial competence because of the scarcity of studies in this respect. According to the World Malaria Report-2014 (1), three species of *Anopheles*; namely, *A. arabiensis*, *A. culicifacies*, and *A. sergenti*, are considered as the major vectors of malaria in Yemen. It is noteworthy that old versions of the same report also consider these as the major vectors. Therefore, the role of other species has to be evaluated because earlier reports documented the presence of other vectors, including *A. gambiae* (6). If the evidence on their role in malaria transmission is reached, the list of vector mosquitoes has to be updated and mapped.

Attention should be given to the involvement of information systems, such as geographic information system (GIS), in laying out a comprehensive map for the potential vectors. GIS-based entomological surveillance and vector habitat mapping will help guide control activities in giving priority to areas with vectors of greater potential to transmit malaria parasites and will convey control efforts from reactive to proactive actions. With the increasing use of insecticides in the control of malaria vectors, the effectiveness of insecticide-based interventions and vector resistance to different insecticides should be assessed. Maps of insecticide resistance in endemic areas are also needed.

Research priorities in the fields of treatment and drug resistance

Antimalarial drug resistance is one of the major obstacles that hamper malaria control efforts; however, studies published on drug resistance over the past two decades are very few in comparison to the magnitude of the problem. In addition, the majority of studies were clinical trials and did not undertake the form of epidemiological surveys. In light of the available studies and in line with the efforts of the NMCP, there is a need for a comprehensive re-assessment of clinical efficacy of the first-line (artesunate-sulfadoxine/pyrimethamine) and second-line (artemether-lumefantrine) antimalarial treatments. Investigating other drug combinations and regimens should be launched to counteract any possible failure of the currently used antimalarial drugs. Regular monitoring of molecular markers of resistance to antimalarial drugs in current use and their relation to the clinical resistance should be prioritized in certain sentinel sites representing different endemic areas, preferably on under five-year-old children to control over the variables of age and immunity. Mapping the distribution of molecular markers of resistance through conducting large-scale studies in different epidemiological strata and disposition of such data into web-based databases will contribute largely to guiding malaria research and control activities.

There is a need to launch a national drug resistance network if malaria elimination is to be achieved. Blood collection on filter paper as dried spots should be initiated even if not being examined. This will help make an archive of blood specimens over time that can be studied later and, therefore, help in studying the spatial and temporal trends in the emergence and spread of drug resistance-associated markers. There is also a lack of studies on the association of treatment-seeking behaviors and antimalarial drug use with the emergence and spread of drug resistance. This shortcoming should be addressed to counteract the role of bad behaviors and inappropriate treatment seeking and use on antimalarial drug resistance.

Although all research priorities might not be included in the present paper, this is only a snapshot of the most pressing areas of research on malaria in Yemen. Establishment of a malaria research unit, either independent or within a vector-borne disease research facility, would boost research on the points raised. This is preferably hosted by an academic institution with highly qualified personnel and well-equipped research facilities. Such a research unit could largely help seal the gap between malaria elimination efforts and the research activities needed to make the success of such efforts feasible. A significant initiative to address this pressing need is the establishment of the Tropical Disease Research Center (TDRC) by the University of Science and Technology (http://www.ust.edu/enj/tdrc). In line with its mission and vision, the TDRC research activities mainly focus on malaria in a way that could contribute to disease elimination from the country. In addition, the center plans to launch the National Drug Resistance Network as the first national platform that will contribute to research and mapping of antimicrobial drug resistance, including resistance to antimalarial drugs.

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Competing interests

The author declares that he has no competing interests associated with this article.

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