

[Close](#)**View Reviewer Comments for Manuscript****MALJ-D-20-00773****"Beyond national indicators: adapting the Demographic and Health Surveys' sampling strategies and questions to better inform subnational malaria intervention policy"**

Click the Reviewer recommendation term to view the Reviewer comments.

	Original Submission
(Reviewer 1)	Minor Revision
Hamzah Hasyim (Reviewer 2)	Minor Revision
Author	Response to Reviewers

[Close](#)

[Close](#)
MALJ-D-20-00773**"Beyond national indicators: adapting the Demographic and Health Surveys' sampling strategies and questions to better inform subnational malaria intervention policy"****Original Submission****(Reviewer 1)**

Reviewer Recommendation Term:		Minor Revision		
Transfer Authorization	Response			
If this submission is transferred to another publication, do we have your consent to include your identifying information?	Yes			
If this submission is transferred to another publication, do we have your consent to include your original review?	Yes			
Custom Review Question(s):	Response			
Level of interest Please indicate how interesting you found the manuscript:	An article of importance in its field			
Quality of written English Please indicate the quality of language in the manuscript:	Acceptable			
Declaration of competing interests Please complete a declaration of competing interests, considering the following questions: <ol style="list-style-type: none"> 1. Have you in the past five years received reimbursements, fees, funding, or salary from an organisation that may in any way gain or lose financially from the publication of this manuscript, either now or in the future? 2. Do you hold any stocks or shares in an organisation that may in any way gain or lose financially from the publication of this manuscript, either now or in the future? 3. Do you hold or are you currently applying for any patents relating to the content of the manuscript? 4. Have you received reimbursements, fees, funding, or salary from an organization that holds or has applied for patents relating to the content of the manuscript? 5. Do you have any other financial competing interests? 6. Do you have any non-financial competing interests in relation to this paper? 	I declare that I have no competing interests.			
If you can answer no to all of the above, write 'I declare that I have no competing interests' below. If your reply is yes to any, please give details below.				
Comments to Author:				
This is a well informed and clear opinion article about how to improve the utility and impact of DHS surveys and, in particular, the MIS sub-surveys to improve Malaria modeling. The paper reads well and is clearly and well written. There were a number of opportunities to inform potentially novice readers who are unfamiliar with the MIS/DHS, however, and about the context in which these surveys operate that may help to clarify some				

points in the article. Notably, while it is clear for anyone using the MIS/DHS surveys that they provide a lot of strengths, these strengths and structures are not well laid out. For example, on page 4 the authors make an immediate shift from discussing "state and provincial" policy efforts to discussing modeling in "Admin-1 and Admin-2" districts. I think the paper lacks a definition of Admin-2 districts: how are they created, what do they mean, and how different they can be from state to state. You might, for example, also note that some states prefer to make healthcare decisions at the Admin-2 level while others may make it at the Admin-1 level could be useful to note. This is implied in the manuscript, but never clearly stated so this should not require large shifts in the manuscript itself. Secondly, I think there is no clear statement of the influence of current data cleaning standards, and how those may or may not affect Admin-2 modeling. If, for example, jittering the geographic data results in attribution of some data from one Admin-2 district to another, it is possible that the modeling enterprise at the Admin-2 level may be at increased risk of bias because of random effects from jittering if those effects are not considered when data managers jitter the data. Other conclusions and suggestions provided seem reasonable.

[Close](#)

[Close](#)
MALJ-D-20-00773**"Beyond national indicators: adapting the Demographic and Health Surveys' sampling strategies and questions to better inform subnational malaria intervention policy"****Original Submission****Hamzah Hasyim (Reviewer 2)**

Reviewer Recommendation Term:		Minor Revision
Transfer Authorization	Response	
If this submission is transferred to another publication, do we have your consent to include your identifying information?	No	
If this submission is transferred to another publication, do we have your consent to include your original review?	No	
Custom Review Question(s):	Response	
Publons Reviewer Recognition. Springer Nature can send verification of this review directly to Publons (a subsidiary of Clarivate Analytics). If you would like to take advantage of this service, please click on the "Yes" option below. Your name, email address, title of the reviewed manuscript, name of the journal, and date of your review submission (the "Review Data") will then be transmitted to Publons after the final decision on the manuscript has been made. If you have already registered at Publons, they will notify you of the receipt of this review and update your profile as per your settings and their policy. If you are not registered with Publons, you will receive an email from them asking you to register in order for them to be able to recognize your review on your new profile page. Publons may use the Review Data to generate derivative metadata for the benefit of Publons and you as a reviewer, carefully considering the sensitivity of such information. For example, Publons may verify your record as a reviewer by updating your profile published on its webservice if you have registered for such service or help editors to identify candidate reviewers. Please find the details of processing in Publons' privacy policy https://publons.com/about/terms	Yes	
Level of interest Please indicate how interesting you found the manuscript:	An article whose findings are important to those with closely related research interests	
Quality of written English Please indicate the quality of language in the manuscript:	Needs some language corrections before being published	
Declaration of competing interests Please complete a declaration of competing interests, considering the following questions: 1. Have you in the past five years received reimbursements, fees, funding, or salary from an organisation that may in any way gain or lose financially from the publication of this manuscript, either now or in the future?	I declare that I have no competing interests.	

2. Do you hold any stocks or shares in an organisation that may in any way gain or lose financially from the publication of this manuscript, either now or in the future?
3. Do you hold or are you currently applying for any patents relating to the content of the manuscript?
4. Have you received reimbursements, fees, funding, or salary from an organization that holds or has applied for patents relating to the content of the manuscript?
5. Do you have any other financial competing interests?
6. Do you have any non-financial competing interests in relation to this paper?

If you can answer no to all of the above, write 'I declare that I have no competing interests' below. If your reply is yes to any, please give details below.

Comments to Editor:

Overall, this manuscript is professionally written and provides useful information to help better understand Adapting the Demographic and Health Surveys program to inform sub-national malaria intervention policy better in the area. However, before recommending for publication, a few comments that ought to be considered. The paper needs minor revisions to improve scientific validity and/or clarity.

Comments to Author:

Reviewer Comments to Author

Evaluations (peer review comments for the author)

1. In general, I gave rate the degree of "good" to which this paper is easy to follow and its logical flow
2. The title and abstract have covered the main aspects of the work?

Title

The title started with a catchy primary title, followed by a subtitle that provides data on the study's content and method. It is a short, easy to understand, and conveys the essential aspects of the research. Indicate the study's design with a commonly used term in the title or the abstract.

Consider adding the text: A cross-sectional study.

Beyond national indicators: Adapting the Demographic and Health Surveys program to inform the sub-national malaria intervention policy better: A cross-sectional study.

In medical research, social science and biology, a cross-sectional study is a type of observational study that analyzes data from a population, or a representative subset, at a specific point in time that is, cross-sectional data.

Use the following as a guide for writing a competitive abstract:

Background:

Provide a brief context for the research

Indicate why it is important

Hypothesis/Objective:

State the goal(s) of the research and the question(s) you are seeking to address with this research

Study Design and Research Methods:

Specifically state what study design was used in the research

If appropriate, state what population or group(s) were studied

Briefly describe the study procedures used to carry out the research

Indicate which measurement techniques were used in the research

Provide information on the analytic data technique(s) that were used

Results:

Briefly describe the main findings or results of your research

Conclusions:

Concisely state what the results mean and their impact on the field of research

3. It is essential to write the results novel, and the study provides an advance in the field to the Introduction or in the result section.

Many papers have shown that adopting the Demographic and Health Surveys (DHS) program will better inform the subnational malaria intervention policy. So, It is essential to write the results novel and the study provide

an advance in the field

4. The authors should have sure that the methods are clear and replicable. This study uses examples from the Nigeria DHS to highlight gaps in the current survey program design; however, it needs to write the methods clear and replicable. Due to this, it is not clear who the target population of this study is and the criteria they selected sample in the inclusion and exclusion criteria.

In epidemiological concepts, the source population is the population from which the study subjects are drawn. Further, the target population is the population to which it might be possible to extrapolate results from a study. Furthermore, the target population of a survey is the population authors wish to study. The sampled population is the population which authors can observe in a sample. The target population is theoretical; The sample population is practical, based on the frame you have access to or can construct. Besides, it is not clear additional questions and expansions to the DHS sampling strategy that would advance the data analyses and modelled estimates that inform national policy recommendations

Do authors have modified the questionnaire? If the survey changed by investigators, please explain how to test the new instrument/tools' validity and reliability test. So, the study results are valid for the source population, target population, and beyond.

5. The authors should have written that all the results presented to match the methods described, if relevant.

6. The authors should have written briefly that the statistical analysis is appropriate to the research question and study design, if relevant.

7. The authors should have written that selecting the controls appropriate for the study design have attempts been made to address potential bias through analytic methods, e.g., sensitivity analysis, if relevant.

8. The authors should have made the underlying data available to the readers

9. The authors should have written that the conclusions correlate to the results found

10. The authors should have made that the figures and tables are clear and legible

11. The authors should have made that the images clear and free from unnecessary modification

12. I have serious concerns about the validity of this manuscript. Seemingly this study has not Ethical clearance. It is better to write in the text concerning the serial number of ethical approvals that was obtained from the Research and Ethical Review Committee

Close

Author's Response To Reviewer Comments

[Close](#)

February 2, 2021
The Editor and Reviewers,
Malaria Journal.

Dear Editor and Reviewers:

Thank you once again for your time and effort in reviewing our opinion piece. We have revised the manuscript based on your comments and feedback.

Please see our response to your comments in the adjourning pages.
We hope this updated manuscript remains of interest to you and worthwhile for the consumers of the journal.

Regards,
Ifeoma D. Ozodiegwu DrPH MPH on behalf of all the coauthors.

Response to Reviewers

Reviewer 1

1. This is a well informed and clear opinion article about how to improve the utility and impact of DHS surveys and, in particular, the MIS sub-surveys to improve Malaria modeling. The paper reads well and is clearly and well written.

Response: We thank reviewer 1 for the time and efforts put into reviewing our piece

2. There were a number of opportunities to inform potentially novice readers who are unfamiliar with the MIS/DHS, however, and about the context in which these surveys operate that may help to clarify some points in the article. Notably, while it is clear for anyone using the MIS/DHS surveys that they provide a lot of strengths, these strengths and structures are not well laid out. For example, on page 4 the authors make an immediate shift from discussing "state and provincial" policy efforts to discussing modeling in "Admin-1 and Admin-2" districts

Response: We have included more information on the strengths and context of the DHS/MIS surveys in lines 82 – 105. It now reads as follows:

"Initiated in 1984, the DHS was originally designed to collect comparable population-based data on indicators of sexual and reproductive health, maternal and child health, and nutrition in low and middle-income countries (LMICs).⁹ As funding for malaria programs increased, it became necessary to continue to make the investment case for additional funding with local data, giving rise to the inclusion of a malaria module in the DHS in 1999 and the introduction of the MIS in 2006.¹⁰ National health strategic planning in LMICs only considered aggregated indicator estimates at the admin-1 level; as such, the sampling methodology of DHS and MIS were devised to capture health status, services and interventions at that level. The shift towards accounting for district-level health and intervention indicators within subnational malaria strategies calls for refreshing the DHS and MIS sampling strategy and questionnaires to meet the needs of national programs.

In their current form, both the DHS and MIS have many strengths that support health decision making. The DHS and MIS capture a wide range of health indicators allowing comprehensive assessment of a country's health situation. As part of their multistage design, survey participants are selected from clusters and households within a fully covered geographic sampling frame, offering researchers the opportunity to examine how ecological and individual-level factors relate to the distribution of health outcomes. Moreover, survey questionnaires are standardized to enhance the comparability of indicators across populations and time. In malaria specific programs and research, analyses by NMCPs and the research community generate insight into spatial and temporal differences in malaria indicators, which allow data-driven prioritization of intervention deployment and serve as parameters for mathematical models. This makes the DHS and MIS an important resource for NMCPs and the global health community."

3. I think the paper lacks a definition of Admin-2 districts: how are they created, what do they mean, and how different they can be from state to state. You might, for example, also note that some states prefer to make healthcare decisions at the Admin-2 level while others may make it at the Admin-1 level could be useful to note. This is implied in the manuscript, but never clearly stated so this should not require large shifts in the manuscript itself.

Response: We have included a definition/description of admin 2 in lines 62 – 67. It is rare that healthcare decisions are made at the admin-2 level so we did not note this. In Nigeria, which we use as an example, healthcare decisions are usually made at the admin-1 level with some input from local government focal persons at the state ministry of health. But admin-2 units typically do not have much autonomy with regards to healthcare decisions. Lines 62 – 67 reads as follows:

"Malaria endemic countries are typically federations comprised of varying numbers of admin-2 units or districts located within a first administrative level (admin-1, also called states or provinces). While the seat of subnational government is usually at the admin-1 level, admin-2 units are officially delineated geographical areas with some form of self-government to decentralize the running of local affairs."

4. Secondly, I think there is no clear statement of the influence of current data cleaning standards, and how those may or may not affect Admin-2 modeling. If, for example, jittering the geographic data results in attribution of some data from one Admin-2 district to another, it is possible that the modeling enterprise at the Admin-2 level may be at increased risk of bias because of random effects from jittering if those effects are not considered when data managers jitter the data. Other conclusions and suggestions provided seem reasonable.

Response: We have added more information on the impact of data collection and cleaning standards on admin-2 modeling predictions in lines 130 – 140. It reads as follows:

"Using the DHS to parameterize fine scale models introduces additional sources of uncertainty. To help NMCPs stratify and plan operations, models must capture data at admin-2. However, estimates of malaria prevalence and intervention coverage from the DHS are only meant to be representative at a state or provincial (admin-1) level (Figure 1 and 2) and are underpowered to measure these indicators at the admin-2 level. Modeling predictions based on parameters from DHS household cluster data would therefore be biased. Moreover, data collection and cleaning standards for georeferenced DHS data also increase the risk of biased admin-2 projections. Sampling errors while using GPS receivers to georeference cluster locations could lead to attribution of admin-2 data from one to another. Additionally, the displacement of cluster locations to protect participants' confidentiality¹¹ and any resultant random effects from data jittering would further exacerbate the problem of misclassifying admin-2 data."

Reviewer 2

1. In general, I gave rate the degree of "good" to which this paper is easy to follow and its logical flow
2. The title and abstract have covered the main aspects of the work?

Title

The title started with a catchy primary title, followed by a subtitle that provides data on the study's content and method. It is a short, easy to understand, and conveys the essential aspects of the research. Indicate the study's design with a commonly used term in the title or the abstract.

Consider adding the text: A cross-sectional study.

Beyond national indicators: Adapting the Demographic and Health Surveys program to inform the sub-national malaria intervention policy better: A cross-sectional study.

In medical research, social science and biology, a cross-sectional study is a type of observational study that analyzes data from a population, or a representative subset, at a specific point in time that is, cross-sectional data.

Use the following as a guide for writing a competitive abstract:

Background:

Provide a brief context for the research

Indicate why it is important

Hypothesis/Objective:

State the goal(s) of the research and the question(s) you are seeking to address with this research

Study Design and Research Methods:

Specifically state what study design was used in the research

If appropriate, state what population or group(s) were studied

Briefly describe the study procedures used to carry out the research

Indicate which measurement techniques were used in the research

Provide information on the analytic data technique(s) that were used

Results:

Briefly describe the main findings or results of your research

Conclusions:

Concisely state what the results mean and their impact on the field of research

3. It is essential to write the results novel, and the study provides an advance in the field to the Introduction or in the result section.

Many papers have shown that adopting the Demographic and Health Surveys (DHS) program will better inform the subnational malaria intervention policy. So, It is essential to write the results novel and the study provide an advance in the field

4. The authors should have sure that the methods are clear and replicable. This study uses examples from the Nigeria DHS to highlight gaps in the current survey program design; however, it needs to write the methods clear and replicable. Due to this, it is not clear who the target population of this study is and the criteria they selected sample in the inclusion and exclusion criteria.

In epidemiological concepts, the source population is the population from which the study subjects are drawn. Further, the target population is the population to which it might be possible to extrapolate results from a study. Furthermore, the target population of a survey is the population authors wish to study. The sampled population is the population which authors can observe in a sample. The target population is theoretical; The sample population is practical, based on the frame you have access to or can construct. Besides, it is not clear additional questions and expansions to the DHS sampling strategy that would advance the data analyses and modelled estimates that inform national policy recommendations

Do authors have modified the questionnaire? If the survey changed by investigators, please explain how to test the new instrument/tools' validity and reliability test. So, the study results are valid for the source population, target population, and beyond.

5. The authors should have written that all the results presented to match the methods described, if relevant.

6. The authors should have written briefly that the statistical analysis is appropriate to the research question and study design, if relevant.

7. The authors should have written that selecting the controls appropriate for the study design have attempts been made to address potential bias through analytic methods, e.g., sensitivity analysis, if relevant.

8. The authors should have made the underlying data available to the readers

9. The authors should have written that the conclusions correlate to the results found

10. The authors should have made that the figures and tables are clear and legible

11. The authors should have made that the images clear and free from unnecessary modification

12. I have serious concerns about the validity of this manuscript. Seemingly this study has not Ethical clearance. It is better to write in the text concerning the serial number of ethical approvals that was obtained from the Research and Ethical Review Committee

Response: We want to thank reviewer two for taking the time to edit and comment on our manuscript. We have made adjustments to long sentences to make it easier to read (see tracked changes in manuscript).

With respect to the comments on manuscript structure, since this is an opinion piece rather than a research article, we followed the guidelines for opinions to be published in the Malaria Journal as described here >>
<https://malariajournal.biomedcentral.com/submission-guidelines/preparing-your-manuscript/opinion>

Close

OPINION

Open Access



Beyond national indicators: adapting the Demographic and Health Surveys' sampling strategies and questions to better inform subnational malaria intervention policy

Ifeoma D. Ozodiegwu^{1*} , Monique Ambrose², Katherine E. Battle², Caitlin Bever², Ousmane Diallo¹, Beatriz Galatas³, Manuela Runge¹ and Jaline Gerardin¹

Abstract

In malaria-endemic countries, prioritizing intervention deployment to areas that need the most attention is crucial to ensure continued progress. Global and national policy makers increasingly rely on epidemiological data and mathematical modelling to help optimize health decisions at the sub-national level. The Demographic and Health Surveys (DHS) Program is a critical data source for understanding subnational malaria prevalence and intervention coverage, which are used for parameterizing country-specific models of malaria transmission. However, data to estimate indicators at finer resolutions are limited, and surveys questions have a narrow scope. Examples from the Nigeria DHS are used to highlight gaps in the current survey design. Proposals are then made for additional questions and expansions to the DHS and Malaria Indicator Survey sampling strategy that would advance the data analyses and modelled estimates that inform national policy recommendations. Collaboration between the DHS Program, national malaria control programmes, the malaria modelling community, and funders is needed to address the highlighted data challenges.

Background

The growing spatial and temporal variability in malaria risk [1–3], increasing diversity in malaria control tools [4], and limited funding availability is precipitating the need for malaria-endemic countries to adopt intervention policies that move away from a one-size-fits-all approach to one that is specifically tailored to their subnational context. The Global Technical Strategy for malaria (GTS) recommends that targeted strategies be country-led [5]. The High Burden to High Impact (HBHI) initiative further describes how each country can drive its strategy with its own data, including routine health facility

reporting, national household surveys, and post-campaign assessments that collect information on current gaps in intervention coverage [6]. Mathematical modelling can be used to integrate these data sources together to predict the impact of possible subnational intervention strategies and explore whether achieving a strategic malaria target is feasible.

Many National Malaria Control Programmes (NMCPs) are now choosing to target interventions at the district level (second administrative level, admin-2), given that this is an operationally feasible unit at which intra-provincial heterogeneity is captured. Malaria endemic countries are typically federations comprised of varying numbers of admin-2 units or districts located within a first administrative level (admin-1, also called states or provinces). While the seat of subnational government is usually at the admin-1 level, admin-2 units are officially

*Correspondence: ifeoma.ozodiegwu@northwestern.edu

¹ Department of Preventive Medicine and Institute for Global Health, Northwestern University, Chicago, IL, USA

Full list of author information is available at the end of the article



© The Author(s) 2021. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

delineated geographical areas with some form of self-government to decentralize the running of local affairs. Monthly reports from health facilities provide routine surveillance data that can be aggregated up to admin-2 units. Routine data is used to identify malaria trends and needs at the local level [7, 8], as recommended by the GTS.

Challenges with data quality and completeness as well as lack of sufficient historical data and delayed reporting hinder the use of routine data to form a rigorous understanding of the country's malaria past and present situation and intervention needs. Because these datasets only include individuals who seek treatment at reporting health facilities, they provide no insight into individuals who live in less-accessible areas or who seek treatment from private and informal health care sectors. The incomplete view of malaria incidence and treatment provided by routine reporting can result in biased estimates of population burden and access to care.

National surveys, such as the Demographic and Health Surveys (DHS) and the Malaria Indicator Surveys (MIS), supplement routine surveillance by providing representative estimates of malaria prevalence and intervention coverage. Initiated in 1984, the DHS was originally designed to collect comparable population-based data on indicators of sexual and reproductive health, maternal and child health, and nutrition in low and middle-income countries (LMICs) [9]. As funding for malaria programmes increased, it became necessary to continue to make the investment case for additional funding with local data, giving rise to the inclusion of a malaria module in the DHS in 1999 and the introduction of the MIS in 2006 [10]. National health strategic planning in LMICs only considered aggregated indicator estimates at the admin-1 level; as such, the sampling methodology of DHS and MIS were devised to capture health status, services and interventions at that level. The shift towards accounting for district-level health and intervention indicators within subnational malaria strategies calls for refreshing the DHS and MIS sampling strategy and questionnaires to meet the needs of national programmes.

In their current form, both the DHS and MIS have many strengths that support health decision making. The DHS and MIS capture a wide range of health indicators allowing comprehensive assessment of a country's health situation. As part of their multistage design, survey participants are selected from clusters and households within a fully covered geographic sampling frame, offering researchers the opportunity to examine how ecological and individual-level factors relate to the distribution of health outcomes. Moreover, survey questionnaires are standardized to enhance the comparability of indicators across populations and time. In malaria specific programs

and research, analyses by NMCPs and the research community generate insight into spatial and temporal differences in malaria indicators, which allow data-driven prioritization of intervention deployment and serve as parameters for mathematical models. This makes the DHS and MIS an important resource for NMCPs and the global health community.

Given the limitations of routine surveillance, NMCPs and modellers use the DHS to understand the subnational malaria context. NMCPs increasingly consider outputs of mathematical models when planning subnational malaria strategy, including making decisions about expansion of chemoprevention and choosing from a set of vector control strategies. To address related questions, epidemiological models must capture historical trends in transmission, current patterns of exposure, and intervention coverage for each subnational area. This piece highlights how DHS and MIS data are utilized by mathematical models and suggest improvements that would enhance both modelling and data analysis efforts from NMCPs to facilitate informed decision-making. For the sake of brevity, the term "DHS" is used to encompass both DHS and MIS surveys.

DHS data is useful for national policy-making but parameterizing subnational malaria transmission models is challenging

Models of malaria transmission used for national strategic planning are informed by household survey data on intervention coverage, transmission intensity, and malaria burden. To set subnational intervention coverages, models rely on DHS measures of treatment-seeking rates for febrile illness among children under five, insecticide-treated nets (ITN) usage at the household level and for different age groups, and coverage of intermittent preventive treatment in pregnancy (IPTp). Modelled transmission intensity can then be calibrated to capture DHS measures of the *Plasmodium falciparum* parasite rate in children under the age of five ($PfPR_{0-5}$).

Using the DHS to parameterize fine scale models introduces additional sources of uncertainty. To help NMCPs stratify and plan operations, models must capture data at admin-2. However, estimates of malaria prevalence and intervention coverage from the DHS are only meant to be representative at a state or provincial (admin-1) level (Figs. 1, 2) and are underpowered to measure these indicators at the admin-2 level. Modelling predictions based on parameters from DHS household cluster data would, therefore, be biased. Moreover, data collection and cleaning standards for georeferenced DHS data also increase the risk of biased admin-2 projections. Sampling errors while using GPS receivers to georeference cluster locations could lead to attribution of admin-2 data from one

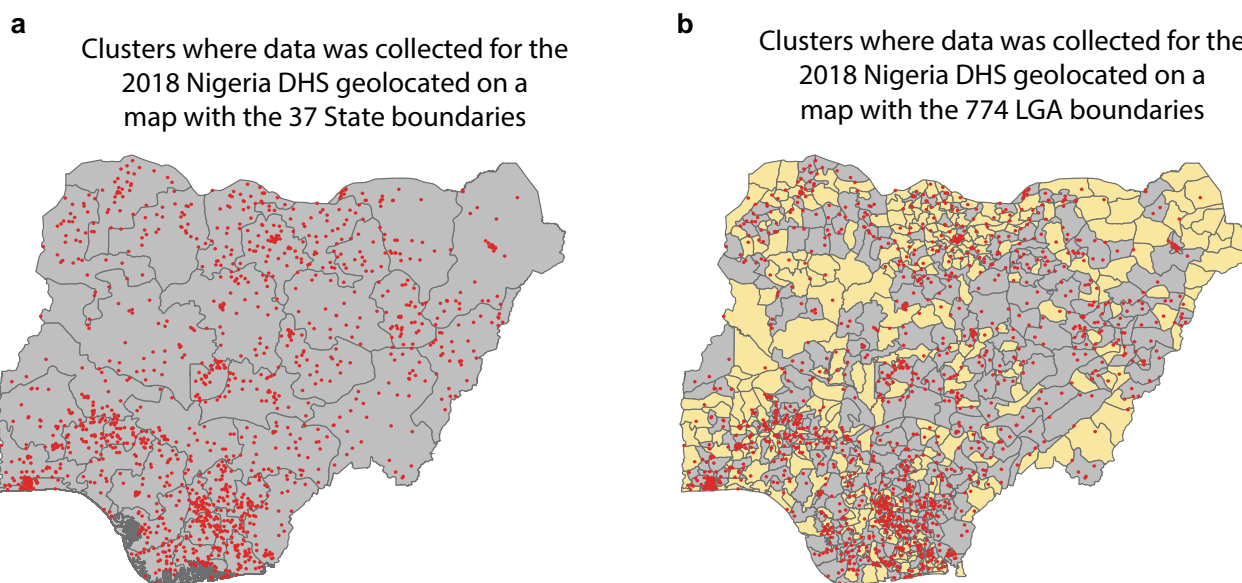


Fig. 1 **a** State-level (admin-1) map of Nigeria with red dots representing clusters where DHS data collection was conducted in 2018. The number of clusters in state boundaries range from 20 to 54 with a median of 36. **b** Local government area (LGA)-level (admin-2) map of Nigeria with red dots representing clusters where DHS data collection was conducted in 2018. LGAs colored in yellow are areas where estimation of malaria indicators will be challenging because they contain zero or one cluster. Number of clusters within LGA boundaries ranged from zero to 11 with a median of two. 103 LGAs had no clusters

to another. Additionally, the displacement of cluster locations to protect participants' confidentiality [11] and any resultant random effects from data jittering would further exacerbate the problem of misclassifying admin-2 data.

Malaria indicators captured by the DHS are subject to seasonal variations in malaria transmission and human behaviour, which limit understanding of malaria transmission intensity, ITN use, and comparability of yearly surveys. Parasite rate is typically at its maximum during the rainy or peak mosquito-biting season and trends downwards in the dry season. Individuals use ITNs during the wetter months and reduce usage in the dryer months when mosquito activity is diminished [12]. Treatment-seeking behaviour can be affected by seasonal accessibility issues and seasonal demands on parents' time, for example, agricultural needs during the wet season. Therefore, malaria indicators from DHS surveys conducted during the dry season months do not necessarily capture parasite rate, ITN use, and case management coverage in the peak transmission season. Surveys conducted in different seasons, even within the same DHS year, are not directly comparable without adjustment for the seasonality effect. NMCPs and modellers resort to other data sources with a narrower geographic scale to capture seasonal and temporal changes in malaria transmission and accurately identify gaps in intervention coverage and areas of high prevalence.

The restriction of current questions to select age groups limit how informative the results are for driving country strategy and parameterizing models. For example, the DHS only tests children under the age of five for malaria infection, which, although important, is of limited utility for categorizing malaria transmission intensity in settings where more of the burden is in older children or adults. $PfPR_{0-5}$ measured during implementation of seasonal malaria chemoprevention (SMC) may be particularly uninformative as $PfPR$ is suppressed in this population and SMC coverage is not assessed in the DHS. Measurements of $PfPR$ in older children can be more informative than $PfPR_{0-5}$ even in high-transmission areas, as children above age two will have some immunity to clinical malaria, and hence less treatment with anti-malarials, yet limited immunity to parasitaemia itself [13]. Some models, therefore, apply standardization algorithms to convert $PfPR_{0-5}$ to $PfPR_{2-10}$ [14]. While such algorithms have been validated in prior work [13], the extent of bias introduced by predicted $PfPR_{2-10}$, especially in fine-scale models, is unknown.

A similar issue arises with using the DHS data to evaluate case management and treatment coverage for uncomplicated malaria, where questions are restricted to children under the age of five. NMCPs, therefore, know little about access to malaria treatment in older children, where burden is increasingly shifting [15]. In the absence of case management information for uncomplicated

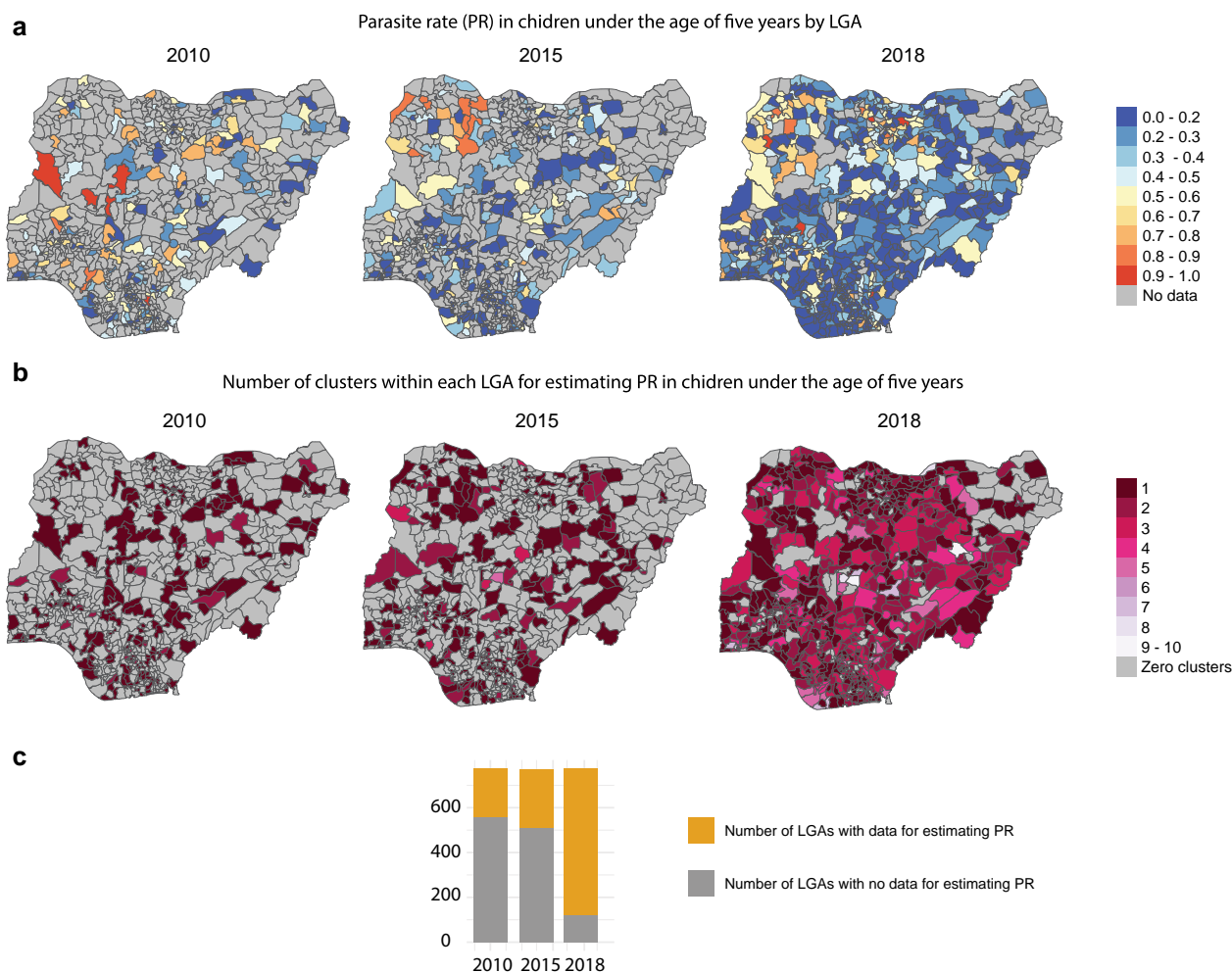


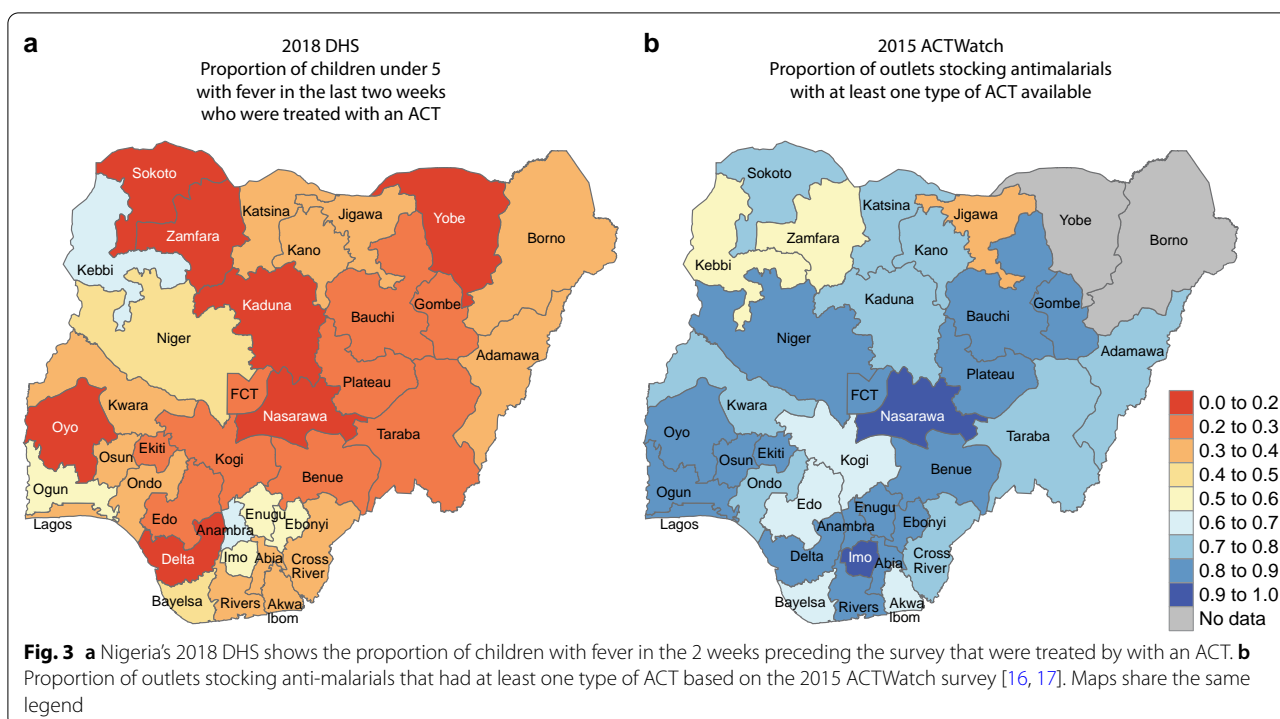
Fig. 2 **a** $PfPR_{0-5}$ according to 2010, 2015, and 2018 Nigeria DHS. The LGA prevalence values depicted are not representative for the population per LGA, as DHS is not powered at the LGA level. **b** Number of clusters located within each LGA boundary used to estimate $PfPR_{0-5}$ in each DHS year. Many LGAs contain zero DHS clusters, although geographic coverage improved substantially in the most recent DHS. **c** Number of LGAs with and without PR data. LGAs without data were 558 in 2010, 510 in 2015 and 121 in 2018, out of 774 total LGAs

malaria in older children and adults, modellers either assume homogeneous coverage by age or turn to site-specific research studies on treatment-seeking behaviour.

Estimating case management rates from DHS data requires analysing questions directed at a subset of DHS participants, which reduces the sample size and may introduce validity issues and inconsistencies. In the 2018 Nigeria DHS, effective case management coverage, that is the proportion of children under the age of five that received artemisinin-based combination therapy (ACT) among those that had a fever within the 2 weeks prior to the survey, was 22% at the national level. Disaggregated at the state level, ACT-related case management was remarkably low in many areas. For example, the 2018 DHS suggests that febrile children were not treated at all

with ACT in Nasarawa, and only about 3 to 4% in Zamfara and Yobe (Fig. 3a).

When these estimates were discussed with the Nigerian National Malaria Elimination Programme, they indicated that the actual ACT use would likely be higher than that seen in the 2018 DHS, and the state level DHS estimates would not agree with their perceived ACT use in many parts of the country. The 2015 ACTWatch survey [16, 17] supports this view, which indicated that most outlets stocking any anti-malarials in individual states had at least one type of ACT medicine for sale (Fig. 3b). While the metrics are clearly different, the ACTWatch data suggests intense penetration of ACT across both the public and private health care sectors in Nigeria, and, together with the Nigerian programme perspective,



calls into question the 2018 DHS results that suggested extremely low rates of artemisinin-based combination therapy in some areas of Nigeria. This discrepancy of trends between access (ACTWatch) and use (DHS) metrics emphasizes the limitations of the current DHS sampling strategy to capture case management coverage among febrile children, who are few in number, and the need for a strengthened DHS data collection system that builds trust and meets NMCP needs.

The gaps that we have identified within the DHS sampling strategy and questionnaires do not diminish the immense contribution of the DHS Program to evidence-based decision-making. However, when DHS measures do not adequately capture malaria indicators, or DHS data are out of concordance with institutional knowledge and beliefs of intervention and treatment access and malaria risk behaviour, deciding where to target interventions becomes more challenging and a data-driven approach nearly impossible.

Recommendations

Having outlined the major barriers to using the DHS for evidence-based subnational malaria strategic planning, we propose changes to the DHS surveys and sampling strategy to improve understanding of the malaria context at the relevant spatial scale of programmatic decision-making and drive more accurate predictions of the impact of targeted interventions.

- 1. Time DHS surveys to capture malaria indicators during the high-transmission season.** Carefully timing the DHS survey to coincide with the high malaria transmission season and collecting data at the same time every year would improve estimation of malaria indicators, and comparability of yearly surveys, even at finer scales. Effective timing provides understanding of transmission intensity and intervention coverage at its peak periods and implies that a smaller sample size would be needed to accurately estimate malaria indicators. Hence, if the DHS retains a similar sampling strategy but conducts surveys only in the wetter months, malaria indicators will be more precisely estimated at both admin-1 and admin-2-level, and NMCPs can more reliably track indicator trends. Suppose accessibility issues preclude peak-season surveys in some districts, a hybrid approach where isolated districts are surveyed at a different time of year may be necessary.
- 2. Support malaria-endemic countries to conduct admin-2-level and/or monthly surveys.** We hope to see the DHS support malaria-endemic countries in conducting more frequent and granular surveys at the admin-2 level. Increasing the spatial resolution of the survey to the admin-2 level will enhance the precision of survey estimates, and if these admin-2 surveys are done monthly, it would lead to excellent understanding of seasonal and temporal changes in

parasite rate and intervention coverage. At the outset, priority could be given to districts in high-transmission areas where intervention targeting will be most beneficial, or surveys could be conducted only during high-transmission months. The survey's frequency and scale could be reduced if low spatial and temporal heterogeneity in malaria indicators are detected within neighboring districts. While we acknowledge that this comes with higher survey implementation costs for the DHS, this will vary for individual countries depending on several factors including coverage of the existing DHS survey, the number of admin-2 areas, and the target population sizes. The extra implementation costs will be relatively lower for some countries and possibly unfeasibly high in others. However, the potential savings from allocating resources to the most-at-risk population and thereby additional lives saved could serve as a justification for increased funding for the DHS to pursue a broader sampling strategy.

3. **Extend blood smear or rapid diagnostic testing (RDTs) to children up to the age of 10 years.** As prevalence in the youngest children declines, testing of older children will be more informative for assessing malaria transmission intensity. In lower-transmission areas, collection of prevalence in adults will become necessary to identify remaining areas of sustained transmission for intervention targeting. Deprioritizing blood smears in favour of RDTs can help mitigate some of the added expense.
4. **Adapt the DHS sampling strategy and survey questions to better capture data that inform estimation of treatment coverage.** To obtain an improved estimate of treatment modalities, we recommend the DHS oversample children in selected high transmission settings where case management with ACT is particularly crucial to prevent death. The current DHS sampling approach may not provide accurate estimates of artemisinin-based combination therapy rates for malarial fevers, which lessens its utility in intervention planning. If recommendation #1 is adopted, the additional sample would not be substantial since the sampling frame for febrile children will be significantly enhanced. Qualitative research is needed to better understand how to word questions around care-seeking and access to effective treatment, as this could be a limiting factor in the accuracy of participant responses, and understanding where the cascade of care falls apart is necessary for identifying solutions to low treatment rates. Questions on case management urgently need to be extended to older children and adults so that policy makers understand how symptoms and treatment

dynamics vary by age, time, and transmission intensity in their country.

5. **Add questions to the DHS to capture data on SMC coverage.** In many areas with highly seasonal malaria transmission, SMC is a crucial intervention to reduce malaria incidence and mortality during the high-transmission season. DHS surveys implemented during peak transmission months would be well-positioned to measure SMC coverage, which is often challenging for NMCPs to calculate from doses distributed due to uncertain population denominators. Measuring SMC coverage will enable NMCPs to better assess implementation quality and to identify gaps and will allow models to generate more accurate predictions of the impact of SMC expansion or changes in scheduling.
6. **Leverage the Service Provision Assessment (SPA) surveys to monitor malaria incidence and case management, even if at an aggregate level.** The SPA surveys, which are part of the DHS portfolio of surveys, provide country-specific overviews of health service delivery. SPA surveys can be leveraged to obtain a snapshot of reported malaria incidence, severity, and case management modalities at the time of the DHS community surveys. This information can be very powerful: NMCPs can contextualize effective treatment results from the survey, and modellers can triangulate data from both surveys to capture and explain transmission dynamics.
7. **Make the DHS dynamic and flexible to adapt to a changing intervention landscape.** The landscape of malaria interventions is heterogeneous and can change with new strategic plans and pilots of intervention deployments. DHS design should be cognizant of local interventions. In areas where new interventions are introduced, survey questions related to the interventions can be asked only in those administrative units. Likewise, if interventions are discontinued in a particular locality, survey questions can be modified in response.

Conclusion

The DHS is already an invaluable tool for informing malaria intervention strategies and could be an even greater asset for subnational planning if the changes we propose are made to augment the existing DHS platform. We call for a dialogue between the DHS Program experts, NMCPs, the malaria modelling community and funders to discuss existing data challenges and design a practical path for overcoming them. As countries move toward geographically tailored national strategies, the need for high-quality information is paramount. The experience

and technical expertise of the DHS Program is essential to meet this need.

Acknowledgements

Not applicable

Authors' contributions

IDO and JG conceptualized the opinion piece. IDO wrote the first draft of the piece. JG, MA, KB, CB, OD, BG and MR edited and revised manuscript drafts. All authors read and approved the final manuscript.

Funding

IDO, OD, MR, and JG were supported by a grant from the Bill and Melinda Gates Foundation (INV-002092). MA, KB, and CB were supported by the Bill & Melinda Gates Foundation, including analysis performed by the Institute for Disease Modeling at the Bill & Melinda Gates Foundation.

Availability of data and materials

All data used in this work are publicly available. DHS is available for download from <https://dhsprogram.com/>. ACTwatch data is available for download from <https://malariaatlas.org/actwatch/>.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interest.

Author details

¹ Department of Preventive Medicine and Institute for Global Health, Northwestern University, Chicago, IL, USA. ² Institute for Disease Modeling, Seattle, WA, USA. ³ Global Malaria Programme, World Health Organization, Geneva, Switzerland.

Received: 21 December 2020 Accepted: 11 February 2021

Published online: 1 March 2021

References

- Snow RW, Sartorius B, Kyalo D, Maina J, Amratia P, Mundia CW, et al. The prevalence of *Plasmodium falciparum* in sub-Saharan Africa since 1900. *Nature*. 2017;550:515–8.
- Onwumele A. An assesment of the spatial pattern of malaria infection in Nigeria. *Int J Med Med Sci*. 2014;6:80–6.
- Mmbando BP, Kamugisha ML, Lusingu JP, Francis F, Ishengoma DS, Theander TG, et al. Spatial variation and socio-economic determinants of *Plasmodium falciparum* infection in northeastern Tanzania. *Malar J*. 2011;10:145.
- WHO. Guidelines for Malaria Vector Control. Geneva, World Health Organization. 2019. <https://apps.who.int/iris/bitstream/handle/10665/310862/9789241550499-eng.pdf?ua=1>.
- WHO. Global technical strategy for malaria 2016–2030. Geneva, World Health Organization. 2015. https://apps.who.int/iris/bitstream/handle/10665/176712/9789241564991_eng.pdf?sequence=1.
- WHO, RBM Partnership to End Malaria. High burden to high impact: a targeted malaria response. Geneva, World Health Organization, 2018. <https://www.who.int/malaria/publications/atoz/high-impact-response/en/> Accessed 11 March 2020.
- Nguyen M, Howes RE, Lucas TCD, Battle KE, Cameron E, Gibson HS, et al. Mapping malaria seasonality in Madagascar using health facility data. *BMC Med*. 2020;18:26.
- Alegana VA, Okiro EA, Snow RW. Routine data for malaria morbidity estimation in Africa: challenges and prospects. *BMC Med*. 2020;18:121.
- Short Fabric M, Choi Y, Bird S. A systematic review of Demographic and Health Surveys: data availability and utilization for research. *Bull World Health Organ*. 2012;90:604–12.
- WHO. World Malaria Report 2020: 20 years of global progress and challenges. Geneva, World Health Organization, 2020. <https://www.who.int/publications/i/item/9789240015791> Accessed 16 Dec 2020).
- Perez-Haydrich C, Warren JL, Burgert CR, Emch ME. Guidelines on the use of DHS GPS data. DHS Spat. Anal. Reports No. 8. Calverton, Maryland, USA: ICF International; 2013. <http://dhsprogram.com/pubs/pdf/SAR8/SAR8.pdf>
- Koenker H, Taylor C, Burgert-Brucker CR, Thwing J, Fish T, Kilian A. Quantifying seasonal variation in insecticide-treated net use among those with access. *Am J Trop Med Hyg*. 2019;101:371–82.
- Smith DL, Guerra CA, Snow RW, Hay SI. Standardizing estimates of the *Plasmodium falciparum* parasite rate. *Malar J*. 2007;6:131.
- Runge M, Snow RW, Molteni F, Thawer S, Mohamed A, Mandike R, et al. Simulating the council-specific impact of anti-malaria interventions: a tool to support malaria strategic planning in Tanzania. *PLoS ONE*. 2020;15:e0228469.
- Steinhardt L, Abubakar A, Uhomobhi P, Maire M, Greby S, Ndodo N, et al. National estimates of malaria infection in older children and adolescents in Nigeria reveal highest prevalence in 5–9-year-olds. Poster session presented at: 69th Annual Meeting; 2020 Nov 15–19; Virtual Meeting.; 2020. <https://cattendee.abstractsonline.com/meeting/9181/Presentation/3108>
- Shewchuk T, O'Connell KA, Goodman C, Hanson K, Chapman S, Chavasse D. The ACTwatch project: methods to describe anti-malarial markets in seven countries. *Malar J*. 2011;10:325.
- Littrell M, Sudoi R, Archer J, Ngigi J, Ujuju C, Mpanya G, et al. Antimalarial market composition and performance in Nigeria and the Democratic Republic of Congo: results from 2013 ACTwatch outlet surveys. *Malar J*. 2014;13:P57.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year











At BMC, research is always in progress.

Learn more biomedcentral.com/submissions



← Completed Reviewer Assignments

Page: 1 of 1 (4 total assignments)

Action  	My Reviewer Number 	Manuscript Number 	Article Type 	Article Title 	Final Disposition 	Date Reviewer Invited 	Date Reviewer Agreed 	Date Review Due 
View Reviewer Comments View Attachments Send E-mail	1	MALJ-D-21-00646	Research	Impact of the COVID-19 pandemic on malaria cases in health facilities in northern Ghana: a retrospective analysis of routine surveillance data	Accept	29 Dec 2021	05 Jan 2022	26 Jan 2022
Author Response View Reviewer Comments View Attachments Send E-mail	1	MALJ-D-21-00405R1	Research	The use of respondent - driven sampling to assess febrile illness treatment - seeking behaviours among forest-goers in Cambodia and Vietnam	Accept	02 Nov 2021	03 Nov 2021	10 Nov 2021
View Reviewer Comments View Attachments Send E-mail	1	MALJ-D-21-00405	Research	The use of respondent - driven sampling to assess febrile illness treatment - seeking behaviours among forest-goers in Cambodia and Vietnam	Accept	27 Jul 2021	27 Jul 2021	17 Aug 2021
View Reviewer Comments View Attachments Send E-mail	2	MALJ-D-20-00773	Opinion	Beyond national indicators: adapting the Demographic and Health Surveys' sampling strategies and questions to better inform subnational malaria intervention policy	Accept	29 Dec 2020	07 Jan 2021	28 Jan 2021

Page: 1 of 1 (4 total assignments)