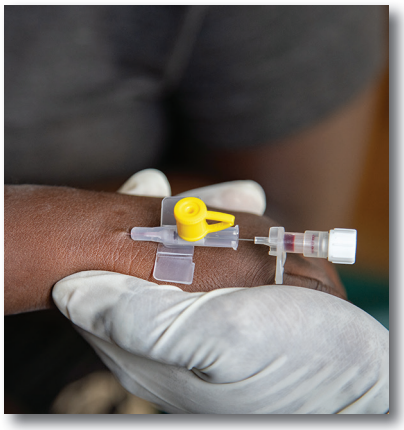
USAID
FROM THE AMERICAN PEOPLE

Review of Health Facility Referrals for Severe Malaria in DHS Program Surveys



DHS OCCASIONAL PAPER NO. 14

AUGUST 2021

This publication was produced for review by the United States Agency for International Development (USAID).
The report was prepared by Cameron Taylor, Joanna Lowell, and Erica Nybro.

DHS Occasional Paper No. 14

Review of health facility referrals for severe malaria in DHS Program Surveys

Cameron Taylor
Joanna Lowell
Erica Nybro

ICF
Rockville, Maryland, USA

Vysnova Partners
Landover, Maryland, USA

Johns Hopkins Center for Communication Programs
Baltimore, Maryland, USA

August 2021

Corresponding author: Cameron Taylor, ICF, 530 Gaither Road, Suite 500, Rockville, MD 20850, USA; telephone: +1 301-407-6500; fax: +1 301-407-6501; email: Cameron.Taylor@icf.com

Acknowledgment: We are grateful to Gbaike Ajayi, Peter Aka, Yodit Bekele, Jean de Dieu Bizimana, Joy Fishel, Shonda Gaylord, Livia Montana, Hamdy Moussa, Sorrel Namaste, Rachel Orlowski, Anjushree Pradhan, Gulnara Semenov, Jeremy Taglieri, and Natalia Wooley who were part of an internal consultative meeting to provide feedback on our initial draft of the paper.

The recommendations expressed herein are those of the authors and do not necessarily represent the views of above-named staff nor of USAID.

Cover Photos: Mwangi Kirubi PMI Impact Malaria

Editors: Cathy Johnson

Document Production: Chris Gramer

This study was carried out with support provided by the United States Agency for International Development (USAID) through The DHS Program (#AID-OAA-C-13-00095). The views expressed are those of the authors and do not necessarily reflect the views of USAID or the United States Government.

The DHS Program assists countries worldwide in the collection and use of data to monitor and evaluate population, health, and nutrition programs. For additional information about the DHS Program contact: DHS Program, ICF, 530 Gaither Road, Suite 500, Rockville, MD 20850, USA. Phone: +1 301-407-6500; Fax: +1 301-407-6501; Email: reports@dhsprogram.com; Internet: www.dhsprogram.com.

Recommended citation:

Taylor, Cameron, Joanna Lowell, and Erica Nybro. 2021. *Review of health facility referrals for severe malaria in DHS Program Surveys*. DHS Occasional Paper No. 14. Rockville, Maryland, USA: ICF.

CONTENTS

TABLES AND FIGURES

ABSTRACT

This paper examines the severe malaria referral process for 188,686 children tested for malaria and anemia in 37 surveys across 19 countries in sub-Saharan Africa collected between 2011 and 2018. We first reviewed the proportion and patterns of children who are referred to a health facility as part of the standard severe malaria referral process, and then considered how these referral patterns would differ under various referral protocols. Across all 37 surveys, 26% of children were positive for malaria by rapid diagnostic test (RDT). Among the children who tested positive, 24% were referred for possible severe malaria based on the standard DHS referral protocol (any of the standard six severe malaria symptoms or hemoglobin <8g/dL). In examining severe malaria referral by background characteristics, we see expected patterns by age, household wealth, residence, and fieldwork year. We had hoped that this analysis would guide adjustments to The DHS Program's referral protocol in order to optimize the number of children who receive artemisinin-based combination therapy (ACT) and referrals while avoiding overburdening the health care system with unnecessary referrals. The lack of data about the percentage of children who actually receive care following their referral, and their ultimate diagnosis, limits our ability to recommend major changes to the protocol. We recommend some smaller changes to surveys that include malaria testing, such as standardizing training on the severe malaria protocol, improving the precision of the "extreme weakness" symptom, and collecting and documenting information about fieldworkers' medical credentials. We also propose reducing the hemoglobin cut-off to limit unnecessary referrals and increase the number of children who can receive ACT in the field; a specific decision about the new hemoglobin cut-off will be taken in the coming months.

1 INTRODUCTION

When the Demographic and Health Surveys (DHS) and Malaria Indicator Surveys (MIS) first introduced malaria testing in 2006, biomarker technicians offered antimalarial treatment to all children with positive rapid diagnostic test (RDT) results. Beginning in 2011, The DHS Program instituted a referral system in which children who test positive for malaria but have no signs or symptoms of severe malaria receive antimalarial treatment, whereas children who test positive for malaria and who have signs or symptoms of severe malaria are referred to the nearest health facility for treatment and are not offered antimalarials by biomarker technicians. Since 2011 when questions on signs and symptoms of severe malaria were added to Biomarker Questionnaires for surveys that included malaria testing, there has not been a comprehensive review of the severe malaria referral process at The DHS Program. The purpose of this paper is to (1) examine the proportion of children who are referred to a health facility as part of the standard malaria referral process, and (2) evaluate the standard malaria referral process for future surveys.

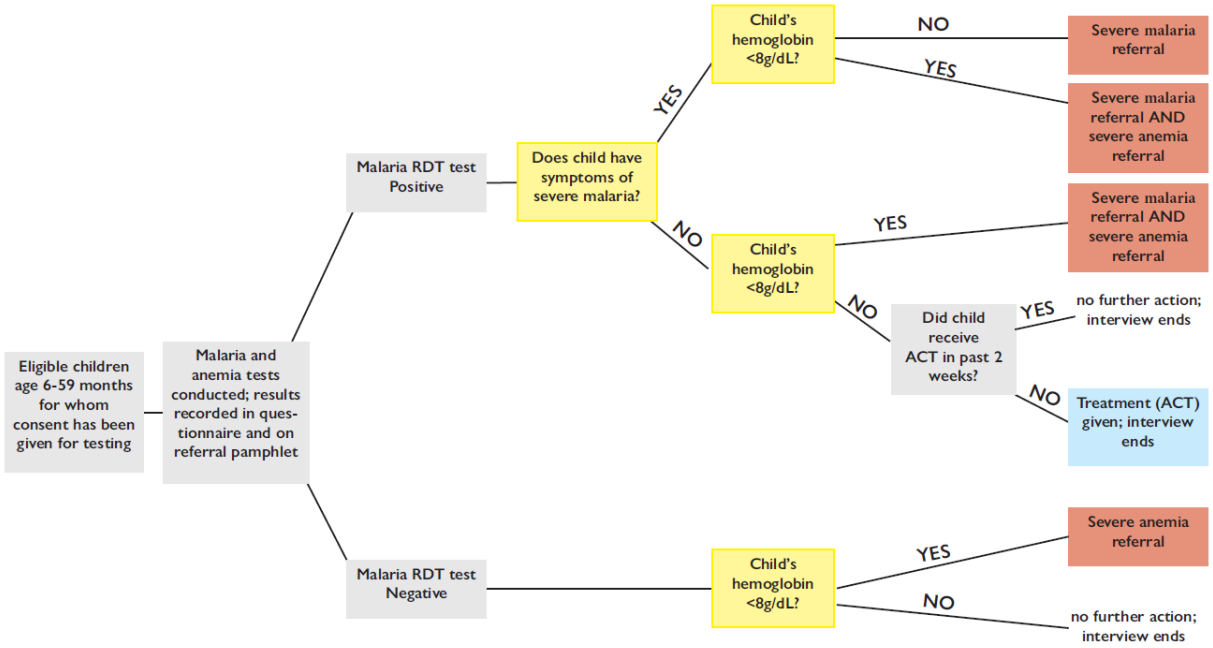
2 THE DHS PROGRAM REFERRAL PROCESS

For most surveys that include malaria biomarkers, eligible children age 6-59 months are identified in surveyed households. After consent is obtained for testing, biomarker technicians use RDTs to determine if children have malaria. The RDTs detect antigens of *Plasmodium falciparum* (*P. falciparum*) in capillary blood collected through a finger or heel prick. *P. falciparum* is the primary cause of severe malaria and is the predominant species found in the countries included in this review.[1,2] Often, capillary blood is also collected for the examination of blood smears by microscopy in the laboratory. DHS and MIS surveys also typically test children age 6-59 months for anemia. Anemia is assessed by determining hemoglobin concentrations in the capillary blood using the HemoCue© 201+ or, on occasion, the HemoCue© 301 point-of-care hemoglobin testing system.

2.1 Overview

Figure 1 provides an overview of The DHS Program referral system for both malaria-positive and malaria-negative children. Children can be referred to the health facility for severe malaria and/or moderate-to-severe anemia. Malaria-positive children may receive referrals for both severe malaria and severe anemia, whereas malaria-negative children may only receive a severe anemia referral. Children who are negative for malaria are not asked about signs/symptoms of severe malaria, making them ineligible for a severe malaria referral.

Figure 1 Overview of anemia and severe malaria referral in post-2010 DHS and MIS surveys



Note: Caretakers of children who received ACTs in the past 2 weeks are told if the child has a high fever, gets sicker, or does not get better in 2 days, then the caretaker should take him/her to a health facility for further examination.

It is important to note that the standard referral system can be adapted for country-specific needs. For example, in the 2015-16 Tanzania DHS/MIS and 2017 Tanzania MIS, children in mainland Tanzania and

Zanzibar were referred using different criteria. Children in mainland Tanzania were referred using the standard DHS Program severe malaria referral system. In Zanzibar, children who tested positive for malaria were referred to the nearest health facility for care in accordance with the Zanzibar Malaria Elimination Programme (ZAMEP) malaria management guidelines. This is mandated since all malaria infections in Zanzibar must be documented by a health facility.

2.1.1 Severe malaria

If a child tests positive for malaria, the caregiver is asked: "Does (NAME) suffer from any of the following illnesses or symptoms: extreme weakness? loss of consciousness? rapid breathing? seizures? bleeding? or jaundice?" These six questions are standard in the Biomarker Questionnaire for surveys that include malaria testing and are used to quickly assess if the child has signs or symptoms of severe malaria. The symptoms are intended to be easily understood by caregivers, even those with a limited education. If the caregiver answers that the child has any of these symptoms, they are read the severe malaria referral statement below and are given a severe malaria referral form to take to the local health clinic. (See Appendix Figure 1 for an example of a severe malaria referral form from the 2020 Kenya MIS.)

> *The malaria test shows that (NAME OF CHILD) has malaria. Your child also has symptoms of severe malaria. The malaria treatment I have will not help your child, and I cannot give you the medication. Your child is very ill and must be taken to a health facility right away.*

The severe malaria questions in a standard Biomarker Questionnaire ask whether a child is experiencing extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, jaundice, heart problems, or dark urine. Of these eight questions, the first six questions have been included in all surveys with malaria testing. Henceforth, they will be referred to as the standard six referral questions.

Although questions about heart problems and dark urine are present in the standard Biomarker Questionnaire, they are occasionally excluded from specific surveys. In addition, some surveys have added specific severe malaria questions, including inability to drink or breastfeed and vomiting everything. In this analysis we will refer to these four signs/symptoms (heart problems, inability to drink or breastfeed, vomiting everything, or dark urine) as survey-specific severe malaria questions.

2.1.2 Anemia

Anemia is assessed by determining hemoglobin concentrations in the blood. If the child has moderate-to-severe anemia defined as a hemoglobin concentration of <8 grams per deciliter (g/dL), the child is given a referral form to take to the nearest health care facility for care. Historically the default cutoff <8 g/dL has been the cutoff for referral for the MIS, and <7 g/dL has been the cutoff for referral for the DHS.[1] The difference in cutoffs reflects the different guidelines followed by malaria and nutrition programs.

[1] As part of the DHS8 standard questionnaire review process that took place in 2019, the cutoffs for anemia referral in MIS and DHS were aligned; the default cutoff for anemia referral is now hemoglobin <8.0 g/dL in both surveys. The rationale was to create consistency across tools and survey type; additionally, this allows us to have a more conservative definition for referral.

Hemoglobin testing to assess anemia is standard in DHS surveys regardless of whether they include malaria testing; in the context of nutrition, a child has severe anemia if their hemoglobin level is <7.0 g/dL.

If the child has moderate-to-severe anemia as defined by the cutoff used in the particular survey, the interviewer reads the following statement to the caregiver, and the caregiver is given a severe anemia referral form to take to the local health clinic. (See Appendix Figure 2 for an example of a severe anemia referral form from the 2020 Kenya MIS.)

> *The anemia test shows that (NAME OF CHILD) has severe anemia. Your child is very ill and must be taken to a health facility immediately.*

In DHS Program final reports, hemoglobin levels are adjusted for altitude in areas that are above 1,000 meters in elevation. However, during fieldwork, biomarker technicians make referrals on the unadjusted hemoglobin levels. To best simulate referral in the field, this review will be using the cutoffs of <8.0 g/dL (not adjusted for altitude) and <7.0 g/dL (not adjusted for altitude). By not adjusting for altitude, we provide a better reflection of children who are referred in the field.

2.1.3 Qualifications of biomarker technicians

The survey implementing agency is typically in charge of recruiting, training, and hiring all fieldworkers including biomarker technicians. Generally, National Statistical Offices (NSOs) serve as the implementing agencies for DHS surveys whereas National Malaria Control Programs (NMCPs) serve as implementing agencies for MIS surveys. Organizationally, NSOs and NMCPs are overseen by different government ministries, and accordingly may have different recruitment strategies and require different qualifications. Even in countries that conduct both DHS and MIS routinely, there may be little overlap between who is recruited to work for each survey. However, because children who test positive for uncomplicated malaria are offered medications in DHS and MIS surveys, most countries require biomarker technicians involved in malaria testing to have a medical qualification (e.g., a doctor, nurse, or medical laboratory technician) or to be supervised by an individual with a medical qualification. Thus, in some surveys all biomarker technicians may have medical qualifications, and in others only a single supervisor per field team has them. And while it is currently standard practice for biomarker technicians to only serve in this role, for many years of the project it was not uncommon to have biomarker technicians also serve as interviewers.

2.1.4 Referral

The following referral review will examine the percentage of malaria-positive children who are referred under the standard six DHS Program referral and the comprehensive referral (Table 1). The standard six DHS Program referral includes symptoms asked in 100% of surveys (extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, or jaundice) as well as hemoglobin <8 g/dL. The comprehensive referral combines the standard six and survey-specific severe malaria questions with the hemoglobin cutoff of <8.0 g/dL.

Table 1 DHS Program severe malaria referral scenarios

Symptoms	Standard six DHS Program referral Extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, jaundice, or hemoglobin <8 g/dL	Comprehensive referral Standard six or survey-specific severe malaria questions or hemoglobin <8 g/dL
Standard Questions		
Extreme weakness	X	X
Loss of consciousness	X	X
Rapid breathing	X	X
Seizures	X	X
Bleeding	X	X
Jaundice	X	X
Survey-Specific Questions		
Heart problems		X
Inability to drink or breastfeed		X
Vomiting everything		X
Dark urine		X
Anemia		
Hemoglobin <8.0 g/dL (not adjusted for altitude)	X	X

2.2 Data

This review used data from DHS and MIS surveys conducted under the auspices of The DHS Program; both are nationally representative, population-based household surveys. The inclusion criteria for the review were all malaria-endemic countries in sub-Saharan Africa that have conducted a DHS or MIS in which children were tested for malaria and anemia and included questions on signs or symptoms of severe malaria. In total this review examined 188,686 children age 6-59 months among 37 surveys across 19 countries in sub-Saharan Africa collected between 2011 and 2018. The study population for this review included malaria-positive children age 6-59 months who stayed in surveyed households the night before the survey and received *P. falciparum* malaria parasite (RDT) and anemia tests.

2.3 Analysis

The review includes a country-level descriptive analysis weighted for complex survey design and a multi-country weighted pooled analysis, both with 95% confidence intervals. The review used an unweighted adjusted logistic regression model to assess the determinants of malaria-positive children receiving the standard DHS Program referral. The model includes age of the child, residence, household wealth, region, survey type, and year of survey fieldwork. All analyses were conducted with StataSE16 (StataCorp LP, College Station, USA).

2.4 Results

2.4.1 Country- and survey-specific sign/symptom results

Among children tested for malaria, 26% were positive by RDT. Malaria prevalence ranged from <1% in both the 2015 Senegal DHS and 2016 Senegal DHS to 61% of children in the 2014 Burkina Faso MIS (Appendix Table A.1).

Questions regarding severe malaria symptoms are not consistent across surveys. Among surveys examined in this paper, 100% asked about the standard six: extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, and jaundice. Ninety-two percent asked about dark urine, 78% asked about heart problems, 24% asked about vomiting everything, and 14% asked about inability or drink or breastfeed. For more details about the specific questions asked in each survey please see Table A.2.

Among children positive for malaria across all surveys, the most prevalent standard sign/symptom of severe malaria was extreme weakness (7%), followed by jaundice (3%) and rapid breathing (3%). Less commonly cited standard symptoms included seizures (1%), loss of consciousness (1%), and bleeding (0.3%) (Table A.3). There was a very weak positive correlation among severe malaria signs or symptoms, with the strongest correlation observed between rapid breathing and extreme weakness (correlation coefficient: 0.36). There are no clear geographical patterns in severe malaria by countries' most recent survey data (Appendix Figure 3).

In looking at severe malaria questions that were only asked in select surveys among malaria-positive children, <1% had heart problems (Table A.4), 9% of children were unable to drink or breastfeed (Table A.5), 8% of children were vomiting everything (Table A.6), and 5% had dark urine (Table A.7).

The prevalence of individual symptoms varies by country. Among children positive for malaria by RDT, Senegal DHS 2014 had the highest percentage of children with extreme weakness (32%). Madagascar MIS 2011 had the highest percentage of children with rapid breathing (14%) as well as the highest percentage of children with bleeding (3%). Angola DHS 2015-16 had the highest percentage of children with jaundice (11%). Guinea DHS 2012 had the highest percentage of children with seizures (9%) as well as dark urine (20%). Mali DHS 2018 had the highest percentage of children with the inability to drink or breastfeed (24%), the highest percentage of children vomiting everything (16%), and children who had loss of consciousness (2%). Burundi MIS 2012 had the highest percentage of children with heart problems (3%). This is summarized in Table 2.

Table 2 Summary of surveys with the highest percentage of children positive for malaria with each listed symptom

Symptoms	Survey with the highest % of children with the listed symptom	%
Standard questions		
Extreme weakness	Senegal DHS 2014	32.0
Loss of consciousness	Mali DHS 2018	2.3
Rapid breathing	Madagascar MIS 2011	14.0
Seizures	Guinea DHS 2012	9.3
Bleeding	Madagascar MIS 2011	3.4
Jaundice	Angola DHS 2015-16	11.2
Survey-specific questions		
Heart problems	Burundi MIS 2012	3.1
Inability to drink or breastfeed	Mali DHS 2018	24.0
Vomiting everything	Mali DHS 2018	15.5
Dark urine	Guinea DHS 2012	19.7

Among children positive for malaria across all surveys, 19% had hemoglobin levels of <8.0 g/dL and 8% had hemoglobin levels of <7.0 g/dL. Mali MIS 2015 had the highest percentage of children with hemoglobin levels <8.0 g/dL (38%) and hemoglobin levels <7.0 g/dL (20%) (Table A.8). Mapping hemoglobin <8 g/dL and <7 g/dL by country's most recent survey, we do not see strong geographic patterns (Appendix Figure 4).

2.4.2 Referral

Standard six DHS Program referral (extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, jaundice, or hemoglobin <8 g/dL)

Under the current DHS Program referral scenario, malaria-positive children with extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, jaundice, or hemoglobin <8 g/dL are referred to the nearest health facility. Across all surveys, 24% of malaria-positive children are referred to the nearest health facility for severe malaria symptoms or severe anemia. This ranges from 7% of malaria-positive children in the Kenya MIS 2015 to 56% in the Senegal DHS 2012-13 (Table 3).

Comprehensive referral (standard or survey-specific severe malaria questions or hemoglobin <8 g/dL)

The comprehensive referral includes the standard six and all survey-specific severe mala questions (heart problems, inability to drink or breastfeed, vomiting everything, or dark urine) as well as hemoglobin cutoff of <8g/dL. Across all surveys, 25% of malaria-positive children are referred to the nearest health facility for severe malaria symptoms. This ranges from 7% of children in the Kenya MIS 2015 to 56% of children in the Senegal DHS 2012-13. However, it should also be noted that not all surveys asked the survey-specific severe malaria questions (Table 3).

Table 3 shows the percentage referred by scenario among children age 6-59 months with malaria according to RDT. The three surveys with the highest percentage referred by scenario are shaded yellow, and the three surveys with the lowest percentage referred by scenario are shaded in green.

Table 3 **Among children age 6-59 months with malaria according to RDT, the percentage referred by scenario**

	Standard six DHS Program referral	Comprehensive referral	Number of children age 6-59 months with malaria infection according to RDT
	Extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, jaundice, or hemoglobin <8 g/dL	Standard six or survey-specific severe malaria questions or hemoglobin <8 g/dL	
Country/Survey	**%**	**%**	**N**
Angola DHS 2015-16	37.0	37.6	891
Benin DHS 2017-18	18.6	20.9	2,241
Burkina Faso MIS 2014	38.0	40.8	3,613
Burkina Faso MIS 2017	21.0	21.3	1,123
Burundi MIS 2012	23.3	23.6	838
Burundi DHS 2016-2017	16.1	16.2	2,204
DRC DHS 2013-14	28.8	31.0	2,536
Ghana DHS 2014	21.3	22.3	929
Ghana MIS 2016	19.0	20.0	801
Guinea DHS 2012	44.3	47.1	1,513
Kenya MIS 2015	6.9	6.9	277
Liberia MIS 2011	14.2	15.5	1,304
Liberia MIS 2016	15.1	15.3	1,290
Madagascar MIS 2011	41.3	45.4	546
Madagascar MIS 2013	30.0	33.2	557
Madagascar MIS 2016	20.1	20.8	338
Malawi MIS 2012	21.2	21.9	946
Malawi MIS 2014	18.3	18.6	738
Malawi MIS 2017	11.2	11.2	892
Mali MIS 2015	46.0	50.1	2,293
Mali DHS 2018	46.6	53.1	836
Mozambique HMIS 2015	15.3	15.3	1,867
Mozambique MIS 2018	34.0	35.2	1,723
Nigeria MIS 2015	19.7	19.9	2,726
Nigeria DHS 2018-19	20.8	20.8	4,109
Senegal DHS 2012-13	56.4	56.4	174
Senegal DHS 2014	47.3	48.5	61
Senegal DHS 2015	38.2	39.3	34
Senegal DHS 2016	34.2	34.2	46
Sierra Leone MIS 2016	16.9	17.6	3,502
Tanzania HMIS 2011-12	23.5	28.7	684
Tanzania DHS 2015-16	18.2	18.2	1,275
Tanzania MIS 2017	11.4	11.4	491
Togo DHS 2013-14	26.8	29.8	1,133
Togo MIS 2017	13.9	13.9	1,299
Uganda MIS 2014-15	11.4	11.5	1,402
Uganda DHS 2016	17.2	17.7	1,431
Total	**24.1**	**25.4**	**48,663**

2.4.3 Pooled results

Among all children tested for malaria in these 37 surveys, 26% were positive by RDT (Table A.1). We see some variation by background characteristics. The proportion of children age 6-59 months with malaria ranges from 20% among children age 6-23 months to 30% among children age 48-59 months. A higher percentage of children from rural areas (30%) were positive for malaria as compared to urban areas (14%). Malaria prevalence decreases with increasing wealth and a higher percentage of children were positive for malaria in MIS surveys (29%) as compared to DHS surveys (23%). Additionally, malaria prevalence in

children is higher in West African countries (31%) as compared to Central/Eastern/Southern Africa (21%). Malaria prevalence is similar between surveys conducted between 2015-2018 (26%) and between 2011-2014 (25%) (Table 4).

Table 4 Pooled survey results, proportion of children age 6-59 months with malaria (RDT)

Background characteristic	Proportion of children age 6-59 months with malaria (RDT)		N
	%	95% LB	
Age group (months)			
6-23	20.2	[19.5-20.9]	61,912
24-35	26.4	[25.5-27.2]	41,300
36-47	29.0	[28.2-29.9]	42,659
48-59	30.1	[29.3-31.1]	42,815
Residence			
Urban	13.7	[12.7-14.7]	51,395
Rural	30.3	[29.5-31.2]	137,292
Wealth index			
Lowest	36.1	[34.9-37.4]	42,993
Second	33.3	[32.2-34.4]	41,503
Middle	27.4	[26.4-28.4]	38,401
Fourth	18.8	[17.9-19.7]	35,508
Highest	7.0	[6.4-7.6]	30,282
Region[1]			
West Africa	30.6	[29.4-31.7]	94,950
Central/Eastern/ Southern Africa	20.9	[20.1-21.8]	93,737
Survey type			
DHS Survey	22.5	[21.5-23.5]	86,374
MIS Survey	28.6	[27.6-29.6]	102,313
Fieldwork year			
2011-2014	24.6	[23.5-25.8]	66,681
2015-2018	26.4	[25.6-27.3]	122,005
Total	25.8	[25.1-26.5]	188,687

[1] West Africa: Benin, Burkina Faso, Ghana, Guinea, Liberia, Mali, Nigeria, Senegal, Sierra Leone, and Togo; Central/Eastern/Southern Africa: Angola, Burundi, DRC, Kenya, Madagascar, Malawi, Mozambique, Tanzania, and Uganda

When examining survey referral scenarios by background characteristic, we observe similar patterns. Across both referral scenarios, severe malaria referral decreases by age group, with a higher percentage of severe malaria among children age 6-23 months as compared to children age 48-59 months. Severe malaria also decreases with increasing household wealth. Severe malaria is higher among children in rural areas as compared to urban areas and is higher among West African countries as compared to Central/Eastern/Southern African countries across both scenarios. Severe malaria is also higher among surveys conducted in 2011-2014 as compared to surveys conducted in 2015-2018. Across both referral scenarios, DHS surveys have a slightly higher severe malaria referral rate as compared to MIS surveys (Table 5).

Table 5 Pooled survey referrals, among children age 6-59 months with malaria according to RDT, the percentage referred by scenario according to background characteristics

Background characteristic	Standard six DHS Program referral		Comprehensive referral		Number of children age 6-59 months with malaria infection according to RDT
	%	95% LB	%	95% LB	
Age group (months)					
6-23	32.9	[31.7-34.2]	33.9	[32.7-35.2]	12,495
24-35	26.8	[25.7-28.0]	28.1	[27.0-29.4]	10,888
36-47	21.2	[20.2-22.3]	22.6	[21.4-23.7]	12,372
48-59	16.1	[15.2-17.1]	17.7	[16.7-18.7]	12,907
Residence					
Urban	20.7	[19.2-22.3]	22.3	[20.7-24.0]	7,041
Rural	24.7	[23.8-25.6]	26.0	[25.0-26.9]	41,621
Wealth index					
Lowest	26.7	[25.3-28.1]	27.9	[26.5-29.4]	15,538
Second	24.4	[23.3-25.5]	25.6	[24.5-26.7]	13,815
Middle	22.6	[21.4-23.8]	24.0	[22.8-25.3]	10,522
Fourth	22.2	[20.9-23.6]	23.6	[22.2-25.0]	6,677
Highest	17.2	[14.9-19.7]	19.0	[16.5-21.9]	2,110
Region[1]					
West Africa	25.8	[24.7-26.9]	27.4	[26.2-28.5]	29,025
Central/Eastern/ Southern Africa	21.7	[20.6-22.7]	22.6	[21.5-23.7]	19,637
Survey type					
DHS Survey	25.1	[24.1-26.2]	26.5	[25.4-27.7]	19,413
MIS Survey	23.5	[22.4-24.6]	24.7	[23.6-25.9]	29,248
Fieldwork year					
2011-2014	29.1	[27.8-30.4]	31.2	[29.8-32.6]	16,414
2015-2018	21.6	[20.7-22.6]	22.5	[21.5-23.5]	32,248
Total	**24.1**	**[23.4-24.9]**	**25.4**	**[24.6-26.3]**	**48,662**

[1] West Africa: Benin, Burkina Faso, Ghana, Guinea, Liberia, Mali, Nigeria, Senegal, Sierra Leone, and Togo; Central/Eastern/Southern Africa: Angola, Burundi, DRC, Kenya, Madagascar, Malawi, Mozambique, Tanzania, and Uganda

The regression analysis shows the adjusted odds of a malaria-positive child receiving the standard six DHS Program referral in relation to the different background characteristics. This regression is adjusted for age of the child, residence, household wealth, region, survey type, and year of survey fieldwork.

Compared with children age 6-23 months, children age 24-35 months (adjusted odds ratio [AOR]: 0.77; 95% CI: 0.73-0.81), 36-47 months (AOR: 0.55; 95% CI: 0.52-0.58) and 48-59 months (AOR: 0.39; 95% CI: 0.37-0.41) were significantly less likely to be referred (Table 6). Rural children were significantly more likely to be referred than urban children (AOR: 1.17; 95% CI:1.09-1.25). Socioeconomic status of the household is associated with the likelihood of referral, with children in the highest wealth quintile having significantly lower odds than those from households in the lowest quintile (AOR:0.66; 95% CI:0.58-0.76). By region, Central/Eastern/Southern Africa had significantly lower odds of referral (AOR: 0.89; 95% CI: 0.85-0.93) as compared to West Africa, and children in MIS surveys were significantly less likely (AOR: 0.76; 95% CI: 0.73-0.80) to receive a referral as compared to DHS surveys. Finally, the children surveyed between 2015 and 2018 were significantly less likely to be referred than those surveyed between 2011 and 2014 (AOR:0.66; 95% CI: 0.63-0.69) (Table 6).

Table 6 Unweighted logistic regression model of children who had the standard six DHS Program referral among children who were positive for malaria, pooled analysis

Background characteristic	Adjusted Odds Ratio	95% Confidence Intervals
Child		
Age Group (months)		
6-23	1 (Reference)	
24-35	0.77***	0.73 - 0.81
36-47	0.55***	0.52 - 0.58
48-59	0.39***	0.37 - 0.41
Household		
Place of Residence		
Urban	1 (Reference)	
Rural	1.17***	1.09 - 1.25
Wealth Quintile		
Lowest	1 (Reference)	
Second	0.93**	0.88 - 0.98
Middle	0.85***	0.80 - 0.90
Fourth	0.87***	0.81 - 0.93
Highest	0.66***	0.58 - 0.76
Region[1]		
West Africa	1 (Reference)	
Central/Eastern/ Southern Africa	0.89***	0.85 - 0.93
Survey		
Survey Type		
DHS survey	1 (Reference)	
MIS survey	0.76***	0.73 - 0.80
Fieldwork Year		
2011-2014	1 (Reference)	
2015-2018	0.66***	0.63 - 0.69

Level of statistical significance *** p<0.001, ** p<0.01, * p<0.05

[1] West Africa: Benin, Burkina Faso, Ghana, Guinea, Liberia, Mali, Nigeria, Senegal, Sierra Leone, and Togo; Central/Eastern/Southern Africa: Angola, Burundi, DRC, Kenya, Madagascar, Malawi, Mozambique, Tanzania, and Uganda

2.5 Discussion

Under the current DHS Program referral process, 24% of malaria-positive children are referred to the nearest health facility for severe malaria symptoms. This includes children with extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, jaundice, or hemoglobin <8 g/dL. However, The DHS Program does not know how many children who receive a referral are brought to the health facility, and among those brought to a health facility, their official diagnosis by a health care provider. Since we do not have this information, it makes it impossible to directly compare the results of this analysis to existing literature on severe malaria which is based on data from the formal health care system.

Examination of health facility referral at a country level shows that Senegal, Mali, Guinea, and Madagascar all have consistently high referral rates across all scenarios. It is worth noting that the sample sizes for the Senegal surveys are drastically smaller than Mali and Guinea, which could be unduly influencing the results for Senegal. These regional patterns are also seen in the pooled regression model with children in

Central/Eastern/Southern Africa having significantly lower odds of being referred as compared to children in West Africa.

Findings from the pooled analysis confirm previous observations that severe malaria is dependent on age.[2,3,4,5,6] Younger children were significantly more likely to have severe malaria as compared to older children. Socioeconomic status of the household is associated with the likelihood of referral, with children in the highest wealth quintile having significantly lower odds than those from households in the lowest quintile. Additionally, rural children were significantly more likely to be referred compared to urban children. The findings by wealth and residence also confirm previous observations that socioeconomic factors contribute to the high burden of malaria in sub-Saharan Africa, which, in turn, increases the likelihood of uncomplicated malaria turning into severe malaria or severe malaria.[7,8]

Malaria-infected children surveyed between 2015 and 2018 were significantly less likely to have severe malaria symptoms than those surveyed between 2011 and 2014. This finding aligns with the 2019 World Malaria Report, which reported a decrease in malaria deaths since 2010.[9] Moreover, prompt diagnosis and treatment-seeking rates have generally increased, helping to prevent mild cases of malaria from developing into severe malaria and death.[1,10] It is unclear why MIS surveys have significantly lower referral rates compared to DHS surveys in this analysis. More exploration is needed into this result.

2.6 Limitations

This review has several limitations. There is a risk of including non-malaria cases or uncomplicated malaria cases into our analysis due to misclassification. Regarding the former, malaria positivity is based on RDT-detectable antigens that continue to circulate in the blood after the infection has cleared. Children who might have cleared the infection could still be RDT positive, and then be asked the severe malaria questions. If they had any symptoms of severe malaria, they would be provided a referral.

Regarding the potential to misclassify uncomplicated malaria cases, since only malaria-positive children are asked the severe malaria questions, we are unable to examine the reliability of reported signs and symptoms because caregivers were not asked questions on severe malaria symptoms for malaria-negative children. It is possible to compare anemia rates between malaria-positive and -negative children; however, this was not examined as part of this analysis.

Severe malaria questions are based on caregiver report rather than a diagnosis by a clinician at a health facility. Although the interviewer for the biomarker questionnaire is a trained biomarker technician (often a doctor, nurse or person with other medical qualifications who may have encountered malaria and other serious illness often as part of their profession), the non-specific nature of the questions remains an issue. The severe malaria questions are simple and designed to minimize confusion by caregivers, even those with a limited education. However, both cultural and regional differences in a caregiver's understanding and reporting of symptoms could exist.

Since children who are classified as having uncomplicated malaria are offered medications in DHS and MIS surveys, most countries require biomarker technicians involved in malaria testing to have a medical qualification or to be supervised by an individual with a medical qualification. Thus, in some surveys all biomarker technicians have medical qualifications, and in others only a single supervisor on each field team has them. However, in trying to examine field team composition for every survey, we could not determine

with 100% certainty if all field teams included members with clinical training. Because of this, we were unable to examine if biomarker technicians with medical training or supervised by team members with medical training correlated with the percentage of children who were referred to health facilities. This omission could bias the results between surveys since surveys that include field staff with clinical training could influence assessments of a child's illness.

All DHS Program survey questionnaires in malaria endemic countries are standardized in either English, French, or Portuguese depending on the official language of the country. As part of the questionnaire adaptation process, these questionnaires are then translated into other official languages of the country or recognized regional languages. This translation of questionnaires could lead to changes to the original meaning of the sign/symptom in the questionnaire. It is important to note that the exact wording of the signs/symptoms questions as seen in the English, French, or Portuguese questionnaires is what was used in this analysis.

As noted in the methodology, the hemoglobin levels in this analysis are unadjusted for altitude. This means that in areas of higher altitude there are potentially fewer instances of referral for severe anemia than in lower altitude areas.[11] While we do not think this drastically influences the results of this analysis, it is an important limitation to note in regard to the referral process. Additionally, HemoCue© machines are prone to error in a non-controlled setting.[12] Measurement error could be more problematic in field settings due to the inherent errors to any method that uses capillary blood. Protocols for standardization of the blood collection practices have been developed to address some of these issues, however, errors can still exist.[12]

3 EVALUATION OF THE REFERRAL PROCESS

As part of the severe malaria referral instituted by The DHS Program surveys in 2011, children identified as severely ill as part of a DHS or MIS survey have been referred to the nearest health facility for treatment. The referral system is a public health service that has potentially saved lives. Since questions on signs and symptoms of severe malaria were added to the Biomarker Questionnaires of surveys that include malaria testing, there has not been a comprehensive review of the severe malaria referral process in The DHS Program.

The main purpose of national surveys such as the DHS and MIS is to provide nationally representative data to support decision-making. However, biomarker testing can also provide an immediate benefit to respondents if results are shared. In DHS Program surveys all children age 6-59 months in a household are eligible for malaria testing. Children are tested for malaria whether they have symptoms or not. DHS Program surveys share the test results with the households, enabling caregivers to obtain real-time information on the malaria infection status of their children without leaving their home and traveling to the health facility. Returning rapid test results to caregivers is straightforward in many cases, however, the ethics of performing home-based biomarker tests becomes complicated when a child is severely sick.[13]

Survey teams are not equipped, trained, or authorized to advise or treat severely sick children. These children should receive treatment from health facilities. But health facility referrals in countries with poor health care infrastructure can be problematic.[13] A survey's policy for referral must consider the types of services that are provided in the community, since a referral might not always be able to link to appropriate or adequate care. In these cases, there could be additional pressure in the future to use surveys as vehicles for provision of care. A survey may provide a rare opportunity for households to interact with clinically trained staff, and to receive important health-related information and/or treatment. Still, the scope and quality of care that can be provided through a household survey is limited. It is also important that survey implementers ensure that receipt of needed health care services does not become an overwhelming consideration in a respondents' decision about survey participation.[13]

In the current protocol for surveys that include malaria testing, caregivers of malaria-positive children with severe symptoms are told that their child is severely sick and are given a health facility referral form (Appendix Figures 1 and 2). Although we know that these forms are distributed, we do not know if children who are given a health facility referral form in fact go to a health facility. We assume that the caregiver understands the severity of the referral, and that they will pursue care, however, there are external factors that might prevent a caregiver from seeking care.

Several questions emerge when reexamining the severe malaria referral including:

1. Does the current DHS referral system misclassify children with uncomplicated malaria as having severe malaria, thus referring children unnecessarily to a (potentially overwhelmed) health facility?

2. Does the current protocol miss an opportunity to provide ACT treatment to more children? Assuming that some referred children will not reach a health facility, would it be better to at least provide ACT? Does provision of ACT discourage households from seeking care?

3. Should The DHS Program also ask about severe malaria (illness) symptoms among malaria-negative children (and therein expand the referral protocol) as a health care service to the community? Do the benefits of this expansion outweigh the additional burden on the survey process?

To ensure that The DHS Program is providing the best possible data quality while also weighing the significance of referral, the remaining sections will (1) examine literature regarding severe malaria signs/symptoms and referral, and (2) explore referral scenarios. At the end of the document, we will provide recommendations for the future.

3.1 Signs or symptoms of severe malaria

Malaria typically begins as an acute febrile illness. If not appropriately treated, (*P. falciparum*) malaria can progress to severe malaria and death. Children with severe malaria frequently develop one or more of the following complications: severe anemia, respiratory distress, or cerebral malaria.[1,14] The clinical manifestations of these severe malaria complications in children include impaired consciousness, respiratory distress (acidotic breathing), multiple convulsions, prostrations, shock, and jaundice.[1,15]

Table 7 outlines the frequency of signs or symptoms of severe malaria in adults and children. The most common signs or symptoms of severe malaria in children include impaired consciousness, respiratory distress, multiple convulsions, and prostration.

According to the World Health Organization (WHO) Management of Severe Malaria Handbook, the initial assessment of children with severe malaria includes any of the following:

- Level of consciousness
- Evidence of seizures or subtle seizure
- Posturing
- Rate and depth of respiration
- Presence of anemia
- Pulse rate and blood pressure
- State of hydration
- Capillary refill time
- Temperature
- Prostration

Immediate laboratory tests include:

- Thick and thin blood films or RDT if microscopy is not immediately possible or feasible
- Erythrocyte volume fraction
- Blood glucose level
- Analysis of cerebrospinal fluid
- Blood culture where feasible

Table 7 Signs or symptoms of *Plasmodium falciparum* malaria in adults and children[2]

Prognostic value (+ to +++)			Frequency (+ to +++)	
Children	Adults	Clinical manifestations	Children	Adults
+++	+++	Impaired consciousness	+++	++
+++	+++	Respiratory distress (acidotic breathing)	+++	++
+	++	Multiple convulsions	+++	+
+	+	Prostration	+++	+++
+++	+++	Shock	+	+
+++	+++	Pulmonary oedema (radiological)	+/−*	+
+++	++	Abnormal bleeding	+/−*	+
++	+	Jaundice	+	+++
		Laboratory indices		
+	+	Severe anaemia	+++	+
+++	+++	Hypoglycaemia	+++	++
+++	+++	Acidosis	+++	++
+++	+++	Hyperlactataemia	+++	++
++	++	Renal impairment†	+	+++
+/−	++	Hyperparasitaemia	++	+

*Infrequent.
†Acute kidney injury.

The clinical epidemiology of severe malaria can also present differently according to age and transmission intensity. Studies have shown that as the intensity of malaria transmission increases, the mean age of severe malaria decreases.[2,3,4,5] In high transmission areas, the risk for severe malaria is greatest among young children (the first few months of life to age 5) with severe anemia presenting as the predominant complication.[2,5] Severe malaria becomes less common in older children when acquired immunity provides a protective effect. Conversely, in low transmission areas, severe malaria is more common in older children and adults with cerebral malaria presenting as the predominant complication.[2]

The WHO World Malaria Report estimates that between 1% and 3% of uncomplicated reported malaria cases moved to the severe stage of disease, and 50-80% of these severe cases were hospitalized.[9]

Severe malaria is clinically similar to other severe febrile illnesses making the specificity of clinical diagnosis low.[2,16] Each clinical symptom of severe malaria (e.g., coma, severe anemia, acidosis) can have other causes (e.g., meningitis, sickle cell disease, septicemia).[2] The interpretation of clinical symptoms is confounded in areas of high transmission where asymptomatic parasitemia is common and may be accompanying severe malaria.[17] In a review by Gwer et al., the authors examined three comorbid conditions (invasive bacterial infection, HIV, and malnutrition) on severe malaria in children and found that malaria is frequently over-diagnosed in the health facility, which results in failure to treat other life-threatening conditions, mainly invasive bacterial infections.[16,18] Malaria parasitemia should always be treated in severely ill children; however, the likelihood of the illness being due to malaria alone is related to parasite density, which is not always examined.[19]

Dalrymple et al. found that although the proportion of fever cases that are accompanied by a *P. falciparum* positive RDT remains high, only approximately a third of these fevers are causally attributable to malaria.[6] This analysis estimated that over a two-week period, one in four children under age five in areas of stable malaria transmission will suffer a fever not caused by *P. falciparum* malaria, whereas only one in every 32

children will suffer a fever directly caused by *P. falciparum*.[6] The high burden of coinfections and comorbidities complicates the diagnosis and referral of malaria-positive children in sub-Saharan Africa.

3.2 Referral for danger signs

In the mid-1990s, in response to the challenges that health care providers faced, the World Health Organization (WHO) together with the United Nations Children's Emergency Fund (UNICEF) and other agencies developed a strategy known as integrated management of childhood illness (IMCI).[17] IMCI aims to integrate management of the common conditions that children present with at health facilities to improve the quality of care for children and reduce severe morbidity and mortality. The IMCI clinical guidelines were created from an evidence-based syndrome approach to case management that targets the following common childhood conditions: malaria, pneumonia, diarrhea, dehydration, measles, malnutrition, anemia, and ear problems, among others.[20,21] The intended audience for these guidelines is lower-level health facilities that have limited diagnostic capacity.[21] The guidelines outline danger signs of severe disease that require immediate referral to a higher-level health facility.

According to IMCI, general danger signs needing urgent attention include inability to drink or breastfeed, vomiting everything, convulsions, and lethargy (Figure 2). For children presenting with fever, the danger signs outlined in IMCI include any general danger signs or stiff neck (Figure 3). The WHO/UNICEF strategy for integrated management of childhood illness at health-facility level recommends that all patients with a history of fever of less than 7 days should be tested for malaria via RDT. In parallel, children should be assessed for acute respiratory infection, diarrhea, and earache (Figure 4).[22]

Figure 2 IMCI General danger signs[20]

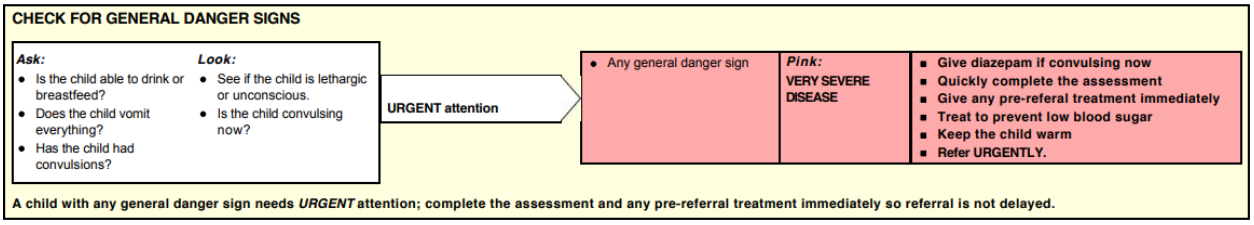


Figure 3 IMCI danger signs for fever[20]

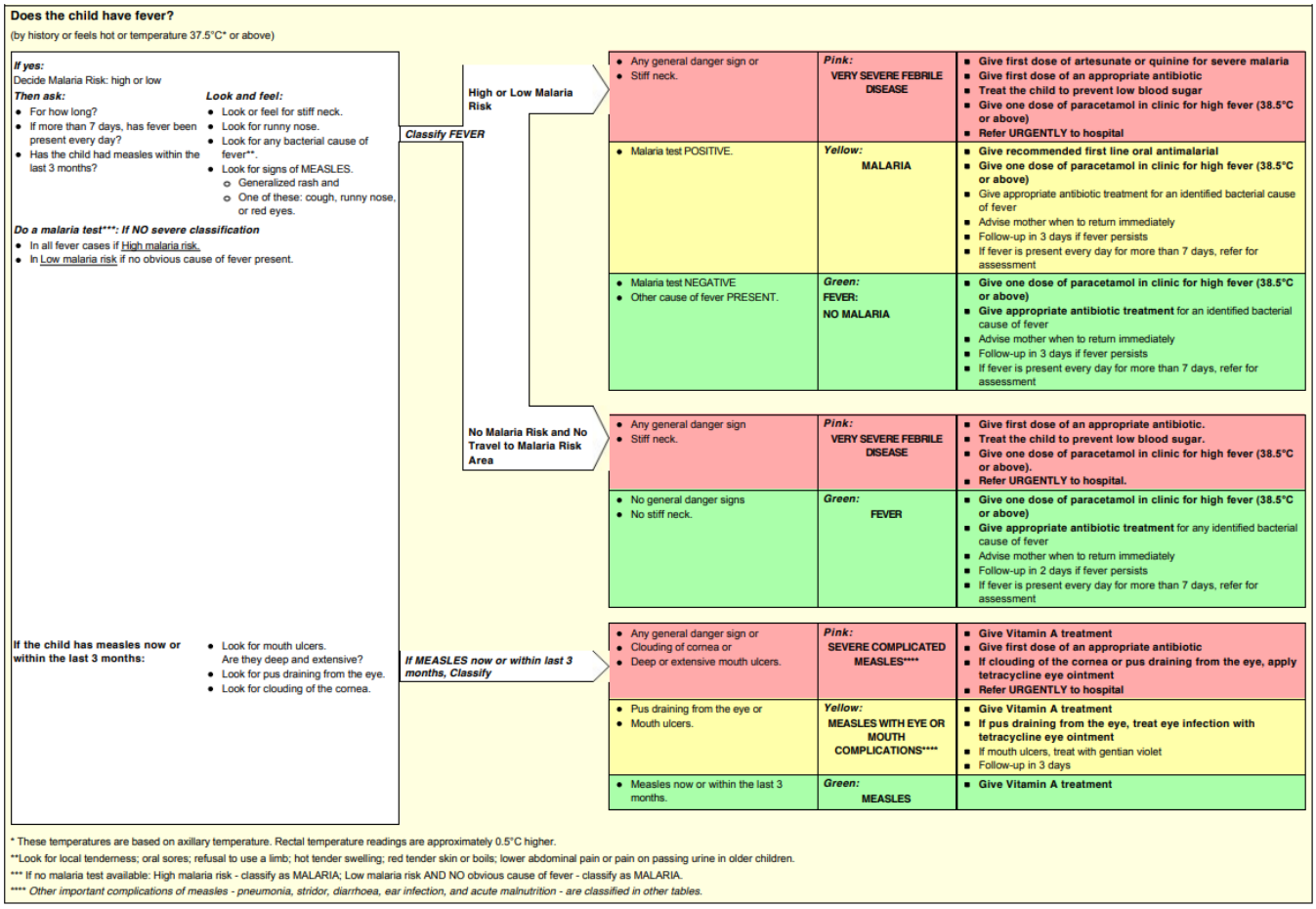
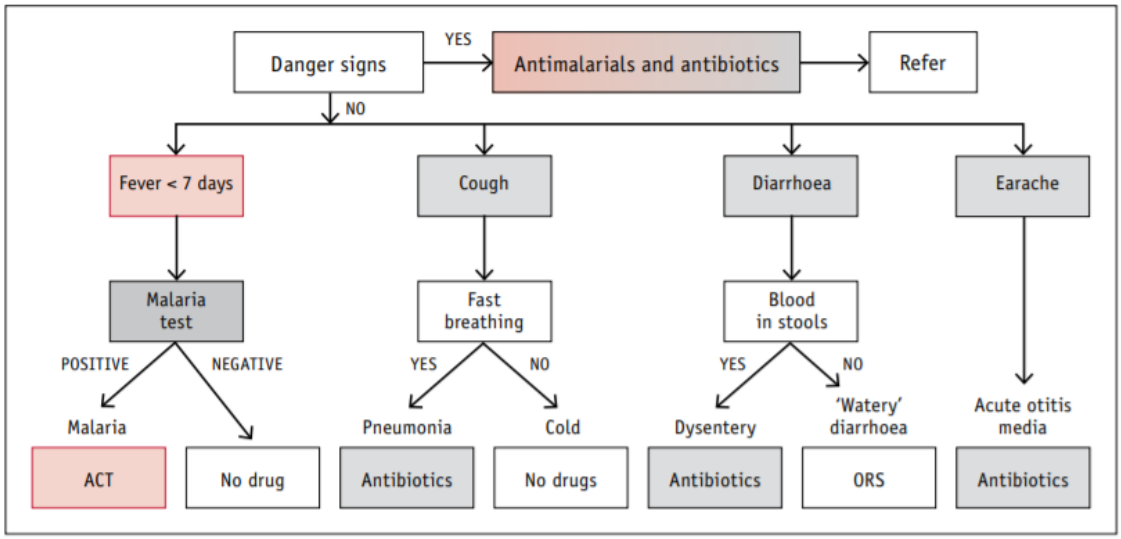


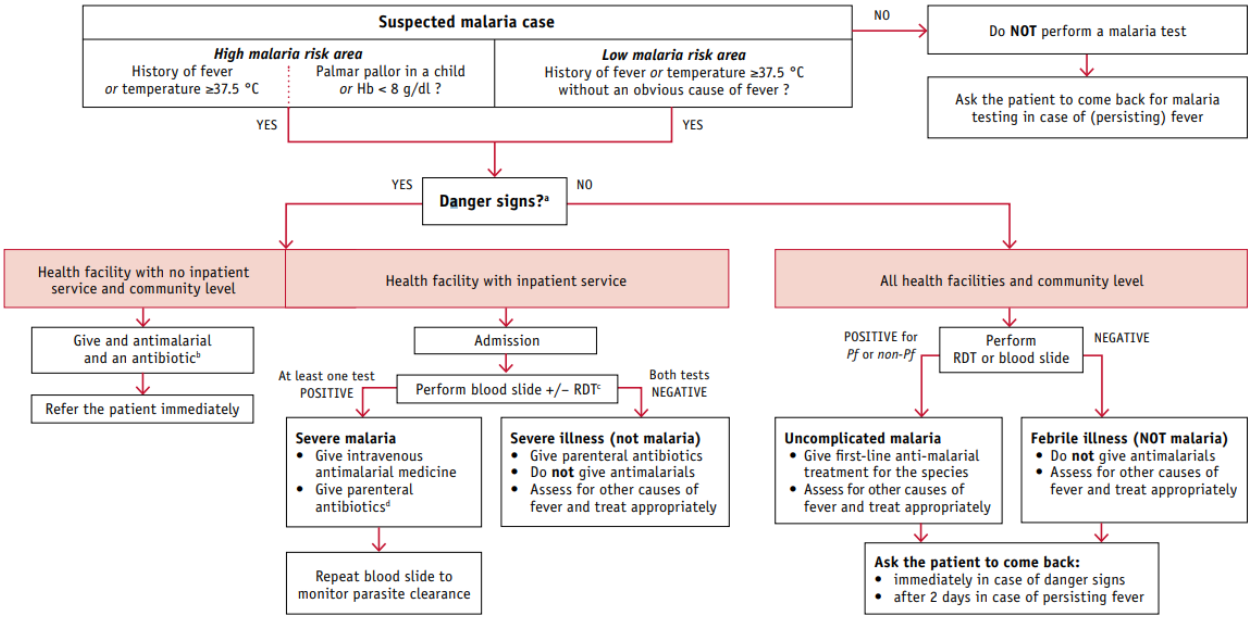
Figure 4 Summary chart of the WHO/UNICEF strategy for integrated management of childhood illness at health facility level[22]



Adapted from *Integrated management of childhood illness: caring for the sick child at health facility level*, WHO/UNICEF, 2010

According to the WHO Universal Access to Malaria Diagnostic Testing Operational Manual, in highly endemic areas, all patients presenting with a history of fever or temperature ≥37.5°C should be tested for malaria (Figure 5).[22] In addition, patients under age 5 with palmar pallor or anyone with a hemoglobin level <8 g/dl should also be tested for malaria. Children should then be assessed for danger signs. Any patient with danger signs of severe disease should be referred to an inpatient facility. These danger signs include the inability to drink or breastfeed, vomiting everything, having convulsions, lethargic or unconscious and present with neck stiffness, chest indrawing or stridor. These are similar to the danger signs outlined in IMCI protocol.

Figure 5 WHO algorithm for malaria diagnosis and treatment: first visit[22]



[a] The following general danger signs are considered criteria for referral at peripheral level [adapted from Integrated Management of Childhood Illness (IMCI) and Integrated Management of Adolescent and Adult Illness (IMAI)]:
in children: unable to drink or breastfeed, vomit everything, have convulsions, are lethargic or unconscious and present with neck stiffness, chest indrawing or stridor;
in adults: are very weak or unable to stand, are lethargic or unconscious or have neck stiffness, convulsions, respiratory distress or severe abdominal pain
[b] Pre-referral treatment as recommended by WHO 2010 *Guidelines for the treatment of malaria* and by Integrated Management of Childhood Illness (IMCI) and Integrated Management of Adolescent and Adult Illness (IMAI): rectal artesunate or intramuscular quinine, artesunate or artemether and intramuscular ampicillin plus gentamicin or intramuscular ceftriaxone
[c] RDT is performed while waiting for the result of the blood slide to decide earlier on treatment and to document malaria in patients who have received pre-referral antimalarial treatment (and might thus have already cleared their parasites).
[d] Because of the possibility of concomitant bacterial infection in severe malaria patients, especially in children, antibiotics should be given beside antimalarials until bacterial infections have been ruled out (including bacteremia by blood cultures if available).

3.3 Other MIS survey referrals

The DHS Program is not the only project that conducts malaria indicator surveys. Other organizations such as Medical Care Development International (MCDI), PATH Malaria Control and Elimination Partnership in Africa (MACEPA), Swiss Tropical and Public Health Institute, and The Carter Center also conduct MIS surveys. The website malariasurveys.org serves as a home for MIS datasets and documentation, including the MIS toolkit which contains a comprehensive package of tools for use in conducting household surveys to assess core malaria indicators. Table 8 outlines severe malaria referral recommendations from other non-DHS Program MIS surveys as listed in the final reports. There is no standard for referral across other non-DHS Program MIS surveys.

Table 8 Non-DHS Program MIS survey severe malaria referrals

Non-DHS Program MIS Survey	Age groups tested	Summary of referral recommendations
2019 Bioko Island MIS	All consenting household members present at the time of the survey were eligible for malaria and anemia testing.	Every malaria-positive case received appropriate treatment. All cases of anemia were referred to a health center.
2016-17 PNG MIS	All consenting household members present at the time of the survey were eligible for malaria and anemia testing. *Other biomarkers:* All household members also had their temperature checked with an electronic thermometer. Children age 2 to 9 years were assessed for splenomegaly.	All malaria-positive participants were treated by the nursing officer following the malaria treatment policy. As a community service, Papua New Guinea Institute of Medical Research (PNGIMR) nursing officers also provided treatment for minor ailments or referral advice to the general public in the villages included in the survey.
2018 Zambia MIS	Children under age 5 were tested for malaria and anemia.	Children found with hemoglobin levels of less than 7 g/dl and a negative RDT were given an appropriate two-week dosage of daily iron and folate and mebendazole (chewable) and referred to a health center and their parent/guardian was given the written results. Mebendazole was given as a presumptive treatment of helminthic infections and was only given to children at least 12 months of age. Children with a positive RDT and clinically not fitting into the severe malaria classification (severe anemia, prostration, impaired consciousness, respiratory distress, convulsions, circulatory collapse, abnormal bleeding, jaundice, and passing black/brown [dark] urine) received immediate treatment for malaria with ACT according to Zambia's national treatment guidelines. Children with a positive RDT and classified as simple malaria with mild to moderate anemia (Hemoglobin [Hb] between 8–11.5 g/dl) were treated with ACT and given a two-week course of folic acid ONLY and no ferrous sulphate. Children clinically assessed by the survey nurse to have severe malaria were transported immediately to the nearest health center. Children already treated with an antimalarial within the previous two weeks were referred to the nearest facility for additional evaluation. Children who were found to be seriously ill, as determined by the survey nurses, were provided transportation to the nearest health facility.
2017 South Sudan MIS	Children under age 5 were tested for malaria and anemia.	Children who had a hemoglobin level under 7.0 g/dl (severe anemia) were given a referral letter and recommendation to be taken to a health facility for follow-up care. Malaria-positive children with signs/symptoms of severe malaria (extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, or jaundice) were referred to a health care center.
2015 Ethiopia MIS	Blood samples were collected from children under age 5 in all 25 households selected per cluster for interview and for all ages in 6 out of 25 households in each cluster.	For children diagnosed with anemia (hemoglobin 5–8 grams per deciliter [g/dl]), results were shared with the parent/guardian, and the children were given artemether-lumefantrine if older than age 4 months as per the national protocol, albendazole if under age 24 months per integrated management of childhood illness national protocol, and a two-week supply of supplemental iron. All children under age 5 with hemoglobin <5g/dl were referred to the nearest health facility for further evaluation and treatment. Subjects with a positive RDT for *P. falciparum* or *P. falciparum*/mixed infection who were not pregnant received immediate treatment for malaria using artemether-lumefantrine per the national protocol and RDT-positive pregnant women were treated with quinine tablets. Those individuals who were positive for *P. vivax* or PAN were only treated using chloroquine (as per national protocol). Subjects who were found to be seriously ill, as determined by the survey interviewers, were advised to immediately visit the nearest possible health facility.

Examination of referral literature

The DHS Program's severe malaria signs/symptoms significantly overlap with danger signs for referral in existing literature. Additionally, The DHS Program's referral does not drastically vary from other non-DHS Program MIS surveys.

Based on this examination, The DHS Program is very liberal in asking about more signs/symptoms of severe malaria than what is outlined as danger signs by IMCI or the WHO guidance for use at health facilities. However, The DHS Program does not ask about a stiff neck, which could be considered an optional sign/symptom in the future.

The DHS Program standard questions	IMCI general danger signs	WHO algorithm for malaria diagnosis and treatment
Loss of consciousness	Lethargic or unconscious	Lethargic or unconscious
Seizures	Have convulsions	Have convulsions
Inability to drink or breastfeed	Unable to drink or breastfeed	Unable to drink or breastfeed
Vomiting everything	Vomiting everything	Vomiting everything
Rapid breathing		Chest indrawing or stridor
Extreme weakness		Prostration
	Stiff neck	Stiff neck
Bleeding		
Jaundice		
Heart problems		
Dark urine		

What is missing:

The DHS Program has never validated caregiver's understanding of sign/symptom questions. While there is overlap between The DHS Program standard questions and the IMCI general danger sign questions (e.g., loss of consciousness, seizures, inability to drink or breastfeed, vomiting everything), we do not have a strong understanding of caregiver's knowledge of extreme weakness, bleeding, jaundice, heart problems, and dark urine in the absence of a clinical examination.

3.4 Referral scenarios

We explored three different referral scenarios to quantify the impact of changing the referral criteria on the ultimate number of children referred for care (Table 9).

Scenario 1 explored the implications of referring children based on the standard six DHS Program referral questions and a hemoglobin cutoff of <7.0 g/dL for all DHS Program surveys (both DHS and MIS surveys).

Scenario 2 explored dropping extreme weakness from the referrable set of severe symptoms because it is a common symptom that accompanies a malaria-positive diagnosis but is more subjective than many of the other symptoms.

Scenario 3 explored streamlining the referral questions to those that are easier to assess and are more indicative of extreme illness. This reduced set is restricted to loss of consciousness, rapid breathing, seizures, or hemoglobin <7.0 g/dL.

Table 9 Referral review scenarios

Symptoms	Standard six DHS Program referral Extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, jaundice, or hemoglobin <8 g/dL	Comprehensive referral Standard six or survey-specific severe malaria questions or hemoglobin <8 g/dL	Scenario 1 Standard six DHS Program referral or hemoglobin <7 g/dL	Scenario 2 Standard six DHS Program referral (except extreme weakness) or hemoglobin <7 g/dL	Scenario 3 Loss of consciousness, rapid breathing, seizures, or hemoglobin <7.0 g/dL
Standard Questions					
Extreme weakness	X	X	X		
Loss of consciousness	X	X	X	X	X
Rapid breathing	X	X	X	X	X
Seizures	X	X	X	X	X
Bleeding	X	X	X	X	
Jaundice	X	X	X	X	
Survey-Specific Questions					
Heart problems		X			
Inability to drink or breastfeed		X			
Vomiting everything		X			
Dark urine		X			
Anemia					
Hemoglobin <8.0 g/dL (not adjusted for altitude)	X	X			
Hemoglobin <7.0 g/dL (not adjusted for altitude)			X	X	X

3.4.1 Scenarios by survey

Scenario 1 (standard six DHS Program severe malaria questions or hemoglobin <7 g/dL)

The criteria for scenario 1 include the standard DHS Program referral, but with the hemoglobin cutoff for referral shifted to <7.0 g/dL. Under this scenario 16% of malaria-positive children would have been referred. By survey, scenario 1 referral rates range from 4% of children in the Kenya MIS 2015 to 42% of children in the Senegal DHS 2012-13 (Table 10).

Scenario 2 (standard six DHS Program severe malaria questions (except extreme weakness) or hemoglobin <7 g/dL)

For scenario 2 the criteria for referral include all standard six DHS Program severe malaria questions *except extreme weakness* and a hemoglobin cutoff of <7.0 g/dL. Under this scenario 13% of malaria-positive children would have received a referral. By survey, scenario 2 referral rates range from 4% of children in the Kenya MIS 2015 to 30% of children in the Guinea DHS 2012 (Table 10).

Scenario 3 (loss of consciousness, rapid breathing, seizures, or hemoglobin <7.0 g/dL)

Scenario 3 is restricted to a limited number of questions on severe malaria symptoms including loss of consciousness, rapid breathing, seizures, or hemoglobin <7.0 g/dL. In scenario 3, 11% of malaria-positive children are referred to the nearest health facility. By survey, scenario 3 referral rates range from 3% of children in the Kenya MIS 2015 to 26% of children in the Guinea DHS 2012 (Table 10).

Table 10 shows the percentage referred by scenario among children age 6-59 months with malaria according to RDT. The three surveys with the highest percentage referred by scenario are shaded yellow and the three surveys with the lowest percentage referred by scenario are shaded in green.

Table 10 Among children age 6-59 months with malaria according to RDT, the percentage referred by scenario

	Standard six DHS Program referral	Comprehensive referral	Scenario 1	Scenario 2	Scenario 3	
	Extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, jaundice, or hemoglobin <8 g/dL	Standard six or survey-specific severe malaria questions or hemoglobin <8 g/dL	Standard six DHS Program referral or hemoglobin <7 g/dL	Standard six DHS Program referral (except extreme weakness) or hemoglobin <7 g/dL	Loss of consciousness, rapid breathing, seizures, or hemoglobin <7.0 g/dL	Number of children age 6-59 months with malaria infection according to RDT
Country/Survey	**%**	**%**	**%**	**%**	**%**	**N**
Angola DHS 2015-16	37.0	37.6	28.7	20.1	15.5	891
Benin DHS 2017-18	18.6	20.9	10.9	9.3	8.0	2,241
Burkina Faso MIS 2014	38.0	40.8	22.5	20.7	19.5	3,613
Burkina Faso MIS 2017	21.0	21.3	11.5	11.3	10.4	1,123
Burundi MIS 2012	23.3	23.6	16.6	15.0	14.6	838
Burundi DHS 2016-2017	16.1	16.2	11.3	8.7	7.9	2,204
DRC DHS 2013-14	28.8	31.0	19.4	14.7	13.6	2,536
Ghana DHS 2014	21.3	22.3	8.1	5.5	5.2	929
Ghana MIS 2016	19.0	20.0	7.6	6.6	6.5	801
Guinea DHS 2012	44.3	47.1	35.1	29.9	25.8	1,513
Kenya MIS 2015	6.9	6.9	4.1	3.6	3.3	277
Liberia MIS 2011	14.2	15.5	7.4	5.6	5.6	1,304
Liberia MIS 2016	15.1	15.3	8.9	7.7	7.5	1,290
Madagascar MIS 2011	41.3	45.4	39.4	24.8	19.0	546
Madagascar MIS 2013	30.0	33.2	25.7	17.7	13.3	557
Madagascar MIS 2016	20.1	20.8	16.3	11.8	10.0	338
Malawi MIS 2012	21.2	21.9	14.3	12.0	11.0	946
Malawi MIS 2014	18.3	18.6	13.9	5.0	4.9	738
Malawi MIS 2017	11.2	11.2	7.2	6.8	6.8	892
Mali MIS 2015	46.0	50.1	32.6	29.3	23.0	2,293
Mali DHS 2018	46.6	53.1	32.8	27.8	24.5	836
Mozambique HMIS 2015	15.3	15.3	8.5	7.8	7.2	1,867
Mozambique MIS 2018	34.0	35.2	24.6	18.1	16.3	1,723
Nigeria MIS 2015	19.7	19.9	10.8	8.3	8.1	2,726
Nigeria DHS 2018-19	20.8	20.8	12.9	7.4	7.1	4,109
Senegal DHS 2012-13	56.4	56.4	42.1	20.3	18.1	174
Senegal DHS 2014	47.3	48.5	39.1	11.9	11.9	61
Senegal DHS 2015	38.2	39.3	30.4	19.0	19.0	34
Senegal DHS 2016	34.2	34.2	21.9	16.6	16.6	46
Sierra Leone MIS 2016	16.9	17.6	9.9	9.2	8.1	3,502
Tanzania HMIS 2011-12	23.5	28.7	17.6	9.0	8.5	684
Tanzania DHS 2015-16	18.2	18.2	10.6	8.6	6.8	1,275
Tanzania MIS 2017	11.4	11.4	4.5	4.5	4.5	491
Togo DHS 2013-14	26.8	29.8	18.9	11.8	9.4	1,133
Togo MIS 2017	13.9	13.9	9.6	8.8	7.8	1,299
Uganda MIS 2014-15	11.4	11.5	7.6	5.4	4.7	1,402
Uganda DHS 2016	17.2	17.7	13.9	10.7	9.9	1,431
Total	**24.1**	**25.4**	**15.9**	**12.6**	**11.2**	**48,663**

Exploration of referral scenarios

It is inevitable that The DHS Program interview and anemia/malaria testing process will identify children who are severely sick. The DHS Program field teams are not prepared to diagnose or treat severe malaria, and often are not staffed with medical providers—and yet it is not appropriate to identify severely ill children and not offer at least some opportunity for treatment. To date, that has been done through referrals to health facilities. The number of children referred to the health facilities depends entirely on the criteria used to define severe malaria. In exploring different referral scenarios, we see a 14 percentage point difference between the most liberal "comprehensive" referral scenario (25%) and the most restrictive hypothetical scenario (11%).

What is missing:

What is not clear, however, is whether the current protocol or any of the hypothetical scenarios is referring the optimum number of severe malaria cases. A very liberal referral protocol may overwhelm an already inundated health care system with uncomplicated malaria cases misclassified as severe malaria, and/or miss children who could have received simple ACT treatment in their own home through the survey field teams. A very conservative protocol might fail to refer severely sick children.

In addition, regardless of the percentage and number of referrals that do occur, The DHS Program does not know how many children are actually taken to the health facility or their official diagnosis by a health care provider. Without this information it is impossible to determine whether the referral processes are effective, overly sensitive, or not sufficiently inclusive. Not giving them ACTs is a missed opportunity, especially if we don't know if they actually go to a health facility for follow-up care. Devoid of data on ultimate receipt of care and diagnosis, we cannot directly compare the results of this analysis to existing literature, which is based on data from the formal health care system.

4 RECOMMENDATIONS

The analytical purpose of this paper is to examine the proportion of children who are referred to a health facility as part of the standard severe malaria referral process in DHS Program surveys. Secondly, we hoped to use that information to inform a new severe malaria referral process for future surveys. We had three key questions in mind:

1. Does the current DHS referral system misclassify children with uncomplicated malaria as having severe malaria, thus, referring children unnecessarily to a (potentially overwhelmed) health facility?

2. Does the current protocol miss an opportunity to provide ACT treatment to more children? Assuming that some referred children will not reach a health facility, would it be better to at least provide ACT? Does provision of ACT discourage households from seeking care?

3. Should The DHS Program also ask about severe malaria (illness) symptoms among malaria-negative children (and therein expand the referral protocol) as a health care service to the community? Do the benefits of this expansion outweigh the additional burden on the survey process?

While analysis of different referral scenarios helped to explore the potential number of children who would be referred under different protocols, the data do not shed light on the actual receipt of care among referred children, or their ultimate diagnosis. Without these critical pieces of information, we cannot make an evidence-based recommendation for a change to the current protocol. It is not possible to know if the current system is under- or over-reporting children, or the possible impact of referring malaria-negative severely sick children. Instead, we use our findings to recommend a series of next steps that will facilitate future analysis in this area and propose mechanisms through which the stakeholder community could answer the three questions above.

4.1 Next Steps: Improving documentation and standardization of DHS Program severe malaria referral protocol

As a result of this review, The DHS Program makes the following recommendations to further streamline the current health facility referrals process and facilitate future analysis of these data.

1) Improve the precision of "extreme weakness" reporting

Among children positive for malaria across all surveys, extreme weakness (7%) was the most prevalent standard sign/symptom of severe malaria. Prostration is the clinical definition of "extreme weakness". The WHO Management of Severe Malaria Handbook defines prostration as "generalized weakness so that the patient is unable to sit, stand, or walk without assistance".[1] The WHO Severe Malaria Supplemental report adds that, in children not old enough to sit up, prostration is defined as the inability to breastfeed.[2]

While extreme weakness is a clinical symptom of malaria, without these more specific prompts, it is a vague concept, which has perhaps led to over-reporting in surveys with malaria testing. The DHS Program recommends adding additional contextual information to "extreme weakness" to improve the precision of the symptom question.

Old: Does (NAME) suffer from any of the following illnesses or symptoms: extreme weakness?

New: Does (NAME) suffer from any of the following illnesses or symptoms: Extreme weakness? That is, the inability to walk, stand, or sit without assistance?

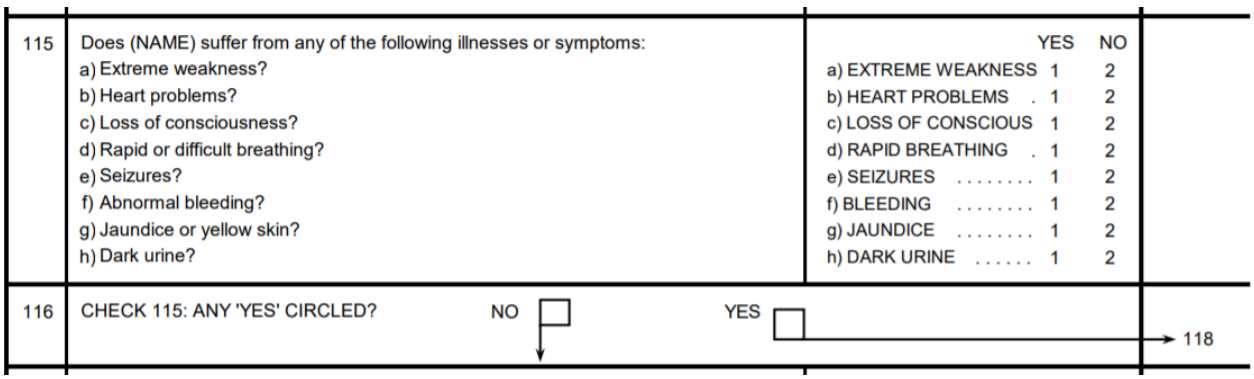
The DHS Program will also add contextual information cited above from WHO about the definition of extreme weakness to the standardized training materials for malaria referral.

2) Generalizing the referral label

In The DHS Program Biomarker Questionnaire, if a child is positive for malaria and has signs or symptoms of severe malaria, we give them a "severe malaria referral". After conducting this analysis, we suspect that children are not being referred for severe malaria alone. We recommend shifting the language from "severe malaria referral" to something that is more general such as "possible severe malaria referral". This is a very minor change that will make referral less definitive and more inclusive of potential co-morbidities.

3) Recoding severe malaria referral questions

DHS survey data are shared through a recode data file that is generated from the raw data. All variables in the raw data file are represented in the recode data file in a standardized format, with the same structure across countries participating in each DHS phase. This standardization is meant to facilitate comparative analysis across surveys. Severe malaria questions were added to questionnaires in 2011 but were never standardly recoded in the datasets. To conduct an analysis with non-recoded variables such as this one, researchers must map each survey variable to individual questions. Going forward, The DHS Program recommends standardly recoding the severe malaria questions in the dataset. This will facilitate future tabulation and analysis of this topic. We also recommend recoding Q116, which summarizes the presence of any of the severe malaria signs/symptoms in children, to clarify that this is the measure of children referred to a health facility. By standardly recoding these variables, program managers and researchers will be able to quickly tabulate the percentage of health facility referrals that were due to severe malaria questions as part of the survey.



4) Better documentation of field team clinical training credentials

Interviewer effects on demographic and health survey data have been documented.[23] We were therefore curious as to whether the severe malaria (illness) referral process was linked with biomarker technicians having medical credentials, or whether their role (whether they served only as a biomarker technician or both as a biomarker technician and an interviewer) was linked with referral decisions. However, this review highlighted that The DHS Program has not consistently documented the credentials of biomarker

technicians or their roles within a team in public documentation. In addition, survey final reports have not consistently documented the roles among the biomarker and other fieldworkers. We hypothesize that a biomarker technician's clinical background and role on the team will have an impact on performance and referrals but have not been able to test this theory with available data. Because individual countries have national policies about who can diagnose and treat children with malaria, The DHS Program cannot standardize these requirements across surveys.

We recommend adding questions about clinical/medical training to the standard DHS Fieldworker Questionnaire. In place since 2015, the Fieldworker Questionnaire collects information about the survey field staff, including basic demographic information and educational levels obtained. However, the current questionnaire does not capture the subject area studied or any specific credentials received. Adding questions to the Fieldworker Questionnaire about the clinical qualifications of the survey team member would help further our understanding of fieldworker effects on health facility referral. Lastly, we recommend adding standard language to final reports that documents the general credentials of the biomarker technicians (clinical or nonclinical) and their roles on the team.

5) Create standardized training materials on severe malaria referral

The DHS Program strengthens capacity in partner countries to implement high-quality DHS Program surveys. DHS technical assistance and capacity strengthening includes equipping biomarker technicians with the skills and techniques to efficiently and effectively measure and test biomarkers in field conditions, and accurately record and report the results as part of the survey process. The DHS Program will create an enhanced and standardized training module that describes in more detail (1) the importance of referral, (2) assessment of signs/symptoms, and (3) preparing biomarker technicians for scenarios that they might encounter during fieldwork.

6) Hemoglobin cut-offs

At the time of publication, The DHS Program had not yet confirmed a new hemoglobin cut-off in regard to the severe malaria referral, but the evidence presented here and in our hypothetical scenarios suggests that a hemoglobin cut-off of 8g/dL is too liberal, greatly limiting the number of children who are eligible to receive ACTs in the field. This analysis will be used to inform a new hemoglobin cut-off in future DHS and MIS surveys.

REFERENCES

1. World Health Organization. 2013. *Management of severe malaria – A practical handbook*. Third edition.

2. 2014. Severe malaria. *Trop Med Int Health* 19 Suppl 1: 7-131.

3. Okiro EA, Al-Taiar A, Reyburn H, Idro R, Berkley JA, Snow RW, 2009. Age patterns of severe paediatric malaria and their relationship to Plasmodium falciparum transmission intensity. *Malaria Journal* 8: 4.

4. Carneiro I, Roca-Feltrer A, Griffin JT, Smith L, Tanner M, Schellenberg JA, Greenwood B, Schellenberg D. 2010. Age-Patterns of Malaria Vary with Severity, Transmission Intensity and Seasonality in Sub-Saharan Africa: A Systematic Review and Pooled Analysis. *PLOS ONE* 5: e8988.

5. Roca-Feltrer A, Carneiro I, Smith L, Schellenberg JRMA, Greenwood B, Schellenberg D. 2010. The age patterns of severe malaria syndromes in sub-Saharan Africa across a range of transmission intensities and seasonality settings. *Malaria Journal* 9: 282.

6. Dalrymple U, Cameron E, Bhatt S, Weiss DJ, Gupta S, Gething PW. 2017. Quantifying the contribution of Plasmodium falciparum malaria to febrile illness amongst African children. *Elife* 6.

7. Wilson ML, Krogstad DJ, Arinaitwe E, Arevalo-Herrera M, Chery L, Ferreira MU, Ndiaye D, Mathanga DP, Eapen A. 2015. Urban Malaria: Understanding its Epidemiology, Ecology, and Transmission Across Seven Diverse ICEMR Network Sites. *The American journal of tropical medicine and hygiene* 93: 110-123.

8. Degarege A, Fennie K, Degarege D, Chennupati S, Madhivanan P. 2019. Improving socioeconomic status may reduce the burden of malaria in sub Saharan Africa: A systematic review and meta-analysis. *PloS one* 14: e0211205-e0211205.

9. World Health Organization. 2019. *World Malaria Report*. Geneva: World Health Organization.

10. Battle KE, Bisanzio D, Gibson HS, Bhatt S, Cameron E, Weiss DJ, Mappin B, Dalrymple U, Howes RE, Hay SI, Gething PW. 2016. Treatment-seeking rates in malaria endemic countries. *Malaria Journal* 15: 20.

11. World Health Organization. 2011. *Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity*. Geneva, World Health Organization: Vitamin and Mineral Nutrition Information System.

12. Karakochuk CD, Hess SY, Moorthy D, Namaste S, Parker ME, Rappaport AI, Wegmüller R, Dary O. 2019. Measurement and interpretation of hemoglobin concentration in clinical and field settings: a narrative review. *Annals of the New York Academy of Sciences* 1450: 126-146.

13. Pappas G, Hyder AA. 2005. Exploring ethical considerations for the use of biological and physiological markers in population-based surveys in less developed countries. *Global Health* 1: 16.

14. World Health Organization. 2019. *Malaria Fact Sheet*. Available at: https://www.who.int/news-room/fact-sheets/detail/malaria. Accessed February 1, 2021.

15. Bejon P, Berkley JA, Mwangi T, Ogada E, Mwangi I, Maitland K, Williams T, Scott JAG, English M, Lowe BS, Peshu N, Newton CRJC, Marsh K. 2007. Defining Childhood Severe Falciparum Malaria for Intervention Studies. *PLOS Medicine* 4: e251.

16. Gwer S, Newton CRJC, Berkley JA. 2007. Over-diagnosis and co-morbidity of severe malaria in African children: a guide for clinicians. *The American journal of tropical medicine and hygiene* 77: 6-13.

17. Gera T, Shah D, Garner P, Richardson M, Sachdev HS. 2016. Integrated management of childhood illness (IMCI) strategy for children under five. *Cochrane Database of Systematic Reviews*.

18. Church J, Maitland K. 2014. Invasive bacterial co-infection in African children with Plasmodium falciparum malaria: a systematic review. *BMC Medicine* 12: 31.

19. Berkley JA, Bejon P, Mwangi T, Gwer S, Maitland K, Williams TN, Mohammed S, Osier F, Kinyanjui S, Fegan G, Lowe BS, English M, Peshu N, Marsh K, Newton CRJC. 2009. HIV Infection, Malnutrition, and Invasive Bacterial Infection among Children with Severe Malaria. *Clinical Infectious Diseases* 49: 336-343.

20. World Health Organization. 2014. *IMCI chart booklet*.

21. World Health Organization. 2018. *Integrated Management of Childhood Illness (IMCI)*. Available at: https://www.who.int/maternal_child_adolescent/topics/child/imci/en/. Accessed February 1, 2021.

22. World Health Organization. 2013. *Universal access to malaria diagnostic testing – An operational manual*.

23. Pullum TW, Juan C, Khan N, Staveteig S, 2018. *The effect of interviewer characteristics on data quality in DHS surveys*. DHS Methodological Reports No. 24. Rockville, Maryland, USA: ICF.

APPENDIX

Figure A.1 Severe malaria referral form from the 2020 Kenya MIS

2020 KENYA MALARIA INDICATOR SURVEY

Severe Malaria Referral

During the 2020 KENYA MIS _____ (Name), age __ __ months or years, was tested for malaria on __ __/__ __/__ __, with a Rapid Diagnostic Test (RDT). He/she tested positive for malaria, and is displaying the following signs of severe malaria:

___ INABILITY TO SIT OR STAND
___ INABILITY TO EAT/DRINK BREAST MILK
___PALE AND /OR COLD EXTREMITIES
___PERSISTENT VOMITING
___HEART PROBLEMS
___LOSS OF CONSCIOUSNESS
___RAPID OR DIFFICULT BREATHING
___SEIZURES
___ABNORMAL BLEEDING
___YELLOW SKIN
___DARK OR BROWN URINE
___HEMOGLOBIN LEVEL OF __ __. __ g/dl (LESS THAN 8.0 g/dl)

THIS CHILD DID NOT RECEIVE TREATMENT FOR MALARIA, SO, HE/SHE NEEDS TO BE TAKEN TO A HEALTH FACILITY RIGHT AWAY.

Name of field staff (2020 KMIS).....Signature.....

Date.....

Figure A.2 Severe anemia referral form from the 2020 Kenya MIS

2020 KENYA MALARIA INDICATOR SURVEY (KMIS)

Severe Anaemia Referral

During the 2020 KENYA MIS, child_____ ,

age __ __ years/months, was tested for anemia on __ __/__ __/__ __. His/her level of hemoglobin was __ __.__ g/dl, which indicates he/she has severe anemia.

This child needs medical attention to treat the anemia

Table A.1 Proportion of children age 6-59 months with malaria (RDT)

	Proportion of children age 6-59 months with malaria (RDT)	
Country/Survey	**%**	**N**
Angola DHS 2015-16	13.4	6,639
Benin DHS 2017-18	36.3	6,165
Burkina Faso MIS 2014	61.4	5,887
Burkina Faso MIS 2017	20.2	5,550
Burundi MIS 2012	21.9	3,820
Burundi DHS 2016-2017	37.9	5,809
DRC DHS 2013-14	30.8	8,238
Ghana DHS 2014	36.4	2,556
Ghana MIS 2016	27.9	2,874
Guinea DHS 2012	46.9	3,224
Kenya MIS 2015	9.0	3,067
Liberia MIS 2011	44.7	2,917
Liberia MIS 2016	45.0	2,866
Madagascar MIS 2011	8.7	6,268
Madagascar MIS 2013	10.0	5,565
Madagascar MIS 2016	5.1	6,569
Malawi MIS 2012	43.4	2,182
Malawi MIS 2014	37.1	1,991
Malawi MIS 2017	36.0	2,482
Mali MIS 2015	32.4	7,080
Mali DHS 2018	19.0	4,406
Mozambique HMIS 2015	40.6	4,602
Mozambique MIS 2018	38.9	4,423
Nigeria MIS 2015	45.1	6,046
Nigeria DHS 2018-19	36.2	11,350
Senegal DHS 2012-13	3.3	5,289
Senegal DHS 2014	1.1	5,451
Senegal DHS 2015	0.6	5,475
Senegal DHS 2016	0.9	5,235
Sierra Leone MIS 2016	52.7	6,643
Tanzania HMIS 2011-12	9.2	7,393
Tanzania DHS 2015-16	14.4	8,843
Tanzania MIS 2017	7.3	6,707
Togo DHS 2013-14	38.0	2,977
Togo MIS 2017	43.9	2,958
Uganda MIS 2014-15	31.7	4,423
Uganda DHS 2016	30.3	4,716
Total	**25.8**	**188,686**

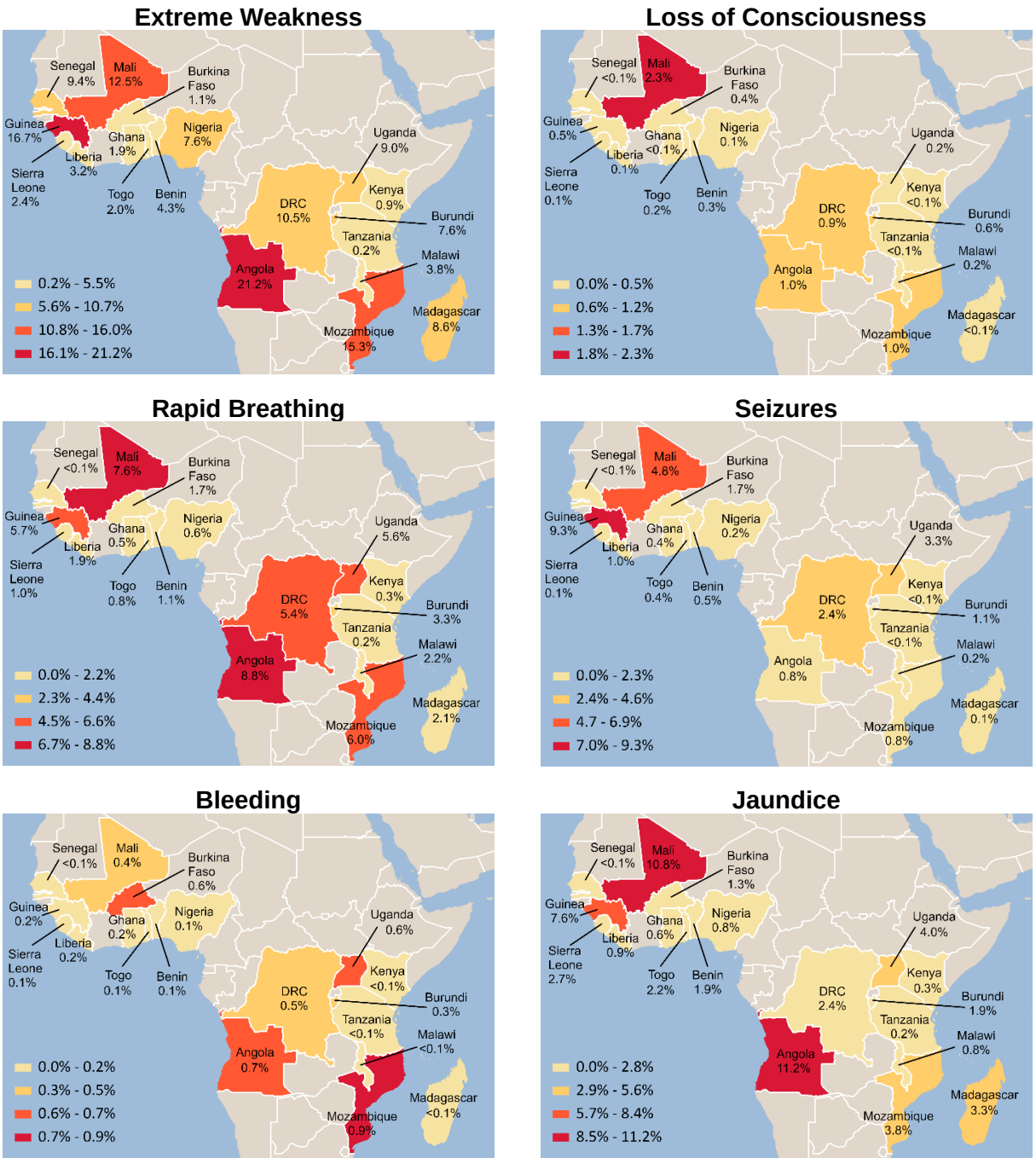
Table A.2 Severe malaria questions found across surveys

Country/ Survey	Extreme weakness	Heart problems	Inability to drink or breastfeed	Vomiting everything	Loss of conscious-ness	Rapid breathing	Seizures	Bleeding	Jaundice	Dark urine
Angola DHS 2015-16	X	X			X	X	X	X	X	X
Benin DHS 2017-18	X	X			X	X	X	X	X	X
Burkina Faso MIS 2014	X	X			X	X	X	X	X	X
Burkina Faso MIS 2017	X	X			X	X	X	X	X	X
Burundi MIS 2012	X	X			X	X	X	X	X	X
Burundi DHS 2016-2017	X	X			X	X	X	X	X	X
DRC DHS 2013-14	X			X	X	X	X	X	X	X
Ghana DHS 2014	X		X	X	X	X	X	X	X	X
Ghana MIS 2016	X		X	X	X	X	X	X	X	
Guinea DHS 2012	X	X			X	X	X	X	X	X
Kenya MIS 2015	X	X			X	X	X	X	X	X
Liberia MIS 2011	X	X	X	X	X	X	X	X	X	X
Liberia MIS 2016	X	X			X	X	X	X	X	X
Madagascar MIS 2011	X			X	X	X	X	X	X	X
Madagascar MIS 2013	X			X	X	X	X	X	X	X
Madagascar MIS 2016	X			X	X	X	X	X	X	X
Malawi MIS 2012	X	X			X	X	X	X	X	X
Malawi MIS 2014	X	X			X	X	X	X	X	X
Malawi MIS 2017	X	X			X	X	X	X	X	X
Mali MIS 2015	X	X			X	X	X	X	X	X
Mali DHS 2018	X		X	X	X	X	X	X	X	
Mozambique HMIS 2015	X	X			X	X	X	X	X	X
Mozambique MIS 2018	X	X			X	X	X	X	X	X
Nigeria MIS 2015	X	X			X	X	X	X	X	X
Nigeria DHS 2018-19	X	X			X	X	X	X	X	X
Senegal DHS 2012-13	X	X			X	X	X	X	X	X
Senegal DHS 2014	X	X			X	X	X	X	X	X
Senegal DHS 2015	X	X			X	X	X	X	X	X
Senegal DHS 2016	X	X			X	X	X	X	X	X
Sierra Leone MIS 2016	X	X			X	X	X	X	X	X
Tanzania HMIS 2011-12	X		X	X	X	X	X	X	X	
Tanzania DHS 2015-16	X	X			X	X	X	X	X	X
Tanzania MIS 2017	X	X			X	X	X	X	X	X
Togo DHS 2013-14	X	X			X	X	X	X	X	X
Togo MIS 2017	X	X			X	X	X	X	X	X
Uganda MIS 2014-15	X	X			X	X	X	X	X	X
Uganda DHS 2016	X	X			X	X	X	X	X	X

Table A.3 Standard six severe malaria symptoms: among children age 6-59 months with malaria according to RDT, percentage classified as having extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, or jaundice by survey

Country/Survey	Among children age 6-59 months with malaria according to RDT, percentage classified as having the following symptoms:						Number of children age 6-59 months with malaria according to RDT
	Extreme weakness	Loss of consciousness	Rapid breathing	Seizures	Bleeding	Jaundice	
Angola DHS 2015-16	21.2	1.0	8.8	0.8	0.7	11.2	891
Benin DHS 2017-18	4.3	0.3	1.1	0.5	0.1	1.9	2,241
Burkina Faso MIS 2014	4.8	0.5	<0.1	0.7	0.4	1.8	3,613
Burkina Faso MIS 2017	1.1	0.4	1.7	1.7	0.6	1.3	1,123
Burundi MIS 2012	11.0	2.0	9.0	2.8	0.5	3.9	838
Burundi DHS 2016-2017	7.6	0.6	3.3	1.1	0.3	1.9	2,204
DRC DHS 2013-14	10.5	0.9	5.4	2.4	0.5	2.4	2,536
Ghana DHS 2014	4.0	<0.1	0.7	0.3	0.1	0.3	929
Ghana MIS 2016	1.9	<0.1	0.5	0.4	0.2	0.6	801
Guinea DHS 2012	16.7	0.5	5.7	9.3	0.2	7.6	1,513
Kenya MIS 2015	0.9	<0.1	0.3	<0.1	<0.1	0.3	277
Liberia MIS 2011	3.6	0.3	0.7	0.7	<0.1	0.2	1,304
Liberia MIS 2016	3.2	0.1	1.9	1.0	0.2	0.9	1,290
Madagascar MIS 2011	24.4	1.0	14.1	3.7	3.4	11.1	546
Madagascar MIS 2013	16.4	1.8	5.3	4.8	2.2	8.5	557
Madagascar MIS 2016	8.6	<0.1	2.1	0.1	<0.1	3.3	338
Malawi MIS 2012	8.8	1.4	5.1	0.7	0.3	2.2	946
Malawi MIS 2014	10.1	0.1	1.2	0.0	0.1	0.5	738
Malawi MIS 2017	3.8	0.2	2.2	0.2	<0.1	0.8	892
Mali MIS 2015	7.9	0.3	3.8	1.3	0.0	10.7	2,293
Mali DHS 2018	12.5	2.3	7.6	4.8	0.4	10.8	836
Mozambique HMIS 2015	2.5	<0.1	1.9	<0.1	<0.1	2.3	1,867
Mozambique MIS 2018	15.3	1.0	6.0	0.8	0.9	3.8	1,723
Nigeria MIS 2015	3.8	0.2	0.9	0.2	<0.1	0.5	2,726
Nigeria DHS 2018-19	7.6	0.1	0.6	0.2	0.1	0.8	4,109
Senegal DHS 2012-13	24.4	<0.1	0.5	<0.1	<0.1	2.8	174
Senegal DHS 2014	31.7	<0.1	<0.1	<0.1	<0.1	<0.1	61
Senegal DHS 2015	11.5	<0.1	<0.1	<0.1	<0.1	<0.1	34
Senegal DHS 2016	9.4	<0.1	<0.1	<0.1	<0.1	<0.1	46
Sierra Leone MIS 2016	2.4	0.1	1.0	0.1	0.1	2.7	3,502
Tanzania HMIS 2011-12	12.7	0.9	1.6	1.2	<0.1	0.7	684
Tanzania DHS 2015-16	6.1	0.4	2.2	0.7	0.1	2.8	1,275
Tanzania MIS 2017	0.2	<0.1	0.2	<0.1	<0.1	0.2	491
Togo DHS 2013-14	11.2	1.4	3.3	0.8	0.6	2.8	1,133
Togo MIS 2017	2.0	0.2	0.8	0.4	0.1	2.2	1,299
Uganda MIS 2014-15	4.1	0.2	1.6	0.5	0.3	1.3	1,402
Uganda DHS 2016	9.0	0.2	5.6	3.3	0.6	4.0	1,431
Total	**7.2**	**0.5**	**2.8**	**1.2**	**0.3**	**2.9**	**48,663**

Figure A.3 Standard six severe malaria symptoms: among children age 6-59 months with malaria according to RDT, percentage classified as having extreme weakness, loss of consciousness, rapid breathing, seizures, bleeding, or jaundice by country's most recent survey



Countries most recent surveys included in figure: Angola DHS 2015-16, Benin DHS 2017-18, Burkina Faso MIS 2017, Burundi DHS 2016-2017, DRC DHS 2013-14, Ghana MIS 2016, Guinea DHS 2012, Kenya MIS 2015, Liberia MIS 2016, Madagascar MIS 2016, Malawi MIS 2017, Mali DHS 2018, Mozambique MIS 2018, Nigeria DHS 2018-19, Senegal DHS 2016, Sierra Leone MIS 2016, Tanzania MIS 2017, Togo MIS 2017, and Uganda DHS 2016

Table A.4 Among children age 6-59 months with malaria infection according to RDT, percentage classified as having heart problems by survey

Country/Survey	Among children age 6-59 months with malaria according to RDT, percentage classified as having heart problems	Number of children age 6-59 months with malaria according to RDT
Angola DHS 2015-16	2.1	891
Benin DHS 2017-18	0.1	2,241
Burkina Faso MIS 2014	0.1	3,613
Burkina Faso MIS 2017	0.5	1,123
Burundi MIS 2012	3.1	838
Burundi DHS 2016-2017	0.5	2,204
Guinea DHS 2012	0.5	1,513
Kenya MIS 2015	<0.1	277
Liberia MIS 2011	<0.1	1,304
Liberia MIS 2016	<0.1	1,290
Malawi MIS 2012	0.5	946
Malawi MIS 2014	0.4	738
Malawi MIS 2017	0.2	892
Mali MIS 2015	0.2	2,293
Mozambique HMIS 2015	0.1	1,867
Mozambique MIS 2018	2.0	1,723
Nigeria MIS 2015	0.2	2,726
Nigeria DHS 2018-19	0.3	4,109
Senegal DHS 2012-13	<0.1	174
Senegal DHS 2014	<0.1	61
Senegal DHS 2015	<0.1	34
Senegal DHS 2016	<0.1	46
Sierra Leone MIS 2016	0.1	3,502
Tanzania DHS 2015-16	0.2	1,275
Tanzania MIS 2017	<0.1	491
Togo DHS 2013-14	3.0	1,133
Togo MIS 2017	0.2	1,299
Uganda MIS 2014-15	0.1	1,402
Uganda DHS 2016	0.4	1,431
Total	**0.5**	**41,436**

Table A.5 Among children age 6-59 months with malaria according to RDT, percentage with an inability to drink or breastfeed by survey

Country/Survey	Among children age 6-59 months with malaria according to RDT, percentage with an inability to drink or breastfeed	Number of children age 6-59 months with malaria according to RDT
Ghana DHS 2014	3.2	929
Ghana MIS 2016	1.8	801
Liberia MIS 2011	4.2	1,304
Mali DHS 2018	23.9	836
Tanzania HMIS 2011-12	12.8	684
Total	**8.5**	**4,554**

Table A.6 Among children age 6-59 months with malaria according to RDT, percentage vomiting everything by survey

Country/Survey	Among children age 6-59 months with malaria according to RDT, percentage vomiting everything	Number of children age 6-59 months with malaria according to RDT
DRC DHS 2013-14	10.3	2,536
Ghana DHS 2014	3.7	929
Ghana MIS 2016	2.0	801
Liberia MIS 2011	3.4	1,304
Madagascar MIS 2011	11.6	546
Madagascar MIS 2013	10.2	557
Madagascar MIS 2016	5.6	338
Mali DHS 2018	15.5	836
Tanzania HMIS 2011-12	6.2	684
Total	**7.8**	**8,531**

Table A.7 Among children age 6-59 months with malaria according to RDT, percentage with dark urine by survey

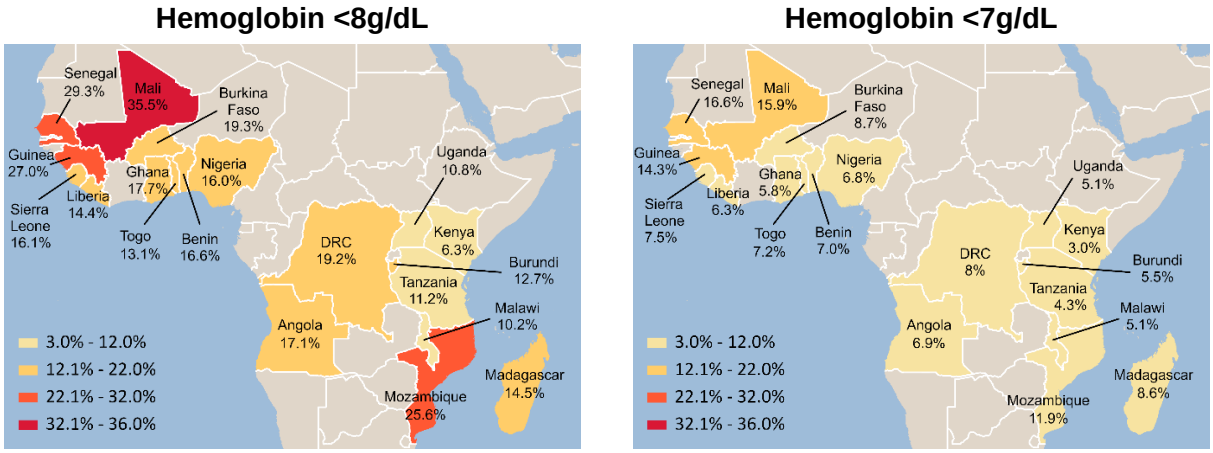
Country/Survey	Among children age 6-59 months with malaria infection according to RDT, percentage with dark urine	Number of children age 6-59 months with malaria according to RDT
Angola DHS 2015-16	6.2	891
Benin DHS 2017-18	7.0	2,241
Burkina Faso MIS 2014	9.3	3,613
Burkina Faso MIS 2017	1.7	1,123
Burundi MIS 2012	6.1	838
Burundi DHS 2016-2017	3.0	2,204
DRC DHS 2013-14	1.7	2,536
Ghana DHS 2014	0.3	929
Guinea DHS 2012	19.7	1,513
Kenya MIS 2015	0.1	277
Liberia MIS 2011	1.2	1,304
Liberia MIS 2016	2.3	1,290
Madagascar MIS 2011	2.4	546
Madagascar MIS 2013	2.5	557
Madagascar MIS 2016	0.4	338
Malawi MIS 2012	2.7	946
Malawi MIS 2014	1.7	738
Malawi MIS 2017	0.7	892
Mali MIS 2015	14.8	2,293
Mozambique HMIS 2015	0.1	1,867
Mozambique MIS 2018	4.9	1,723
Nigeria MIS 2015	0.9	2,726
Nigeria DHS 2018-19	0.5	4,109
Senegal DHS 2012-13	<0.1	174
Senegal DHS 2014	1.3	61
Senegal DHS 2015	5.2	34
Senegal DHS 2016	<0.1	46
Sierra Leone MIS 2016	5.9	3,502
Tanzania DHS 2015-16	1.0	1,275
Tanzania MIS 2017	<0.1	491
Togo DHS 2013-14	12.7	1,133
Togo MIS 2017	1.8	1,299
Uganda MIS 2014-15	0.7	1,402
Uganda DHS 2016	3.5	1,431
Total	**4.5**	**46,342**

Table A.8 Among children age 6-59 months with malaria according to RDT, percentage with hemoglobin <8 g/dL and <7 g/dL by survey

Country/Survey	Among children age 6-59 months with malaria according to RDT, percentage classified as having the following hemoglobin levels:		Number of children age 6-59 months with malaria according to RDT
	Hemoglobin <8g/dL[1]	Hemoglobin <7g/dL[1]	
Angola DHS 2015-16	17.1	6.9	891
Benin DHS 2017-18	16.6	7.0	2,241
Burkina Faso MIS 2014	34.6	17.7	3,613
Burkina Faso MIS 2017	19.3	8.7	1,123
Burundi MIS 2012	19.1	8.7	838
Burundi DHS 2016-2017	12.7	5.5	2,204
DRC DHS 2013-14	19.2	8.0	2,536
Ghana DHS 2014	18.7	4.7	929
Ghana MIS 2016	17.7	5.8	801
Guinea DHS 2012	27.0	14.3	1,513
Kenya MIS 2015	6.3	3.0	277
Liberia MIS 2011	13.1	4.6	1,304
Liberia MIS 2016	14.4	6.3	1,290
Madagascar MIS 2011	5.1	1.6	546
Madagascar MIS 2013	13.9	4.9	557
Madagascar MIS 2016	14.5	8.6	338
Malawi MIS 2012	14.5	6.3	946
Malawi MIS 2014	9.8	4.0	738
Malawi MIS 2017	10.2	5.1	892
Mali MIS 2015	37.6	20.0	2,293
Mali DHS 2018	35.5	15.9	836
Mozambique HMIS 2015	14.3	6.3	1,867
Mozambique MIS 2018	25.6	11.9	1,723
Nigeria MIS 2015	17.0	7.2	2,726
Nigeria DHS 2018-19	16.0	6.8	4,109
Senegal DHS 2012-13	36.8	18.1	174
Senegal DHS 2014	23.2	11.9	61
Senegal DHS 2015	32.0	19.0	34
Senegal DHS 2016	29.3	16.6	46
Sierra Leone MIS 2016	16.1	7.5	3,502
Tanzania HMIS 2011-12	12.9	6.3	684
Tanzania DHS 2015-16	12.4	4.4	1,275
Tanzania MIS 2017	11.2	4.3	491
Togo DHS 2013-14	17.5	5.5	1,133
Togo MIS 2017	13.1	7.2	1,299
Uganda MIS 2014-15	7.8	3.1	1,402
Uganda DHS 2016	10.8	5.1	1,431
Total	**18.6**	**8.4**	**48,663**

[1] Hemoglobin levels are not adjusted for altitude.

Figure A.4 Among children age 6-59 months with malaria according to RDT, percentage with hemoglobin <8 g/dL and <7 g/dL by country's most recent survey



Countries most recent surveys included in figure: Angola DHS 2015-16, Benin DHS 2017-18, Burkina Faso MIS 2017, Burundi DHS 2016-2017, DRC DHS 2013-14, Ghana MIS 2016, Guinea DHS 2012, Kenya MIS 2015, Liberia MIS 2016, Madagascar MIS 2016, Malawi MIS 2017, Mali DHS 2018, Mozambique MIS 2018, Nigeria DHS 2018-19, Senegal DHS 2016, Sierra Leone MIS 2016, Tanzania MIS 2017, Togo MIS 2017, and Uganda DHS 2016