Methods and Applications

Global Assistance and the Cascade of Malaria Prevention and Control — Sub-Saharan Africa, 2011–2022

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ABSTRACT

Introduction: Approximately 70% of funding for malaria prevention and control (P&C) in Sub-Saharan Africa comes from global assistance, yet progress has stagnated over the past decade.

Methods: We constructed a cascade of malaria P&C services and analyzed its coverage and quality across 26 African countries from 2011–2022. Panel analysis was conducted to examine the effectiveness of four major donors [the United States of America (USA), the United Kingdom (UK), the Global Fund to Fight AIDS, Tuberculosis and Malaria (GF), and United Nations International Children's Emergency Fund (UNICEF)], which account for 90% of global funding, in implementing the cascade.

Results: Recommended practice coverage doubled during 2011–2016 but decreased by 10% by 2022. Unrecommended practices followed the same pattern. Total funding from 2011–2020 reached 7.15 billion USA Dollar (USD), with the USA and GF steadily contributing 94.65%, while the UK and UNICEF demonstrated notable funding reductions. Overall, the funding showed limited correlation with the cascade coverage and quality, promoting directly only the upstream measures.

Conclusion: Our findings highlight four key challenges: retrogression of cascade coverage since the late 2010s, persistent gaps between recommended and unrecommended practices, funding constraints, and limited direct effects of donor funding. Strengthening health system capacity at the farthest end of the cascade may provide a solution to this dilemma.

Sub-Saharan Africa accounted for over 90% of global malaria cases and deaths annually after 2010, with approximately 75% of the total malaria prevention and control (P&C) funding sourced from global donors (*1*). The United States of America (USA), the United Kingdom (UK), the Global Fund to Fight AIDS, Tuberculosis and Malaria (GF), and the United Nations agencies provided about 90% of total global assistance, covering most countries in this region over the past decade (*1*). Through combined local and global efforts, malaria prevalence and mortality nearly halved from 2000 to 2015; however, this momentum has not been maintained, with a notable rebound following the coronavirus disease 2019 (COVID-19) pandemic (*2*). Given the current challenges and limited funding, it is imperative to identify the obstacles to malaria P&C progress in Sub-Saharan Africa and maximize the effectiveness of available resources. Although service coverage and quality have been identified as major barriers to malaria P&C development in Africa, few studies in the past five years have comprehensively analyzed P&C service status across Sub-Saharan Africa, and even fewer have statistically examined donor effects on malaria-related service improvements. This study aims to construct a cascade of malaria P&C practices, analyze major donors' funding contributions to each level of the cascade and their effects, identify challenges, provide suggestions for improving global anti-malarial assistance effectiveness, and promote malaria P&C development in Africa.

METHODS

Data Sources

Data on malaria P&C practice coverage and febrile rates were obtained from the Demographic and Health Surveys (DHS) and the Malaria Indicator Surveys (MIS). These surveys provided data on: insecticide-treated mosquito net (ITNs) use and indoor residual spraying (IRS) implementation in households; intermittent preventive treatment during pregnancy (IPTp) among women aged 15–49; diagnostic blood

testing, and type and timing of treatment among febrile children under age 5 (U-5 children). Thus, the target population is limited to these groups. Data on country characteristics, including population, gross nation income (GNI), malaria incidence, and domestic malaria funding, were obtained from the World Bank dataset, the Global Burden of Disease Study 2021 (GBD 2021), and the World Health Organization (WHO)'s World Malaria Reports. Funding data for the major donors — USA, UK, GF, and United Nations International Children's Emergency Fund (UNICEF) — were obtained from official reports of the corresponding agencies and cross-checked with the World Malaria Reports and the Institute for Health Metrics and Evaluation (IHME) Development Assistance for Health (DAH) database. Links to all data sources are available in Supplementary Table S1(available at https://weekly.chinacdc.cn/).

Indicators

Based on WHO recommendations (*3*) and considering data availability, a comprehensive malaria P&C cascade was defined to include: 1) ITNs and IRS use, 2) IPTp service, 3) care-seeking when fever occurs, 4) blood testing, 5) timely medical treatment, and 6) full course of medicine use. Donor funding was categorized into 1) ITNs and IRS, 2) IPTp, 3) diagnosis, and 4) treatment, and estimated accordingly. Each level of the cascade was further classified as "recommended" or "unrecommended" based on the WHO Guidelines for Malaria (*3*). The definitions of recommended practices (RPs) and unrecommended practices (UPs) are listed in Supplementary Table S2 (available at https://weekly.chinacdc.cn/). As most countries lacked data on diagnostic results, it was impossible to determine whether children who received anti-malarial drugs were diagnosed with malaria; therefore, levels 5) and 6) in the cascade included all children treated with drugs. To describe trends in cascade coverage, considering the limited data points for each country, we developed a new indicator called balanced annual percentage change (BAPC). The formula is:

$$b_{ijk} = \frac{c_{ij(p+1)} - c_{ijp}}{L_{ijk}}$$

$$BAPC_{ij} = \frac{\sum_{k=1}^{k=n} L_{ijk} b_{ijk}}{\sum_{k=1}^{k=n} L_{ijk}}$$

where k is the sequence number of the periods between two available data points, and period k begins at year p and ends at year $p+1$; c_{ijp} is the coverage of measure j of country i in year p; L_{ijk} is the length of time of period k; n is the total number of the periods. This indicator describes and compares countries' overall trends in the coverage of each cascade measure.

Statistical Analysis

The frequency and timing of surveys varied greatly across countries. To include as many countries as possible, we divided the 2011–2022 time range into four periods: 2011–2013, 2014–2016, 2017–2019, and 2020–2022. One data point represented a country's condition in the corresponding period, and countries with two or more data points were included.

For analyzing donor funding effects, one-year lagged panel analysis (*4*) was selected, with control variables including 1) malaria incidence, 2) population, 3) GNI, and 4) domestic malaria funding. The dependent variables were interpolated and explanatory variables were min-max normalized. Data was processed with IBM SPSS Statistics 20 (IBM Corp., Armonk, NY, USA). Figures were created with Origin 2023 (OriginLab Corp., Northampton, MA, USA).

RESULTS

This study included 1,638,505 person-time observations across 26 countries. The average sample size per country in each period was 12,036 for children under age 5 (U-5) and 11,388 for women aged 15–49. Detailed demographic characteristics of the study countries and sample sizes are presented in Supplementary Tables S3–S5 (available at https://weekly.chinacdc.cn/).

The Cascade of Malaria P&C

The coverage of cascade components among U-5 children and women aged 15–49 by country and period are presented in Supplementary Table S4 and Table S5; and Figure 1 panels (A)–(D) illustrate the population-balanced coverage of the malaria P&C cascade, febrile rates, and malaria incidence among U-5 children across the four study periods. From 2011–2013 to 2014–2016, coverage of all P&C measures nearly doubled. However, since 2016, all rates have declined at different but nonetheless alarming rates. Notably, blood test rates were lower than treatment rates during 2011–2016, and by

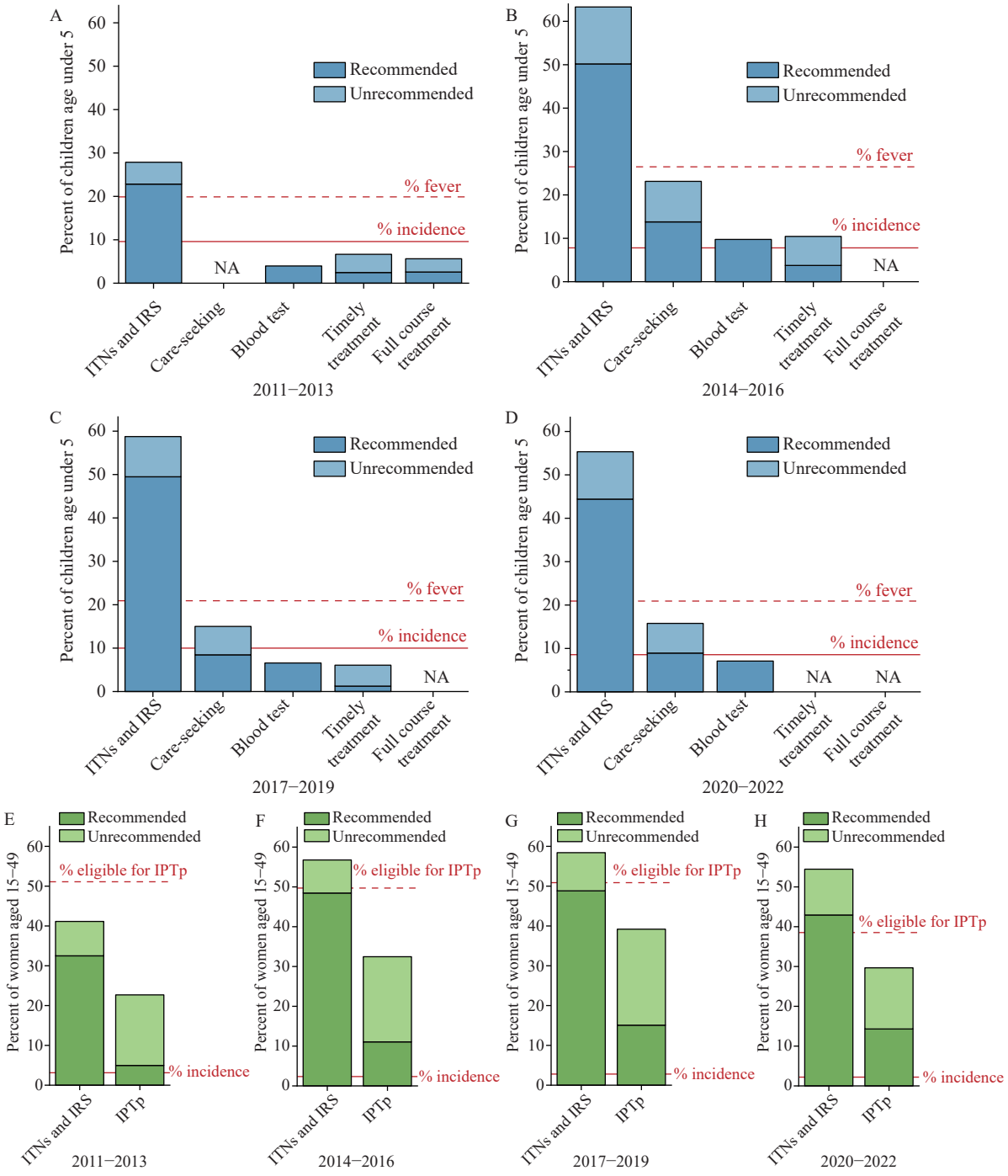

FIGURE 1. Coverage of the cascade of malaria prevention and control. (A) children under age 5 (U-5) in 2011−2013; (B) children under age 5 (U-5) in 2014−2016; (C) children under age 5 (U-5) in 2017−2019; (D) children under age 5 (U-5) in 2020−2022; (E) women aged 15−49 in 2011−2013; (F) women aged 15−49 in 2014−2016; (G) women aged 15−49 in 2017−2019; (H) women aged 15−49 in 2020−2022.

Note: The dotted red lines represent the average fever rates reported in the DHS: (A) 19.90%, (B) 26.49%, (C) 20.93%, and (D) 20.92%. The solid red lines indicate the average malaria incidence rates reported in the IHME GBD 2021: (A) 9.61%, (B) 7.79%, (C) 10.01%, and (D) 8.57%. The dotted red lines represent the pregnancy rates among surveyed women reported in the DHS: (E) 51.09%, (F) 49.71%, (G) 50.87%, and (H) 38.51%. The solid red lines indicate the average malaria incidence rates reported in the IHME GBD 2021: (E) 3.13%, (F) 2.35%, (G) 2.78%, and (H) 2.21%.

Abbreviation: NA=not available; ITNs=insecticide treated nets; IRS=indoor residual spraying; IPTp=intermittent preventive treatment during pregnancy; IHME=institute for health metrics and evaluation; GBD=global burden of disease.

2014–2016, treatment rates exceeded incidence rates. These findings suggest potential mistreatment of febrile children without confirmed diagnoses, although data quality limitations may have contributed to these discrepancies. By 2017–2019, blood test rates surpassed treatment rates, but without data on diagnostic results, it remained impossible to determine whether all treated children had confirmed malaria diagnoses. As shown in Figure 1 panels (E)–(H), among women aged 15–49, RP coverage of ITNs and IRS followed similar trends to those observed in U-5 children, while IPTp coverage increased throughout the 12-year period, albeit at a decreasing pace. Comparatively, RP coverage in women showed a faster and more sustainable growth.

Figure 2 presents the BAPC of cascade coverage. RP coverage of ITNs and IRS increased to varying degrees among both U-5 children and women in 16 countries. For IPTp, only Mali and Ghana exhibited declines in RP coverage, while most countries showed considerable progress; meanwhile, UP coverage decreased in approximately half of the countries. Changes in care-seeking rates varied substantially across countries; growth in blood test rates was most promising, while treatment rates trended downward in most countries. Countries exhibited three main types of practice changes: Type I (ideal) — overall increase with RP increasing while UP decreasing, or RP increasing faster than UP; Type II (less ideal) — widened RP-UP gap with UP increasing faster than RP, or RP decreasing while UP increased more rapidly; Type III (unideal) — overall decrease with RP increasing but UP decreasing faster, or RP decreasing while UP increasing more slowly, or both decreasing. For ITNs and IRS, IPTp, care-seeking, and treatment, 0.00%, 4.17%, 26.67%, and 19.05% of countries fell into Type II, while 38.46%, 18.18%, 60.00%, and 57.14% fell into Type III, respectively.

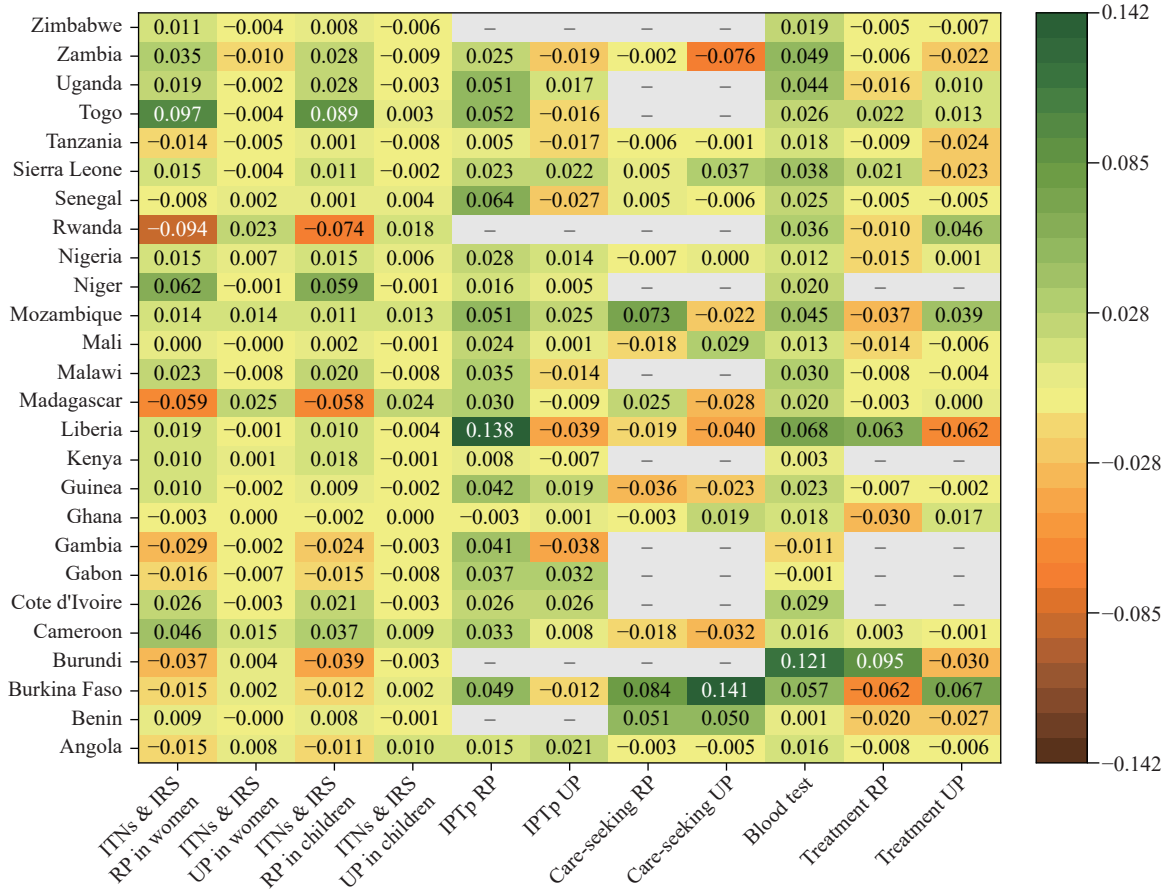

FIGURE 2. BAPC of the cascade coverage by country.
Note: − indicates missing values.
Abbreviation: BAPC=balanced annual percentage change; ITNs=insecticide treated nets; IRS=indoor residual spraying; IPTp=intermittent preventive treatment during pregnancy; RP=recommended practice; UP=unrecommended practice.

Funding to the Cascade and Effects

Figure 3 illustrates the funding contributions from the four major donors to the 26 study countries by component and year. During 2011–2020, total funding reached 7.15 billion USD, increasing from 627.24 million USD in 2011 to 721.89 million USD in 2020, with an annual average of 715.43 million USD. The USA and the GF contributed 94.65% of total funding with relatively stable patterns. In contrast, funding from the UK and UNICEF showed considerable volatility, with rapid austerity evident. The procurement and distribution of ITNs were the primary focus for the USA, UK, and UNICEF, accounting for 57.78%, 54.39%, and 56.33% of their annual funding, respectively. The GF emphasized medical supply and service optimization for IPTp (37.97%) and treatment (36.62%) simultaneously.

The results of the one-year lagged panel regression are presented in Table 1. Based on Breusch-Pagan and Hausman tests, random effect model was selected. For both U-5 children and women aged 15–49, aggregated funding was positively correlated with coverage of ITNs and IRS total coverage and RP. Among individual donors, only the USA demonstrated effectiveness in improving coverage of ITNs and IRS, care-seeking, and IPTp.

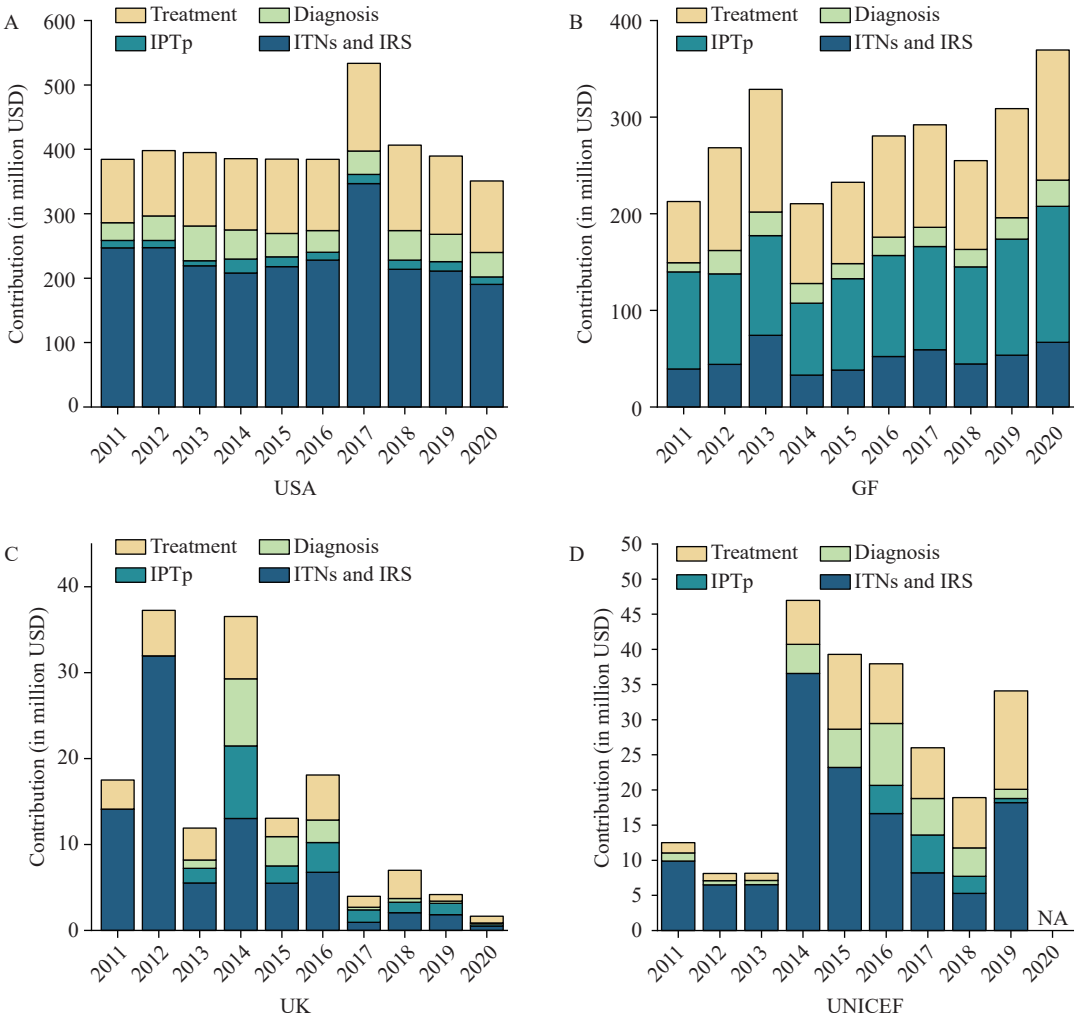

FIGURE 3. Funding from major donors by type of intervention. (A) United States of America (USA); (B) Global Fund to Fight AIDS, Tuberculosis and Malaria (GF); (C) United Kingdom (UK); (D) United Nations International Children's Emergency Fund (UNICEF).
Abbreviation: USA=United States of America; GF=Global Fund to fight AIDS, Tuberculosis and Malaria; UK=United Kingdom; UNICEF=United Nations International Children's Emergency Fund; ITNs=insecticide treated nets; IRS=indoor residual spraying; IPTp=intermittent preventive treatment during pregnancy.

TABLE 1. One-year lagged panel regression of cascade coverage and major donors' funding.

Population Donor	U-5 children					Women aged 15–49				
	USA	UK	GF	UNICEF	Total	USA	UK	GF	UNICEF	Total
ITNs and IRS										
As recommended	0.271* (0.062, 0.481)	−0.136 (−0.363, 0.090)	0.075 (−0.102, 0.253)	−0.045 (−0.301, 0.209)	0.251* (0.048, 0.454)	0.247* (0.052, 0.442)	−0.145 (−0.354, 0.063)	0.057 (−0.106, 0.222)	−0.032 (−0.267, 0.203)	0.226* (0.037, 0.415)
Unrecommended	0.002 (−0.106, 0.111)	−0.008 (−0.130, 0.113)	−0.039 (−0.133, 0.054)	−0.005 (−0.142, 0.130)	−0.016 (−0.121, 0.088)	−0.007 (−0.059, 0.045)	0.001 (−0.052, 0.054)	0.001 (−0.040, 0.043)	−0.012 (−0.072, 0.046)	−0.006 (−0.057, 0.044)
In total	0.279* (0.046, 0.513)	−0.137 (−0.393, 0.118)	0.036 (−0.164, 0.236)	−0.049 (−0.337, 0.238)	0.239* (0.012, 0.465)	0.248* (0.058, 0.439)	−0.144 (−0.349, 0.061)	0.205 (−0.074 0.484)	−0.038 (−0.419, 0.342)	0.227* (0.042, 0.412)
IPTp										
As recommended	–	–	–	–	–	0.189* (0.015, 0.363)	−0.182 (−0.446, 0.082)	−0.068 (−0.294, 0.157)	−0.026 (−0.289, 0.249)	−0.048 (−0.270, 0.174)
Unrecommended	–	–	–	–	–	0.092 (−0.035, 0.220)	−0.045 (−0.228, 0.137)	−0.007 (−0.194, 0.178)	−0.007 (−0.167, 0.152))	0.002 (−0.154, 0.159)
In total	–	–	–	–	–	0.285* (0.094, 0.475)	−0.204 (−0.480, 0.072)	−0.073 (−0.317, 0.171)	−0.016 (−0.302, 0.269)	−0.042 (−0.283, 0.197)
Care−seeking										
Within 24 h	0.201 (−0.039, 0.441)	−0.081 (−0.509, 0.346)	−0.285 (−0.532, 0.039)	0.194 (−0.159, 0.547)	−0.085 (−0.340, 0.169)	–	–	–	–	–
After 24 h	0.356* (−0.127, 0.584)	0.031 (−0.390, 0.454)	−0.139 (−0.388, 0.109)	0.039 (−0.304, 0.383)	0.102 (−0.149, 0.324)	–	–	–	–	–
In total	0.539 (−0.127, 0.951)	−0.049 (−0.800, 0.701)	−0.239 (−0.575, 0.150)	0.235 (−0.380, 0.851)	0.015 (−0.431, 0.465)	–	–	–	–	–
Blood test	0.061 (−0.130, 0.252)	−0.195 (−0.469, 0.078)	0.075 (−0.088, 0.239)	−0.053 (−0.259, 0.152)	−0.041 (−0.165, 0.082)	–	–	–	–	–
Treatment										
Within 24 h	−0.050 (−0.225, 0.124)	−0.005 (−0.204, 0.192)	0.002 (−0.218, 0.222)	−0.051 (−0.180, 0.283)	−0.024 (−0.219, 0.170)	–	–	–	–	–
After 24 h	0.116 (−0.062, 0.295)	0.010 (−0.192, 0.213)	0.137 (−0.088, 0.364)	0.043 (−0.199, 0.285)	0.160 (−0.033, 0.354)	–	–	–	–	–
In total	0.051 (−0.111, 0.215)	0.032 (−0.148, 0.212)	0.131 (−0.073, 0.335)	0.076 (−0.137, 0.289)	0.120 (−0.054, 0.296)	–	–	–	–	–

Note: – indicates missing values.
Abbreviation: USA=United States of America; UK=United Kingdom; GF=Global Fund to Fight AIDS, Tuberculosis and Malaria; UNICEF=United Nations International Children's Emergency Fund; ITNs=Insecticide Treated Nets; IRS=Indoor Residual Spraying; IPTp=Intermittent Preventive Treatment during Pregnancy.
* indicates $P<0.05$.

DISCUSSION

From 2011 to 2016, the coverage of each level of the prevention and control cascade nearly doubled. This finding aligns with a 2015 publication that reported care-seeking rates exceeding 50% and first-line medication compliance rates below one-third across 43 Sub-Saharan African countries (*5*). However, after 2016, most services experienced declining coverage at varying rates, with over half of the countries falling into the type III category for care-seeking and treatment. Such a decrease partially corresponds with World Malaria Reports 2017–2023, and warns of the difficulties in developing these health system components. Additionally, the type II countries of a considerable proportion require special attention due to the potential harm caused by the widening gap between UPs and RPs, as supported by substantial evidence (*6*–*8*).

The panel analysis results align with existing studies (*9*–*10*). Two potential concerns require attention: first, for services showing statistically significant relationships between assistance funding and service coverage, the effects may manifest in both RPs and UPs, suggesting limited control over implementation processes. Second, prevention and care-seeking represent upstream components of the malaria P&C cascade, which depend more directly on material supply and behavioral change advocacy. The downstream components — including parasitological diagnosis through blood testing and timely, full-course treatment — place higher demands on the individual capacities of doctors in public and private health facilities, community health workers, laboratory technicians, pharmacists, and even drug retailers, calling for greater attention from governments and external partners.

Meanwhile, most funding from the UK, the GF, and UNICEF showed no statistically significant impact on improving cascade coverage. Three possible explanations exist: 1) funding data exhibited little pattern, particularly for the UK amid Brexit and accompanying policy shifts (*11*); 2) considering the substantial investment needed to sustain various measures throughout the P&C system, donors' influence may lie in maintaining existing coverage; and 3) increased funding and materials alone had limited impact on service accessibility and availability, indicating the considerable mediating effect of overall health system capacity, as noted above.

Effective implementation of national malaria strategic plans requires a systematic approach involving enhanced political will and governance mechanisms, indigenous medical manufacturing capacity, well-maintained supply chains, and improved primary and secondary health services (*12*). Our results suggest that capacity building and quality assurance at the farthest end of the health system are urgently needed. For example, to correctly manage non-malarial febrile illnesses (*13*), strengthen supply chain management and stock-out reporting (*14*), and support public and private health facilities — including clinics, drug shops, and pharmacies — in their compliance with treatment guidelines based on adequate drug supply (*15*).

This study has several limitations: 1) seeing the retrospective nature of the DHS program, the data may be subject to recall bias; 2) due to the limited surveyed groups in the DHS, service coverage could only be measured in children under age 5 and women aged 15–49, rather than the entire population; and 3) the domestic malaria funding (as a controlled variable) could not be broken down into detailed programs. Overall, this study suggests that strengthening capacity at the farthest end of the health system, supported by increased global funding, may offer a pathway to avoid the gloomy outlook for malaria control and elimination.

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SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Data sources.

Data	Source
Cascade coverage, from DHS and MIS	https://www.dhsprogram.com/topics/malaria/index.cfm
Malaria incidence, from IHME GBD 2021	https://ghdx.healthdata.org/ihme_data
Population and GNI, from World Development Indicators of the World Bank	https://databank.worldbank.org/source/world-development-indicators
Domestic funding for malaria, extracted from the WHO's World Malaria Reports (for example, Annex 4-C in the 2023 World Malaria Report)	https://www.who.int/teams/global-malaria-programme/reports
Funding of the USA, from annual funding tables of President's Malaria Initiative (PMI), the agency of the USA to deliver anti-malaria assistance abroad	https://www.pmi.gov/resources/malaria-operational-plans-mops/
Funding for international development of the UK	https://www.gov.uk/guidance/statistics-on-international-development
GF allocation for countries by disease	https://data-service.theglobalfund.org/downloads
Funding of UNICEF, from UNICEF Supply Annual Reports	https://www.unicef.org/research-and-reports

SUPPLEMENTARY TABLE S2. Definition of the recommended and the unrecommended practices.

Cascade level	Recommended practice (RP)	Unrecommended practice (UP)
ITNs and IRS	Only one measure was deployed in the household for the utmost cost-effectiveness; in the case of ITNs, the net was treated with insecticide within three years before the survey.	ITNs and IRS were co-deployed in the household, which would provide no additional benefit than a single measure; in the case of ITNs alone, the net was not treated with insecticide or was treated more than three years before the survey.
IPTp	At least three doses of Sulfadoxine-pyrimethamine (SP) for IPTp during antenatal care (ANC) visits.	Less than three doses of SP for IPTp during ANC visits.
Care-seeking when fever	The febrile child was taken to seek medical care within 24 hours of fever.	The febrile child was taken to seek medical care after 24 hours of fever.
Blood test	In all settings, suspected malaria should be confirmed with a parasitological test.	–
Timely medical treatment	Anti-malaria drug was given within 24 hours of fever.	Anti-malaria drug was given after 24 hours of fever.
Full course of medicine use	The drug was taken as any times as the guidance recommended.	The drug was taken less or more times than the guidance recommended.

SUPPLEMENTARY TABLE S3. Demographic characteristics of the included countries (2011–2022 average).

Country	Domestic funding for malaria (million USD)	Population (million)	GNI (million USD)	Incidence in children under 5 (%)	Incidence in women aged 15–49 (%)
Angola	35.84	28.75	59,250	7.14	2.55
Benin	3.53	11.13	11,575	15.76	3.55
Burkina Faso	27.90	19.03	12,250	15.25	3.58
Burundi	1.77	10.84	1,775	7.81	2.53
Cameroon	22.36	23.40	29,000	8.68	2.74
Cote d'Ivoire	16.60	24.05	43,500	11.58	3.00
Gabon	3.67	2.04	9,500	8.09	2.83
Gambia	0.86	2.29	1,128	4.97	2.89
Ghana	24.60	29.20	44,500	11.29	3.12
Guinea	3.64	11.80	7,925	15.52	3.55
Kenya	3.61	47.33	60,000	1.87	0.75
Liberia	10.01	4.65	1,600	13.25	2.98
Madagascar	0.03	25.23	10,350	2.63	1.26
Malawi	1.39	17.23	7,425	8.33	2.74
Mali	4.57	18.53	12,750	13.17	3.16
Mozambique	14.06	27.39	11,750	13.72	3.44
Niger	10.27	20.68	11,050	11.66	3.21
Nigeria	5.71	186.25	370,000	11.10	3.10
Rwanda	14.35	11.83	6,950	1.50	0.92
Senegal	15.59	14.63	18,000	1.12	1.35
Sierra Leone	0.35	7.42	3,325	16.15	3.60
Tanzania	27.43	53.80	42,000	4.43	1.85
Togo	3.27	7.58	4,850	11.04	3.03
Uganda	5.91	38.53	24,250	8.07	2.50
Zambia	16.00	16.55	18,000	6.32	2.09
Zimbabwe	1.51	14.33	14,000	1.73	1.79

Abbreviation: USD=United States Dollar; GNI=Gross National Income.

SUPPLEMENTARY TABLE S4. The malaria P&C cascade coverage in children under 5 by country, 2011–2022.

Country	Period	Sample size	Febrile number	ITNs and IRS RP	ITNs and IRS UP	Care-seeking RP	Care-seeking UP	Blood test	Treatment RP	Treatment UP
Angola	2011–2013	9,681	2,645	0.27	0.03	0.30	0.31	0.27	0.14	0.14
Benin	2011–2013	17,489	1,141	0.66	0.09	–	–	0.18	0.18	0.27
Burkina Faso	2011–2013	–	–	–	–	–	–	–	–	–
Burundi	2011–2013	4,985	1,690	0.48	0.07	–	–	0.28	0.07	0.18
Cameroon	2011–2013	147,276	2,680	0.01	0.01	–	–	–	0.12	0.14
Cote d'Ivoire	2011–2013	9,742	1,662	0.36	0.04	–	–	0.11	0.09	0.07
Gabon	2011–2013	7,446	1,315	0.30	0.25	–	–	0.13	0.14	0.11
Gambia	2011–2013	10,701	977	0.69	0.06	–	–	0.33	0.03	0.04
Ghana	2011–2013	–	–	–	–	–	–	–	–	–
Guinea	2011–2013	8,531	1,883	0.20	0.11	–	–	0.08	0.16	0.14
Kenya	2011–2013	–	–	–	–	–	–	–	–	–
Liberia	2011–2013	4,340	1,617	0.39	0.05	–	–	0.32	0.09	0.46
Madagascar	2011–2013	8,109	959	0.87	0.05	–	–	0.05	0.08	0.10
Malawi	2011–2013	2,813	676	0.47	0.13	–	–	0.22	0.23	0.09
Mali	2011–2013	12,882	809	0.63	0.09	–	–	0.12	0.14	0.13
Mozambique	2011–2013	12,683	1,313	0.44	0.06	–	–	0.31	0.22	0.08
Niger	2011–2013	15,291	1,563	0.16	0.10	–	–	0.14	0.04	0.19
Nigeria	2011–2013	35,361	3,691	0.16	0.05	–	–	0.11	0.20	0.15
Rwanda	2011–2013	3,779	876	0.70	0.06	–	–	0.30	0.02	0.09
Senegal	2011–2013	–	–	–	–	–	–	–	–	–
Sierra Leone	2011–2013	14,958	2,859	0.37	0.15	–	–	0.41	0.09	0.41
Tanzania	2011–2013	–	–	–	–	–	–	–	–	–
Togo	2011–2013	–	–	–	–	–	–	–	–	–
Uganda	2011–2013	9,839	2,860	0.41	0.15	–	–	0.27	0.14	0.53
Zambia	2011–2013	–	–	–	–	–	–	–	–	–
Zimbabwe	2011–2013	7,187	515	0.26	0.05	–	–	0.07	0.02	0.03
Angola	2014–2016	–	–	–	–	–	–	–	–	–
Benin	2014–2016	–	–	–	–	–	–	–	–	–
Burkina Faso	2014–2016	8,419	2,617	0.71	0.05			0.31	0.28	0.22
Burundi	2014–2016	15,544	4,640	0.37	0.08	0.54	0.19	0.64	0.35	0.09
Cameroon	2014–2016	–	–	–	–	–	–	–	–	–
Cote d'Ivoire	2014–2016	–	–	–	–	–	–	–	–	–
Gabon	2014–2016	–	–	–	–	–	–	–	–	–
Gambia	2014–2016	–	–	–	–	–	–	–	–	–
Ghana	2014–2016	4,159	894	0.18	0.00	0.46	0.27	0.34	0.14	0.35
Guinea	2014–2016	–	–	–	–	–	–	–	–	–
Kenya	2014–2016	4,724	1,290	0.45	0.13			0.39	0.15	0.09
Liberia	2014–2016	3,926	1,134	0.38	0.05	0.33	0.44	0.50	0.06	0.56
Madagascar	2014–2016	9,149	693	0.74	0.85	–	–	0.12	0.05	0.03
Malawi	2014–2016	2,621	594	0.63	0.07	–	–	0.35	0.30	0.09
Mali	2014–2016	9,539	2,104	0.65	0.09	–	–	0.14	0.09	0.18
Mozambique	2014–2016	–	–	–	–	–	–	–	–	–

Continued

Country	Period	Sample size	Febrile number	ITNs and IRS RP	ITNs and IRS UP	Care-seeking RP	Care-seeking UP	Blood test	Treatment RP	Treatment UP
Niger	2014–2016	–	–	–	–	–	–	–	–	–
Nigeria	2014–2016	8,292	2,622	0.35	0.09	0.36	0.31	0.13	0.16	0.25
Rwanda	2014–2016	9,505	1,388	0.55	0.10	–	–	0.35	0.04	0.08
Senegal	2014–2016	8,746	1,146	0.55	0.05	–	–	0.11	0.02	0.03
Sierra Leone	2014–2016	8,460	1,639	0.38	0.08	0.51	0.20	0.53	0.03	0.55
Tanzania	2014–2016	12,745	1,667	0.48	0.13	0.49	0.40	0.35	0.05	0.41
Togo	2014–2016	8,583	1,413	0.30	0.14	–	–	0.25	0.09	0.13
Uganda	2014–2016	6,108	1,413	0.67	0.11	–	–	0.36	0.07	0.70
Zambia	2014–2016	16,657	2,745	0.55	0.06	0.52	0.55	0.52	0.02	0.44
Zimbabwe	2014–2016	8,082	799	0.29	0.03	–	–	0.13	0.01	0.01
Angola	2017–2019	18,311	1,943	0.18	0.08	0.28	0.28	0.37	0.09	0.10
Benin	2017–2019	16,266	2,429	0.71	0.08	0.31	0.30	0.18	0.06	0.11
Burkina Faso	2017–2019	7,562	1,220	0.50	0.05	0.57	0.18	0.50	0.09	0.42
Burundi	2017–2019	–	–	–	–	–	–	–	–	–
Cameroon	2017–2019	12,595	1,388	0.59	0.02	0.37	0.35	0.21	0.14	0.14
Cote d'Ivoire	2017–2019	–	–	–	–	–	–	–	–	–
Gabon	2017–2019	–	–	–	–	–	–	–	–	–
Gambia	2017–2019	–	–	–	–	–	–	–	–	–
Ghana	2017–2019	4,159	929	0.17	0.00	0.40	0.30	0.38	0.05	0.40
Guinea	2017–2019	9,778	1,221	0.20	0.14	0.45	0.35	0.20	0.12	0.12
Kenya	2017–2019	–	–	–	–	–	–	–	–	–
Liberia	2017–2019	7,372	1,472	0.37	0.09	0.48	0.40	0.52	0.22	0.34
Madagascar	2017–2019	7,306	1,055	0.67	0.11	0.32	0.29	0.16	0.03	0.06
Malawi	2017–2019	2,950	794	0.61	0.08	0.32	0.25	0.40	0.18	0.07
Mali	2017–2019	11,760	1,503	0.62	0.14	0.31	0.30	0.16	0.05	0.09
Mozambique	2017–2019	5,691	1,275	0.69	0.13	0.41	0.31	0.50	0.00	0.31
Niger	2017–2019	–	–	–	–	–	–	–	–	–
Nigeria	2017–2019	38,097	7,536	0.39	0.11	0.39	0.39	0.14	0.00	0.23
Rwanda	2017–2019	3,548	870	0.68	0.08	0.36	0.20	0.37	0.00	0.18
Senegal	2017–2019	15,178	2,378	0.62	0.05	0.33	0.24	0.18	0.01	0.05
Sierra Leone	2017–2019	12,618	1,476	0.46	0.13	0.53	0.31	0.64	0.22	0.28
Tanzania	2017–2019	9,623	1,502	0.44	0.11	0.41	0.35	0.39	0.02	0.34
Togo	2017–2019	4,446	777	0.59	0.13	0.40	0.19	0.33	0.15	0.17
Uganda	2017–2019	9,748	1,973	0.52	0.13	0.60	0.27	0.54	0.04	0.59
Zambia	2017–2019	12,219	1,550	0.65	0.03	0.51	0.32	0.67	0.01	0.37
Zimbabwe	2017–2019	–	–	–	–	–	–	–	–	–
Angola	2020–2022	–	–	–	–	–	–	–	–	–
Benin	2020–2022	–	–	–	–	–	–	–	–	–
Burkina Faso	2020–2022	15,379	2,623	0.62	0.06	0.82	0.61	0.65	–	–
Burundi	2020–2022	–	–	–	–	–	–	–	–	–
Cameroon	2020–2022	5,548	1,344	0.43	0.14	0.32	0.25	0.26	–	–
Cote d'Ivoire	2020–2022	12,595	1,726	0.59	0.02	0.42	0.27	0.37	–	–

Continued

Country	Period	Sample size	Febrile number	ITNs and IRS RP	ITNs and IRS UP	Care-seeking RP	Care-seeking UP	Blood test	Treatment RP	Treatment UP
Gabon	2020–2022	8,291	1,311	0.16	0.19	0.43	0.30	0.12	−	−
Gambia	2020–2022	10,640	1,326	0.43	0.04	0.60	0.19	0.24	−	−
Ghana	2020–2022	−	1,451	−	−	0.44	0.38	0.45	−	−
Guinea	2020–2022	5,205	921	0.29	0.09	0.34	0.28	0.28	−	−
Kenya	2020–2022	5,200	745	0.51	0.14	0.31	0.30	0.41	−	−
Liberia	2020–2022	3,717	1,026	0.45	0.05	0.29	0.36	0.52	−	−
Madagascar	2020–2022	15,972	1,439	0.33	0.28	0.39	0.20	0.23	0.05	0.11
Malawi	2020–2022	−	−	−	−	−	−	−	−	−
Mali	2020–2022	11,567	2,424	0.63	0.09	0.26	0.39	0.24	−	−
Mozambique	2020–2022	12,163	1,039	0.31	0.12	0.64	0.24	0.53	−	−
Niger	2020–2022	6,212	1,569	0.71	0.09	0.38	0.28	0.32	−	−
Nigeria	2020–2022	13,721	3,732	0.29	0.11	0.32	0.31	0.22	0.00	0.06
Rwanda	2020–2022	9,709	−	0.41	0.13	−	−	−	−	−
Senegal	2020–2022	8,999	1,697	0.50	0.06	0.35	0.22	0.26	0.00	0.00
Sierra Leone	2020–2022	−	−	−	−	−	−	−	−	−
Tanzania	2020–2022	−	1,014	−	−	0.46	0.40	0.45	−	−
Togo	2020–2022	−	−	−	−	−	−	−	−	−
Uganda	2020–2022	−	−	−	−	−	−	−	−	−
Zambia	2020–2022	−	−	−	−	−	−	−	−	−
Zimbabwe	2020–2022	−	−	−	−	−	−	−	−	−

Note: missing values are marked by −. The tables present the cascade coverage in children under 5 (U-5 children) by country and period, along with the average coverage for each period. For ITNs and IRS coverage, the numerator represents the number of U-5 children with access to ITNs and IRS, while the denominator represents the total number of U-5 children (sample size). For care-seeking, blood test, and treatment coverage, the numerator represents the number of U-5 children with access to the corresponding services, while the denominator represents the number of febrile U-5 children. All averages are weighted by the corresponding denominator indicators.

SUPPLEMENTARY TABLE S5. The malaria P&C cascade coverage for women aged 15–49 by country, 2011–2022.

Country	Period	Sample size	Number of women aged 15-49 eligible for IPTp	ITNs and IRS RP	ITNs and IRS UP	IPTp RP	IPTp UP
Angola	2011–2013	8,849	5,331	0.26	0.03	0.09	0.25
Benin	2011–2013	17,957	–	0.65	0.10	–	–
Burkina Faso	2011–2013	–	–	–	–	–	–
Burundi	2011–2013	5,319	–	0.48	0.08	–	–
Cameroon	2011–2013	16,417	7,612	0.09	0.06	0.13	0.32
Cote d'Ivoire	2011–2013	11,381	5,412	0.37	0.04	0.07	0.25
Gabon	2011–2013	8,772	4,123	0.26	0.25	0.02	0.21
Gambia	2011–2013	11,928	5,375	0.62	0.06	0.06	0.88
Ghana	2011–2013	–	–	–	–	–	–
Guinea	2011–2013	9,561	4,983	0.20	0.11	0.12	0.22
Kenya	2011–2013	–	–	–	–	–	–
Liberia	2011–2013	4,188	2,311	0.40	0.06	0.28	0.37
Madagascar	2011–2013	8,550	4,334	0.83	0.07	0.04	0.28
Malawi	2011–2013	2,993	1,707	0.42	0.14	0.13	0.68
Mali	2011–2013	11,652	6,723	0.61	0.10	0.11	0.45
Mozambique	2011–2013	14,097	7,623	0.44	0.07	0.10	0.32
Niger	2011–2013	12,103	7,675	0.15	0.10	0.09	0.53
Nigeria	2011–2013	40,296	20,110	0.15	0.04	0.06	0.21
Rwanda	2011–2013	5,229	–	0.61	0.08	–	–
Senegal	2011–2013	–	–	–	–	–	–
Sierra Leone	2011–2013	17,368	8,488	0.37	0.16	0.21	0.46
Tanzania	2011–2013	–	–	–	–	–	–
Togo	2011–2013	–	–	–	–	–	–
Uganda	2011–2013	9,673	4,907	0.39	0.17	0.10	0.39
Zambia	2011–2013	–	–	–	–	–	–
Zimbabwe	2011–2013	10,105	4,395	0.24	0.06	0.05	0.10
Angola	2014–2016	–	–	–	–	–	–
Benin	2014–2016	–	–	–	–	–	–
Burkina Faso	2014–2016	8,442	4,875	0.71	0.05	0.27	0.44
Burundi	2014–2016	17,826	8,660	0.36	0.07	0.08	0.12
Cameroon	2014–2016	–	–	–	–	–	–
Cote d'Ivoire	2014–2016	–	–	–	–	–	–
Gabon	2014–2016	–	–	–	–	–	–
Gambia	2014–2016	–	–	–	–	–	–
Ghana	2014–2016	5,347	2,377	0.16	0.00	0.62	0.29
Guinea	2014–2016	–	–	–	–	–	–
Kenya	2014–2016	5,664	2,639	0.41	0.14	0.23	0.38
Liberia	2014–2016	4,629	2,259	0.38	0.05	0.25	0.60
Madagascar	2014–2016	11,094	3,873	0.70	0.08	0.04	0.30
Malawi	2014–2016	2,970	1,624	0.58	0.08	0.00	0.92
Mali	2014–2016	7,900	5,062	0.69	0.09	0.23	0.45

Continued

Country	Period	Sample size	Number of women aged 15-49 eligible for IPTp	ITNs and IRS RP	ITNs and IRS UP	IPTp RP	IPTp UP
Mozambique	2014–2016	–	–	–	–	–	–
Niger	2014–2016	–	–	–	–	–	–
Nigeria	2014–2016	8,218	4,340	0.33	0.08	0.23	0.35
Rwanda	2014–2016	13,765	–	0.57	0.10	–	–
Senegal	2014–2016	9,573	4,470	0.54	0.05	0.04	0.67
Sierra Leone	2014–2016	8,601	–	0.39	0.08	–	–
Tanzania	2014–2016	14,370	7,050	0.46	0.16	0.07	0.61
Togo	2014–2016	10,011	5,010	0.25	0.12	0.23	0.55
Uganda	2014–2016	5,747	3,017	0.66	0.11	0.27	0.38
Zambia	2014–2016	18,174	9,345	0.56	0.06	0.51	0.42
Zimbabwe	2014–2016	10,819	–	0.27	0.04	–	–
Angola	2017–2019	15,242	8,947	0.20	0.09	0.18	0.37
Benin	2017–2019	16,496	–	0.70	0.09	–	–
Burkina Faso	2017–2019	7,729	4,519	0.49	0.06	0.57	0.37
Burundi	2017–2019	–	–	–	–	–	–
Cameroon	2017–2019	15,378	6,463	0.56	0.02	0.31	0.44
Cote d'Ivoire	2017–2019	–	–	–	–	–	–
Gabon	2017–2019	–	–	–	–	–	–
Gambia	2017–2019	–	–	–	–	–	–
Ghana	2017–2019	5,347	2,308	0.15	0.00	0.61	0.31
Guinea	2017–2019	11,120	5,530	0.21	0.13	0.34	0.45
Kenya	2017–2019	–	–	–	–	–	–
Liberia	2017–2019	8,708	4,267	0.37	0.09	0.39	0.52
Madagascar	2017–2019	8,379	5,227	0.62	0.14	0.10	0.28
Malawi	2017–2019	3,923	1,941	0.54	0.09	0.34	0.59
Mali	2017–2019	10,945	6,368	0.60	0.15	0.25	0.46
Mozambique	2017–2019	6,404	3,377	0.68	0.13	0.42	0.45
Niger	2017–2019	–	–	–	–	–	–
Nigeria	2017–2019	42,407	21,792	0.37	0.11	0.17	0.47
Rwanda	2017–2019	5,096	–	0.70	0.09		
Senegal	2017–2019	18,094	8,486	0.61	0.05	0.20	0.73
Sierra Leone	2017–2019	16,487	7,377	0.43	0.15	0.35	0.59
Tanzania	2017–2019	10,443	5,364	0.46	0.13	0.20	0.61
Togo	2017–2019	4,867	2,488	0.52	0.13	0.39	0.50
Uganda	2017–2019	9,262	4,826	0.56	0.15	0.41	0.49
Zambia	2017–2019	14,922	7,372	0.65	0.04	0.59	0.36
Zimbabwe	2017–2019	–	–	–	–	–	–
Angola	2020–2022	–	–	–	–	–	–
Benin	2020–2022	–	–	–	–	–	–
Burkina Faso	2020–2022	18,284	6,446	0.63	0.06	0.56	0.37
Burundi	2020–2022	–	–	–	–	–	–
Cameroon	2020–2022	6,880	2,346	0.42	0.15	0.43	0.39

Continued

Country	Period	Sample size	Number of women aged 15-49 eligible for IPTp	ITNs and IRS RP	ITNs and IRS UP	IPTp RP	IPTp UP
Cote d'Ivoire	2020–2022	15,378	5,674	0.56	0.02	0.30	0.49
Gabon	2020–2022	10,051	4,457	0.12	0.18	0.35	0.50
Gambia	2020–2022	13,012	5,799	0.41	0.04	0.43	0.54
Ghana	2020–2022	−	5,189	−	−	0.60	0.30
Guinea	2020–2022	5,996	2,147	0.28	0.09	0.50	0.39
Kenya	2020–2022	7,210	2,064	0.52	0.14	0.32	0.30
Liberia	2020–2022	4,813	1,594	0.43	0.05	0.69	0.26
Madagascar	2020–2022	20,820	9,315	0.31	0.28	0.31	0.20
Malawi	2020–2022	−	−	−	−	−	−
Mali	2020–2022	11,156	4,934	0.63	0.10	0.34	0.42
Mozambique	2020–2022	14,570	5,153	0.30	0.13	0.24	0.43
Niger	2020–2022	6,236	2,734	0.68	0.09	0.24	0.57
Nigeria	2020–2022	14,837	5,497	0.29	0.10	0.31	0.33
Rwanda	2020–2022	14,776	−	0.39	0.14	−	−
Senegal	2020–2022	11,152	3,615	0.55	0.07	0.42	0.51
Sierra Leone	2020–2022	−	−	−	−	−	−
Tanzania	2020–2022	−	5,836	−	−	0.26	0.45
Togo	2020–2022	−	−	−	−	−	−
Uganda	2020–2022	−	−	−	−	−	−
Zambia	2020–2022	−	−	−	−	−	−
Zimbabwe	2020–2022	−	−	−	−	−	−

Note: missing values are marked by −. The tables present the cascade coverage in women aged 15–49 by country and period, along with the average coverage for each period. For ITNs and IRS coverage, the numerator represents the number of women aged 15–49 with access to ITNs and IRS, while the denominator represents the total number of women aged 15–49 (sample size). For IPTp coverage, the numerator represents the number of women aged 15–49 with access to IPTp service, while the denominator represents the number of women aged 15–49 who were pregnant and eligible for IPTp. All averages are weighted by the corresponding denominator indicators.