Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Presumptive malaria treatment and malaria outcomes in Ghana from 2016 to 2025

Franklin Asiedu-Bekoe
Ghana Health Service
Abdul Gafaru Mohammed
mohammedabdulgafaru46@gmail.com
Ghana Health Service
Alexander Asamoah
Ghana Health Service
George Adu Asumah
Ghana Health Service
Dora Dadzie
Ghana Health Service
Grace Adjoa Ocansey
Ghana Health Service
Joel Jeffrey Idun-Acquah
Ghana Health Service
Paul Boateng
Ghana Health Service
Adomako Isaac
Ghana Health Service
Ivy Forson
Ghana Health Service
Paul Kosi Abiwu Hilarius
Ghana Health Service

Research Article

Keywords: Malaria, Presumptive treatment, Diagnostic adherence, Health information systems, Ghana

Posted Date: November 9th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11381594/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Presumptive malaria treatment and malaria outcomes in Ghana from 2016 to 2025

Franklin Asiedu-Bekoe[1], Abdul Gafaru Mohammed[2,3*], Alexander Asamoah[2], George Adu Asumah[2], Dora Dadzie[2], Grace Adjoa Ocansey[2], Joel Jeffrey Idun-Acquah[2], Paul Boateng[2], Adomako Isaac[2], Ivy Forson[2], Paul Hilarius Kosi Abiwu[2]

[1]Public Health Division, Ghana Health Service, Accra, Ghana

[2]National Malaria Elimination Programme, Public Health Division, Ghana Health Service, Accra, Ghana

[3]Department of Environmental Health Sciences, School of Public Health and Health Sciences, University of Massachusetts Amherst, Amherst, Massachusetts, USA

***Corresponding author:** Abdul Gafaru Mohammed;
mohammedabdulgafaru46@gmail.com

Abstract

Background: Ghana requires parasitological confirmation of suspected malaria before antimalarial treatment, yet some patients are treated without a positive test. We described trends in presumptive malaria treatment from 2016 to 2025 and its association with malaria outcomes.

Methods: We conducted an ecological panel analysis of annual malaria case management indicators reported through the District Health Information Management System 2 for all 16 regions (160 region-years). The presumptive malaria treatment (PMT) rate was the percentage of treated uncomplicated cases without a positive test. We compared 2016–2020 with 2021–2025 and used two-way fixed-effects panel regression to relate PMT to confirmed incidence and admission, mortality, and case fatality rates, with bootstrap inference and a 2018–2025 sensitivity analysis.

Results: The national PMT rate fell from 33.5% in 2016 (not-tested component only) to 3.6% in 2025, with a temporary rise to 8.2% in 2024. All regions improved, and Greater Accra had the highest rate in 2021–2025 (11.3%). The under-five share of malaria admissions fell from 48.0% to 27.9%, while their share of deaths stayed near half. Within regions, each percentage-point rise in PMT was associated with 2.28 fewer confirmed cases per 1,000 population (95% CI −3.84 to −0.71; bootstrap p = 0.028), with no statistically significant association with admission, mortality, or case fatality rates.

Conclusions: Presumptive malaria treatment declined in every region, although Greater Accra and northern regions kept the highest rates and the national rate rebounded in 2024. Confirmed malaria incidence is best interpreted alongside not-tested and test-negative treatment rates.

Keywords: Malaria, Presumptive treatment, Diagnostic adherence, Health information systems, Ghana

Introduction

Malaria remains a leading cause of illness and death in sub-Saharan Africa. An estimated 282 million cases and 610,000 deaths occurred worldwide in 2024, 94% and 95% of them in the World Health Organization (WHO) African Region, and global progress is not on track to meet the 2025 milestones of the Global Technical Strategy for Malaria [1]. Malaria is endemic throughout Ghana, with perennial transmission in the forest and coastal zones and intensely seasonal transmission in the northern savannah, and it accounts for roughly 30% of outpatient attendances and 23% of admissions [2]. As Ghana shifts from control toward elimination under the National Malaria Elimination Strategic Plan 2024–2028, decisions on where to target interventions rest more and more on routine surveillance [3, 4]. Those data are only as informative as the diagnosis behind them. Because many febrile presentations have non-malarial causes, confirmed case counts track true malaria only when suspected cases are tested and treatment follows the result [5, 6].

In 2010, WHO recommended parasitological confirmation of all suspected malaria before treatment, replacing earlier guidance that allowed presumptive treatment of febrile young children in high-transmission settings where diagnostics were scarce [7]. The Test, Treat, Track initiative reinforced this recommendation in 2012 [8], and Ghana built test-based management into its national guidelines and strategic plans [4, 6]. Treatment without confirmation has nevertheless persisted, and recent studies from Ghana identify supply and staffing constraints as major drivers. In 69 facilities in the Volta and Oti regions, 59.4% of clinicians reported frequent stock-outs of rapid diagnostic tests (RDTs) and 65.2% reported a lack of diagnostic facilities, and 81.7% of untested febrile children received an artemisinin-based combination therapy (ACT) [9]. Prescribers in Greater

Accra, Upper West, and the former Brong Ahafo Region described erratic RDT supply at community-based health planning and services (CHPS) compounds, too few microscopes and laboratory staff for the queues they faced, and patients who regarded testing as a waste of time [10].

Limited confidence in negative results sustains a second form of presumptive treatment, in which patients are given antimalarials after a negative test. Two-thirds of clinicians in Volta and Oti believed that RDTs gave inaccurate results, and half of the test-negative children they saw received ACTs [9]. In Greater Accra, 21.4% of test-negative and 42.7% of untested febrile outpatients were prescribed ACTs, and inappropriate prescribing was far less likely in facilities that had RDTs in stock [11]. Prescribers explained such decisions by citing earlier experiences of microscopy-positive patients with negative RDTs, fear that untreated patients would return with severe malaria, and limited training in investigating non-malarial fever [10].

These practices carry costs for patients, for the health system, and for surveillance. Patients receive ACTs they do not need, while bacterial and other causes of fever may go untreated [12, 13]. Unnecessary prescribing wastes antimalarial commodities and adds drug pressure at a time when artemisinin partial resistance has been confirmed in several African countries [1], and it forgoes the savings that test-based management achieves even in high-transmission areas of Ghana [14]. Presumptive treatment also alters what routine data mean. A case treated without a positive test is not counted as confirmed malaria, so a change in testing practice can move confirmed incidence without any change in transmission [15].

Ghana has invested heavily in RDT scale-up, prescriber training, and District Health Information Management System 2 (DHIMS2) reporting, but most evidence on presumptive treatment in the country comes from facility surveys, qualitative studies, and

trials covering a few districts [9–11, 16]. National evidence spanning several years and all 16 regions, and relating diagnostic practice to the outcomes the program monitors, remains limited. Using ten years of regional DHIMS2 reports, we described trends in presumptive malaria treatment from 2016 to 2025 and its association with malaria outcomes.

Methods

Study design

We conducted a longitudinal ecological panel study based on secondary analysis of aggregated malaria case management indicators routinely reported through DHIMS2, with no individual participant data. The unit of analysis was the region-year, with each of Ghana's 16 administrative regions observed annually from 2016 to 2025, giving a balanced panel of 160 region-year observations. The study is reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Supplementary File 1).

Study setting

Ghana has a projected population of 33 million people based on the 2021 population census [17]. It borders Burkina Faso to the north, Togo to the east, Côte d'Ivoire to the west, and the Gulf of Guinea to the south, and is divided into 16 administrative regions and 261 districts. Six of the current regions (Ahafo, Bono East, North East, Oti, Savannah, and Western North) were created in 2019 from former regions; all values in this analysis, including those for 2016–2018, refer to the current 16-region boundaries. Malaria transmission is perennial in the forest and coastal zones and highly seasonal in the northern savannah [2]. Prevention includes insecticide-treated nets, seasonal malaria chemoprevention in the northern regions, indoor residual spraying in selected districts,

and malaria vaccination of young children, introduced with RTS,S/AS01 in 42 districts in seven regions in 2019, extended to 51 more districts in 2023, and expanded with R21/Matrix-M to 43 districts in Upper West, Northern, Savannah, and Western North in 2024 [2, 4, 18].

National malaria case management guidelines require parasitological confirmation of all suspected cases by RDT or light microscopy before antimalarial treatment, in line with WHO recommendations adopted progressively from 2010 [6, 7]. Uncomplicated malaria is treated with ACTs, principally artemether-lumefantrine. Services are delivered through CHPS compounds, health centers, polyclinics, and district, regional, and teaching hospitals, all of which report malaria morbidity, treatment, and mortality through DHIMS2. Successive national strategic plans have set targets for test-based diagnosis and financed RDT procurement, microscopy quality assurance, prescriber training, and supportive supervision [4].

Data source and extraction

We extracted annual region-level aggregates from DHIMS2, the national repository for malaria morbidity, mortality, diagnostic, and treatment reports, for January 2016 to December 2025. Annual rather than monthly aggregates were used because the objectives concerned multi-year trends, and annual totals avoid seasonal fluctuation in a panel model. For each region-year we extracted: (1) uncomplicated malaria cases confirmed by RDT or microscopy; (2) suspected uncomplicated malaria cases that tested negative but were treated with antimalarials; (3) suspected uncomplicated malaria cases treated with antimalarials without any diagnostic test; (4) malaria admissions, by age group (under five years; five years and above); (5) in-hospital malaria deaths, by the same age groups; and (6) the mid-year population, taken from Ghana Statistical Service projections entered in DHIMS2. Facilities report to DHIMS2 individually, and DHIMS2

aggregates their reports through the current organizational hierarchy. When the six new regions were created in 2019, their districts and facilities were reassigned in this hierarchy, so the 2016–2018 values for all 16 regions were produced by aggregating the reports of each facility under its current district and region. Population denominators are Ghana Statistical Service district projections held in DHIMS2 and aggregated through the same hierarchy. To check the reconstruction, we compared year-on-year changes in the six new regions and their four parent regions: between 2018 and 2019, the year of the reorganization, confirmed cases changed by −14.6% to 32.0% and admissions by −15.8% to 50.1%, within the range observed between other consecutive years (−30.4% to 68.5% and −50.3% to 96.7%), with no obvious discontinuity in this descriptive check.

Study variables

For each region-year, let C be confirmed uncomplicated malaria cases, NT cases treated without a test, and TN cases treated despite a negative test. In DHIMS2 these are separate, mutually exclusive data elements, each suspected uncomplicated case being recorded in only one of them. Because DHIMS2 does not record treatment of confirmed cases separately and national guidelines require antimalarial treatment of every confirmed uncomplicated case, we took T = C + NT + TN as the number of antimalarial-treated cases, assuming that all confirmed cases were treated. The primary exposure, the presumptive malaria treatment (PMT) rate, was (NT + TN)/T × 100, the percentage of treated cases that received antimalarials without a positive test. Its two components were the not-tested treatment rate, NT/T × 100, and the test-negative treated rate, TN/T × 100; the two components sum to the PMT rate. The test-negative treated rate is the share of antimalarial treatment given after a negative test. Because the number of patients who tested negative is not in its denominator, it does not measure prescribing adherence among all test-negative patients.

The four primary outcomes were confirmed malaria incidence (C per 1,000 population), malaria admission rate (admissions per 1,000 population), malaria mortality rate (in-hospital malaria deaths per 100,000 population), and in-hospital case fatality rate (CFR; deaths per 100 malaria admissions). Secondary outcomes were the under-five share of malaria admissions and deaths and the age-specific CFR among admitted patients under five years and five years and above.

Data management

Non-numeric entries were set to missing. Following Ghana's DHIMS2 reporting convention, in which a blank entry denotes no event, blank entries for in-hospital deaths (24 region-years, 19 of them in 2023–2025) were coded as zero; no other missing value was imputed. The test-negative treated element was not reported for any region in 2016, and in 2017 only two regions entered values (30 cases in Ashanti and 2 in Northern, against 33,069 and 3,299 in 2018), so we treated the element as reported from 2018. For 2016 and 2017 the PMT rate therefore consists of the not-tested component only and is an incomplete estimate. Analyses of the test-negative treated rate used the 128 region-years from 2018 to 2025, and analyses of the PMT and not-tested rates used all 160 region-years. Rates with a zero denominator were set to missing. We confirmed that the panel contained ten observations per region and 16 per year, and reviewed the distribution of every variable (minimum, maximum, mean, and interquartile range) for implausible values before analysis.

Statistical analysis

All analyses were performed in Python 3.12 using pandas, NumPy, SciPy, statsmodels, and linearmodels. National annual rates were calculated by summing numerators and denominators across the 16 regions in each year. Regional rates for the whole period, and for the periods 2016–2020 and 2021–2025, were calculated in the same way, as the

ratio of summed counts across the relevant years, so that each rate is weighted by case volume. Change between periods was expressed in two ways. The absolute change, in percentage points, was the PMT rate in 2021–2025 minus the PMT rate in 2016–2020. The relative change, in percent, was the absolute change divided by the 2016–2020 rate and multiplied by 100. Negative values indicate a decline in both measures. Age composition was summarized as the under-five share of admissions and deaths and as age-specific CFR.

Associations between each of the three exposures (PMT, not-tested, and test-negative treated rates) and each of the four outcomes were examined in three steps. First, Spearman rank correlation coefficients were estimated across all available region-years, with two-sided p-values from the t-distribution approximation. Second, pooled ordinary least squares (OLS) models with a single exposure and an intercept (12 models) were fitted for comparison; these models ignore the panel structure and were interpreted as unadjusted. Third, two-way fixed-effects panel models were fitted:

$$Y_{rt} = \alpha_r + \lambda_t + \beta X_{rt} + \varepsilon_{rt}$$

where Yrt is the outcome in region r and year t, Xrt is the exposure, αr are region fixed effects, λt are year fixed effects, and εrt is the error term. Region effects absorb stable differences between regions, such as transmission ecology and health system structure. Year effects absorb changes common to all regions in a given year, such as national policy, commodity procurement cycles, and the COVID-19 disruption of 2020. β therefore represents the within-region change in the outcome associated with a one-percentage-point change in the exposure, beyond the national trend. Coefficients were estimated with the PanelOLS estimator of linearmodels. Standard errors were clustered by region with the CR1 small-sample correction, and 95% confidence intervals and p-values used a t distribution with 15 degrees of freedom. Because cluster-robust inference can be

unreliable with 16 clusters, we also obtained p-values from a wild cluster restricted bootstrap with Webb weights (9,999 replications). In a sensitivity analysis, all fixed-effects models were re-estimated for 2018–2025 (128 region-years), when both components were reported for every region. Statistical significance was set at $p < 0.05$.

Results

National trends in presumptive treatment, 2016–2025

The national PMT rate fell from 33.5% in 2016 to 3.6% in 2025, with most of the decline achieved by 2019 (10.4%); because the test-negative component was not reported in 2016 and 2017, values for those years are incomplete estimates. From 2018, when both components were reported, the rate fell from 14.5% to 3.6%, with a temporary rise to 8.2% in 2024 (**Fig. 1**). The not-tested component accounted for both the overall decline and the 2024 rise, whereas the test-negative treated rate stayed between 1.0% and 1.9% from 2018 onward.

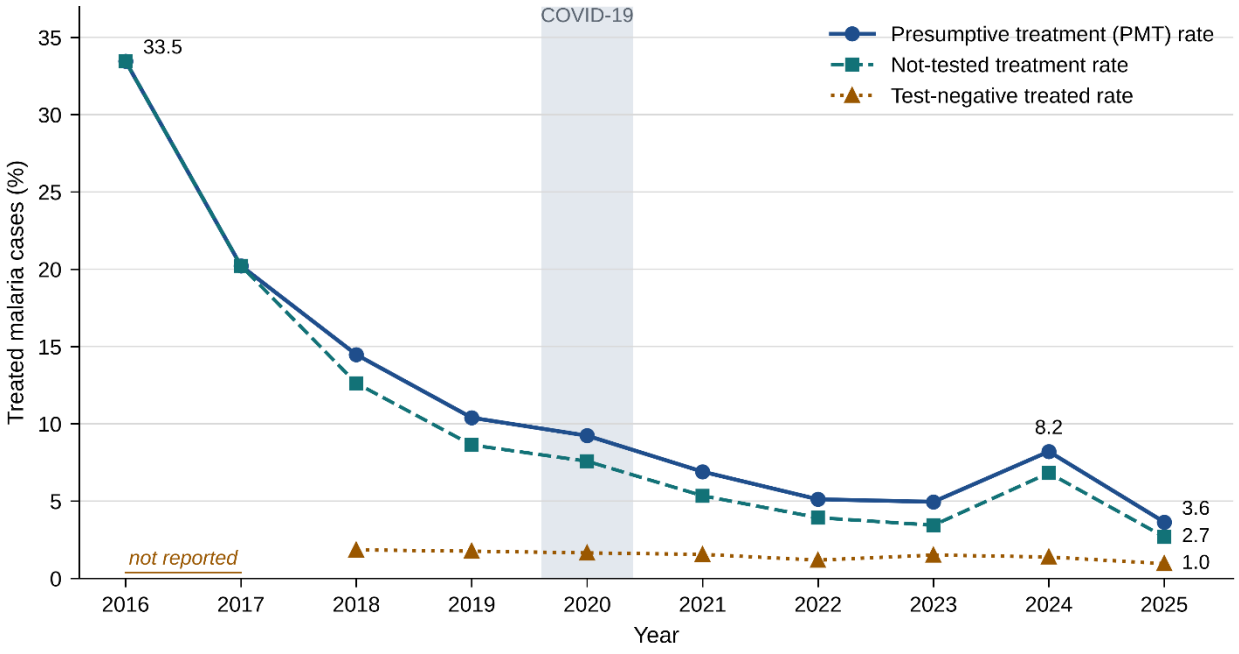


Fig. 1: National presumptive malaria treatment rate and its components, Ghana, 2016–2025

Regional variation and change between periods

Over 2016–2025, the PMT rate was highest in Northern (22.2%), Greater Accra (21.6%), and North East (20.6%) and lowest in Upper West (5.7%) (**Table 1**). Greater Accra combined one of the highest PMT rates with the lowest confirmed incidence in the country (39.2 per 1,000 population).

Table 1. Presumptive malaria treatment rates, period change, and malaria outcomes by region, Ghana, 2016–2025

Region	PMT 2016–2025 (%)	PMT 2016–2020 (%)	PMT 2021–2025 (%)	Absolute change (pp)	Relative change (%)	Confirmed incidence (/1,000)	Admission rate (/1,000)	Mortality rate (/100,000)	CFR (%)
Northern	22.2	33.6	9.5	−24.1	−71.8	97.8	20.6	2.84	0.14
Greater Accra	21.6	29.5	11.3	−18.2	−61.7	39.2	4.9	0.42	0.09
North East	20.6	37.0	8.2	−28.7	−77.7	149.6	17.9	3.32	0.18
Savannah	20.0	30.4	8.5	−21.9	−71.9	180.4	15.9	2.04	0.13
Ashanti	17.2	26.5	8.0	−18.5	−69.6	136.0	15.2	0.68	0.04
Volta	14.4	22.6	4.8	−17.8	−78.7	152.1	9.7	1.45	0.15
Western	13.5	18.2	6.7	−11.5	−63.2	259.4	14.9	0.98	0.07
North Western	10.6	14.2	6.5	−7.7	−54.1	220.5	10.0	0.81	0.08
Bono East	10.5	12.1	8.6	−3.5	−28.6	265.2	15.7	2.46	0.16
Eastern	9.4	14.6	4.5	−10.1	−68.9	217.2	10.5	0.91	0.09
Central	9.2	15.4	2.7	−12.7	−82.7	190.9	8.6	0.81	0.10
Oti	8.4	13.0	3.4	−9.7	−74.0	198.1	9.6	1.20	0.13
Bono	7.5	9.1	5.7	−3.4	−37.6	303.0	14.7	1.61	0.11
Ahafo	7.4	9.3	5.4	−3.9	−42.1	274.0	16.7	0.59	0.04
Upper East	5.9	8.9	1.9	−7.0	−78.7	342.7	12.5	1.28	0.10
Upper West	5.7	10.0	0.9	−9.2	−91.1	283.1	19.8	2.54	0.13

PMT, presumptive malaria treatment; pp, percentage points; CFR, in-hospital case fatality rate. Rates are pooled as the ratio of summed counts over the stated years; outcome indicators are pooled over 2016–2025. Absolute change = PMT 2021–2025 minus PMT 2016–2020; relative change = absolute change ÷ PMT 2016–2020 × 100. Changes were computed from unrounded rates and may differ by 0.1 from values derived from the rounded rates shown. Regions are ordered by the 2016–2025 PMT rate.

Every region had a lower PMT rate in 2021–2025 than in 2016–2020 (Fig. 2). The largest absolute declines were in North East (−28.7 percentage points), Northern (−24.1), and

Savannah (−21.9), whereas Bono East, Bono, and Ahafo declined by less than 4 points. By 2021–2025, Greater Accra had the highest rate (11.3%) and Upper West the lowest (0.9%).

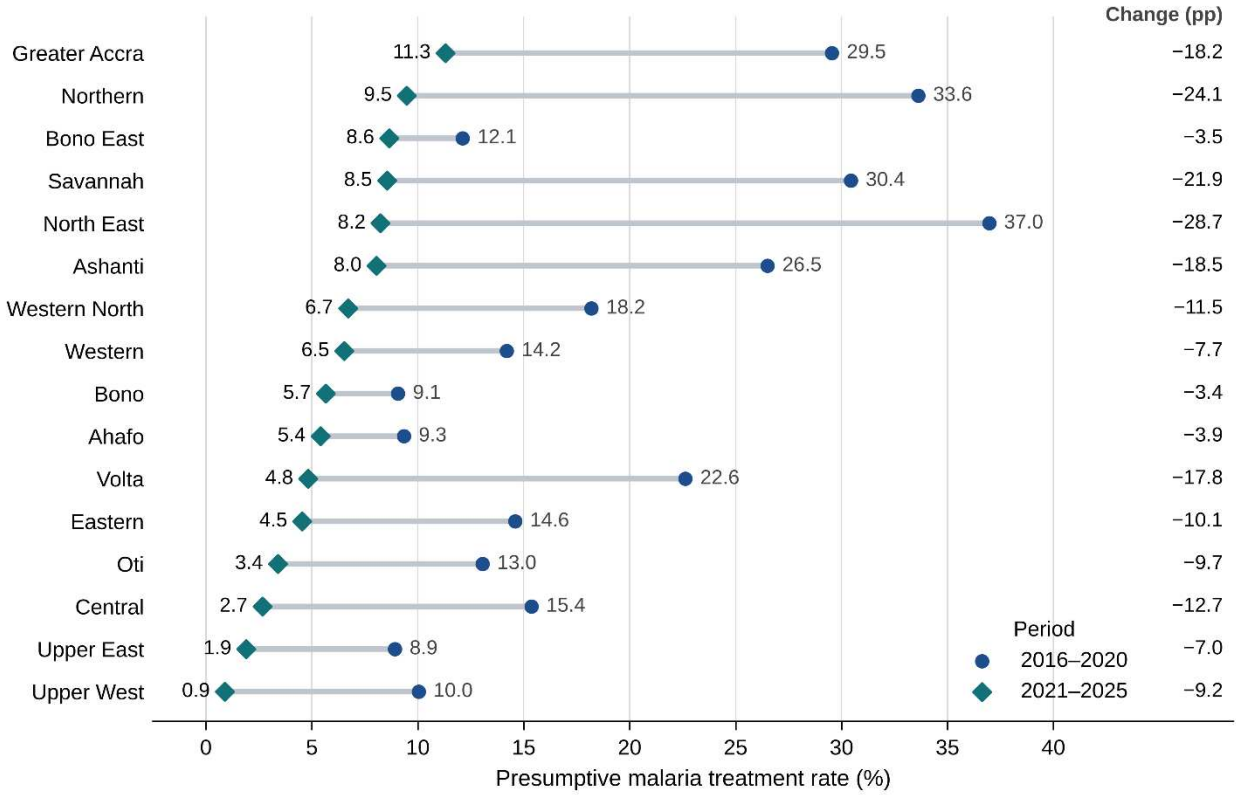


Fig. 2: Presumptive malaria treatment rate by region, 2016–2020 and 2021–2025, Ghana

Malaria admissions and deaths by age group

Malaria admissions among children under five fell by 48.9% between 2016 and 2025, whereas admissions among persons aged five years and above peaked in 2023 at 60.2% above the 2016 level and remained 22.2% higher in 2025 (Fig. 3). The under-five share of admissions consequently declined from 48.0% to 27.9%.

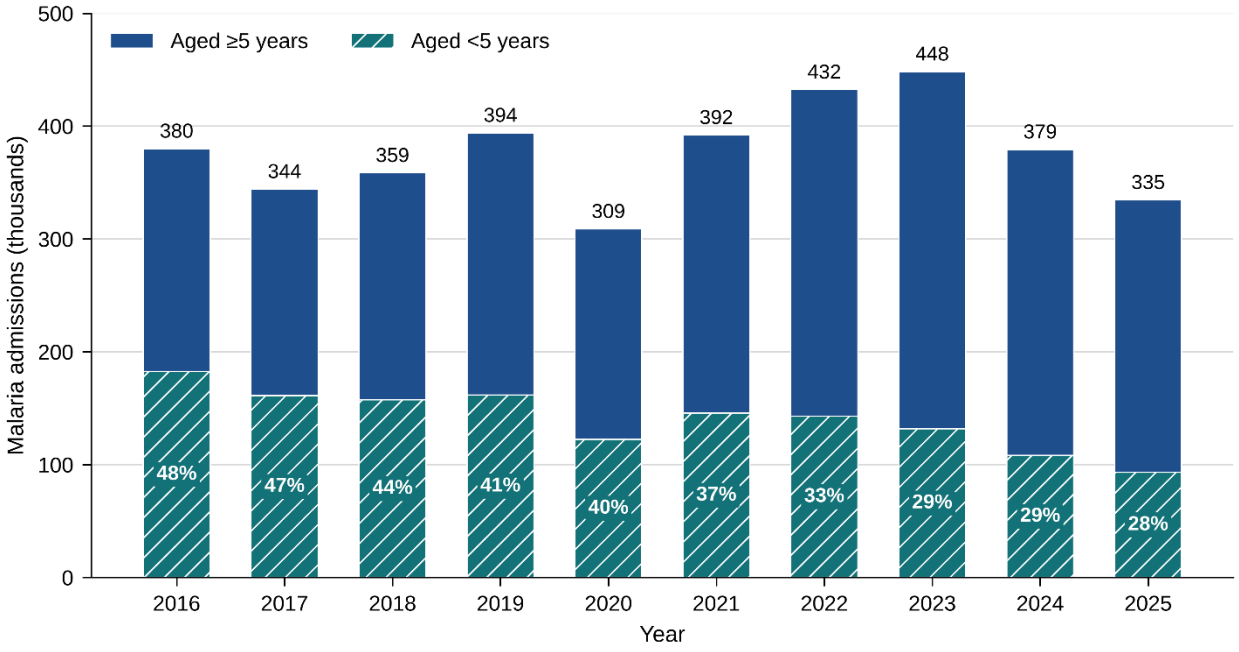


Fig. 3: National malaria admissions by age group, Ghana, 2016–2025

In-hospital malaria deaths fell by 95.9%, from 1,264 in 2016 to 52 in 2025, yet the under-five share of deaths showed no consistent trend and stayed near half throughout (**Table 2).** The CFR among admitted children under five, similar to that of older patients in 2016, was about twice as high by 2025 (0.026% vs 0.012%).

Table 2. National malaria admissions, deaths, and case fatality by age group, Ghana, 2016–2025

Year	Admissions <5 y	Admissions ≥5 y	Under-five share of admissions (%)	Deaths <5 y	Deaths ≥5 y	Under-five share of deaths (%)	CFR <5 y (%)	CFR ≥5 y (%)
2016	182,453	197,583	48.0	590	674	46.7	0.323	0.341
2017	161,157	183,056	46.8	327	272	54.6	0.203	0.149
2018	157,366	201,172	43.9	245	172	58.8	0.156	0.085
2019	161,657	232,370	41.0	168	168	50.0	0.104	0.072
2020	122,478	186,409	39.7	148	160	48.1	0.121	0.086
2021	145,587	246,527	37.1	127	150	45.8	0.087	0.061
2022	143,022	289,373	33.1	72	75	49.0	0.050	0.026
2023	131,811	316,550	29.4	77	69	52.7	0.058	0.022
2024	108,243	271,095	28.5	35	39	47.3	0.032	0.014
2025	93,171	241,367	27.9	24	28	46.2	0.026	0.012

CFR, in-hospital case fatality rate (deaths per 100 malaria admissions in the same age group); y, years.

Unadjusted associations between presumptive treatment and outcomes

In unadjusted analyses, a higher PMT rate was associated with lower confirmed incidence (β = −3.36 per 1,000; 95% CI: −4.39 to −2.34) and with higher mortality and case fatality rates (both p < 0.001), whereas no statistically significant association was detected with the admission rate (**Table 3**).

Table 3. Unadjusted associations between presumptive treatment indicators and malaria outcomes, Ghana, 2016–2025

Exposure	Outcome	Spearman r	p-value	OLS β	95% CI	OLS p-value	N
PMT rate	Confirmed incidence (/1,000)	−0.493	<0.001	−3.363	−4.390 to −2.337	<0.001	160
	Admission rate (/1,000)	0.060	0.453	0.073	0.000 to 0.145	0.050	160
	Mortality rate (/100,000)	0.430	<0.001	0.129	0.106 to 0.151	<0.001	160
	CFR (%)	0.489	<0.001	0.007	0.006 to 0.008	<0.001	160
Not-tested rate	Confirmed incidence (/1,000)	−0.414	<0.001	−2.882	−3.929 to −1.836	<0.001	160
	Admission rate (/1,000)	0.122	0.125	0.086	0.015 to 0.158	0.018	160
	Mortality rate (/100,000)	0.457	<0.001	0.132	0.111 to 0.153	<0.001	160
	CFR (%)	0.490	<0.001	0.007	0.006 to 0.008	<0.001	160
Test-negative treated rate	Confirmed incidence (/1,000)	−0.467	<0.001	−30.322	−38.261 to −22.382	<0.001	128
	Admission rate (/1,000)	−0.196	0.027	−1.028	−1.605 to −0.451	<0.001	128
	Mortality rate (/100,000)	0.035	0.697	−0.047	−0.151 to 0.056	0.368	128
	CFR (%)	0.159	0.073	0.004	−0.003 to 0.010	0.243	128

Spearman rank correlation and pooled OLS regression across 160 region-years (128 for the test-negative treated rate, 2018–2025). OLS, ordinary least squares; PMT, presumptive malaria treatment; CFR, in-hospital case fatality rate. β is the change in the outcome per one-percentage-point increase in the exposure. Each model contains one exposure and an intercept.

Fixed-effects panel regression

After adjustment for region and year fixed effects, the PMT rate remained inversely associated with confirmed incidence: each one-percentage-point increase within a region corresponded to 2.28 fewer confirmed cases per 1,000 population (95% CI: −3.84 to

−0.71; p = 0.007; bootstrap p = 0.028) (**Table 4**). The not-tested treatment rate showed the same association (β = −2.06; 95% CI: −3.72 to −0.39; bootstrap p = 0.042).

Table 4. Fixed-effects panel regression of malaria outcomes on presumptive treatment indicators, Ghana, 2016–2025

Exposure	Admission rate (/1,000)	Mortality rate (/100,000)	CFR (%)	Confirmed incidence (/1,000)
PMT rate	0.140 (−0.031 to 0.311) p = 0.101 bootstrap p = 0.088	0.071 (−0.009 to 0.150) p = 0.078 bootstrap p = 0.125	0.001 (−0.002 to 0.004) p = 0.533 bootstrap p = 0.546	**−2.277** **(−3.844 to −0.711)** **p = 0.007** **bootstrap p = 0.028**
Not-tested treatment rate	0.147 (−0.040 to 0.335) p = 0.114 bootstrap p = 0.105	0.069 (−0.019 to 0.157) p = 0.117 bootstrap p = 0.184	0.001 (−0.003 to 0.005) p = 0.589 bootstrap p = 0.593	**−2.059** **(−3.724 to −0.395)** **p = 0.019** **bootstrap p = 0.042**
Test-negative treated rate	−0.368 (−1.424 to 0.688) p = 0.469 bootstrap p = 0.445	−0.109 (−0.300 to 0.082) p = 0.243 bootstrap p = 0.204	−0.005 (−0.011 to 0.001) p = 0.096 bootstrap p = 0.077	−8.610 (−19.596 to 2.376) p = 0.116 bootstrap p = 0.061

Values are β, 95% CI, and p-value from cluster-robust standard errors (CR1 correction; t distribution with 15 degrees of freedom), followed by the p-value from a wild cluster restricted bootstrap with Webb weights (9,999 replications). Each model includes one exposure, region fixed effects, and year fixed effects (16 clusters; 160 region-years for the PMT and not-tested rates and 128 for the test-negative treated rate, 2018–2025). β is the within-region change in the outcome per one-percentage-point increase in the exposure; each cell is a separate model. Bold indicates p < 0.05 (cluster-robust). PMT, presumptive malaria treatment; CFR, in-hospital case fatality rate.

Discussion

Over ten years, the share of malaria cases in Ghana treated without a positive test fell steeply, with most of the decline before 2019 and a fall from 14.5% to 3.6% between 2018 and 2025, when both components were reported, and every region treated a smaller share of cases without confirmation in 2021–2025 than in 2016–2020. Regional differences narrowed but did not disappear, and a rebound in 2024 interrupted the national decline. Over the same decade, malaria admissions shifted toward persons aged five years and above, while recorded in-hospital malaria deaths fell by 96%. Within regions, years with more presumptive treatment had lower reported confirmed incidence, and no statistically significant independent association was detected between presumptive treatment and admissions, mortality, or case fatality.

The national decline is consistent with the adoption of test-based management after the 2010 WHO recommendation and the Test, Treat, Track initiative, and with successive strategic plans that financed RDT procurement, microscopy quality assurance, and prescriber training [4, 6–8]. Almost all of the decline came from a fall in the not-tested treatment component, with little change in the share of treatment given after a negative test. The test-negative treated rate stayed between about 1% and 2% from 2018 to 2025. This residual practice is the form that facility studies in Ghana attribute to distrust of negative RDTs and fear of missing severe malaria [9–11], and it is unlikely to respond to further gains in testing alone. Support for investigating non-malarial fever and structured follow-up of test-negative patients address these concerns more directly. The 2024 rebound also came from the not-tested component, which suggests that the gains depend on uninterrupted access to testing. Because RDT availability was the strongest correlate of inappropriate ACT prescribing in Greater Accra [11], facility-level RDT stock data for 2024 deserve review alongside these trends. Sustaining test-based management also preserves its cost advantage in Ghana [14] and limits unnecessary drug pressure as artemisinin partial resistance spreads in Africa [1].

Regions followed different paths. Northern, North East, and Savannah began the period with the highest rates and recorded the largest absolute declines, which narrowed their gap with the rest of the country, although Northern and Savannah remained among the four highest in 2021–2025. Greater Accra declined proportionally less and, by 2021–2025, had the highest PMT rate of any region despite having the lowest confirmed incidence. Bono East, Bono, and Ahafo started from lower levels but improved least, leaving Bono East third highest in the recent period. These differing trajectories call for region-specific responses rather than a single national approach. In the northern regions, where CHPS compounds depend on RDTs, keeping RDTs in stock at the lowest level of care is the most direct way to protect recent gains [9, 10]. In Greater Accra,

disaggregating presumptive treatment by facility type and ownership would show where supervision is most needed, since adherence to Test, Treat, Track in Ghana has been lowest in hospitals and highest in CHPS compounds [9]. In Bono, Bono East, and Ahafo, district-level review could identify the facilities that account for most unconfirmed treatment. Orienting newly posted prescribers and laboratory staff on test-based management before they assume duty, as Ghanaian prescribers themselves recommend, applies in every region [10].

The fall in the under-five share of admissions from 48.0% to 27.9%, alongside a 22% rise in admissions among persons aged five years and above, is consistent with the pattern seen elsewhere in Africa, where declining transmission delays the acquisition of clinical immunity and moves hospital burden toward older children and adults [19]. Interventions aimed at young children have probably contributed in Ghana, including seasonal malaria chemoprevention in the north and malaria vaccination, which expanded from 42 districts in 2019 to cover 11 of the 16 regions by 2024 [2, 18], although this analysis cannot separate their effects. The group aged five years and above spans school-age children to older adults, and other Ghanaian surveillance shows the highest test positivity among children aged 5–14 years [20], so school-age children are a plausible contributor to the rise. Two further findings temper the shift. Children under five still accounted for about half of malaria deaths throughout the period, and by 2025 their CFR among admitted cases was roughly double that of older patients. Clinical attention therefore needs to widen to older age groups while severe malaria care for young children remains a priority.

Unadjusted analyses suggested that regions and years with more presumptive treatment had higher mortality and case fatality, but these associations did not persist after adjustment for region and year. Presumptive treatment and recorded deaths both fell steeply over the decade, and the year effects absorb this shared secular decline, which

accounts for most of the unadjusted correlation. The inverse association with confirmed incidence, by contrast, remained after adjustment, and two mechanisms explain it without any change in transmission. First, cases treated without a positive test are not counted as confirmed, so within a region a year with more unconfirmed treatment records fewer confirmed cases for the same underlying burden. Second, confirmed cases form part of the PMT denominator, so a rise in confirmed cases lowers the PMT rate even if unconfirmed treatment does not change, a form of mathematical coupling that produces correlation between ratio variables sharing a component [21]. The coefficient should therefore not be read as presumptive treatment reducing malaria. Its practical implication is that confirmed incidence reported through DHIMS2 should be presented with the not-tested and test-negative treatment rates, particularly when regions are compared or elimination progress is judged [15].

This analysis covered all 16 regions over ten years in a balanced panel, separated presumptive treatment into its not-tested and test-negative components, and used two-way fixed-effects models to remove stable regional differences and national year-to-year changes. It also has several limitations. First, the design is ecological, and associations observed at the region-year level cannot be extended to individual patients. Second, the test-negative treated element was not reported in 2016 or 2017, so the PMT rate in those years understates presumptive treatment by an unknown amount, and comparisons involving 2016–2020 combine complete and incomplete estimates; the 2018–2025 sensitivity analysis, which avoids these years, gave a similar association between the PMT rate and confirmed incidence. Finally, the fixed-effects models relied on 16 clusters; we used small-sample corrections and wild cluster bootstrap inference, but 24 regression models were fitted without adjustment for multiple comparisons, so associations with p-values near 0.05 should be treated with caution.

Conclusions

Presumptive malaria treatment in Ghana fell from one in three treated cases in 2016 to fewer than one in 25 in 2025, mainly through a decline in the not-tested treatment component, although Greater Accra, Northern, Bono East, and Savannah retained the highest rates. Within regions, more presumptive treatment corresponded with lower reported confirmed incidence with no statistically significant association detected with admissions or deaths, so confirmed incidence should be reported alongside not-tested and test-negative treatment rates.

Declarations

Acknowledgements

We thank the regional and district health information officers, malaria focal persons, and facility staff whose monthly reporting through DHIMS2 made this analysis possible.

Author contributions

FAB and PHKA conceived the study. AGM and DD curated and analyzed the data and wrote the first draft. GAA, DD, AA, GAO, JJIA, PB, and IF contributed to data acquisition, validation, and interpretation. PHKA reviewed the methods and results. AI reviewed the manuscript. All authors read and approved the final manuscript.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data availability

The data that support the findings of this study are available from the Ghana Health Service District Health Information Management System 2 (DHIMS2),

https://dhims.chimgh.org/, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Ghana Health Service.

Ethical Approval and accordance

This study was a secondary analysis of aggregated region-level malaria case management indicators routinely reported through DHIMS2. The indicators contain no individual identifiers, and no participants were recruited, contacted, or examined. The study protocol was reviewed by the Ghana Health Service Ethics Review Committee (GHS-ERC), which waived the requirement for full ethical approval. Permission to use the indicators was granted by the National Malaria Elimination Programme, Ghana Health Service. The research was carried out in accordance with the guidelines and regulations of the Ghana Health Service Ethics Review Committee and with the principles of the Declaration of Helsinki.

Consent to participate

The aggregated indicators include counts for children under five years and for persons aged five years and above, so events among persons under 18 years contributed to the regional totals. No individual, child or adult, was enrolled, and none of the counts can be linked to any person. Because the study used only anonymized aggregated routine data, the Ghana Health Service Ethics Review Committee waived the requirement for informed consent, including informed consent from the parents or legal guardians of children under 16 years.

Consent to publish

Not applicable. The manuscript contains no individual person’s data in any form.

Clinical trial number

Not applicable.

Competing interests

The authors declare no competing interests.

References

1. World Health Organization. World malaria report 2025. Geneva: World Health Organization; 2025.

2. Adjei MR, Tweneboah PO, Bonsu G, et al. An assessment of Ghana's pilot of the RTS,S malaria vaccine implementation programme; 2019–2021: a retrospective study. Malar J. 2024;23(1):290. https://doi.org/10.1186/s12936-024-05113-8

3. Mohammed AG, Tamal CS, Odikro MA, et al. Malaria data analysis using routine surveillance data, Sunyani Municipality, Ghana, 2020 [Preprint]. Research Square. 2021. https://doi.org/10.21203/rs.3.rs-168549/v1

4. National Malaria Elimination Programme. National Malaria Elimination Strategic Plan 2024–2028. Accra: Ghana Health Service; 2023.

5. Babayara MNK, Addo B. Presumptive treatment of malaria in Ghana: was it ever useful? Evidence from the Kassena-Nankana District of Northern Ghana. Malar Res Treat. 2018;2018:3408089. https://doi.org/10.1155/2018/3408089

6. Baiden F, Malm K, Bart-Plange C, et al. Shifting from presumptive to test-based management of malaria: technical basis and implications for malaria control in Ghana. Ghana Med J. 2014;48(2):112–22. https://doi.org/10.4314/gmj.v48i2.10

7. World Health Organization. Guidelines for the treatment of malaria. 2nd ed. Geneva: World Health Organization; 2010.

8. World Health Organization. T3: Test. Treat. Track. Scaling up diagnostic testing, treatment and surveillance for malaria. Geneva: World Health Organization; 2012.

9. Kweku M, Der JB, Blankson WK, et al. Assessment of the performance and challenges in the implementation of the test, treat and track (T3) strategy for malaria control among children under-five years in Ghana. PLoS One. 2022;17(12):e0278602. https://doi.org/10.1371/journal.pone.0278602

10. Kolekang AS, Afrane Y, Apanga S, et al. Challenges with adherence to the 'test, treat, and track' malaria case management guideline among prescribers in Ghana. Malar J. 2022;21(1):332. https://doi.org/10.1186/s12936-022-04365-6

11. Bonful HA, Awua AK, Adjuik M, et al. Extent of inappropriate prescription of artemisinin and anti-malarial injections to febrile outpatients, a cross-sectional analytic survey in the Greater Accra region, Ghana. Malar J. 2019;18(1):331. https://doi.org/10.1186/s12936-019-2967-8

12. Bisoffi Z, Gobbi F, Buonfrate D, et al. Diagnosis of malaria infection with or without disease. Mediterr J Hematol Infect Dis. 2012;4(1):e2012036. https://doi.org/10.4084/MJHID.2012.036

13. D'Acremont V, Lengeler C, Mshinda H, et al. Time to move from presumptive malaria treatment to laboratory-confirmed diagnosis and treatment in African children with fever. PLoS Med. 2009;6(1):e252. https://doi.org/10.1371/journal.pmed.0050252

14. Tawiah T, Hansen KS, Baiden F, et al. Cost-effectiveness analysis of test-based versus presumptive treatment of uncomplicated malaria in children under five years in an area of high transmission in central Ghana. PLoS One. 2016;11(10):e0164055. https://doi.org/10.1371/journal.pone.0164055

15. Perkins MD, Bell DR. Working without a blindfold: the critical role of diagnostics in malaria control. Malar J. 2008;7(Suppl 1):S5. https://doi.org/10.1186/1475-2875-7-S1-S5

16. Baiden F, Bruce J, Webster J, et al. Effect of test-based versus presumptive treatment of malaria in under-five children in rural Ghana: a cluster-randomised trial. PLoS One. 2016;11(4):e0152960. https://doi.org/10.1371/journal.pone.0152960

17. Ghana Statistical Service. Ghana 2021 Population and Housing Census: general report. Accra: Ghana Statistical Service; 2021.

18. UNICEF Ghana. Ghana expands malaria vaccine rollout [press release]. 2024. https://www.unicef.org/ghana/press-releases/ghana-expands-malaria-vaccine-rollout. Accessed 8 Oct 2026.

19. Mogeni P, Williams TN, Fegan G, et al. Age, spatial, and temporal variations in hospital admissions with malaria in Kilifi County, Kenya: a 25-year longitudinal observational study. PLoS Med. 2016;13(6):e1002047. https://doi.org/10.1371/journal.pmed.1002047

20. Bagonluri AC, Odikro MA, Akowuah G, et al. Subnational malaria surveillance for elimination planning: analysis of routine district data from Bole District, Ghana, 2018–2022. J Interv Epidemiol Public Health. 2026;9(3):144. https://doi.org/10.37432/jieph-d-25-00062

21. Kronmal RA. Spurious correlation and the fallacy of the ratio standard revisited. J R Stat Soc Ser A Stat Soc. 1993;156(3):379–92. https://doi.org/10.2307/2983064

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTable1.docx
- SupplementaryFile1STROBEchecklist.docx