Determinants of improvement trends in health workers’ compliance with outpatient malaria case-management guidelines at health facilities with available “test and treat” commodities in Kenya

Beatrice Amboko1*, Kasia Stepniewska2,3, Lucas Malla1, Beatrice Machini4, Philip Bejon1,3, Robert W. Snow1,3, Dejan Žurovac1,3

1 KEMRI-Wellcome Trust Research Programme, Nairobi, Kenya, 2 WorldWide Antimalarial Resistance Network, Oxford, United Kingdom, 3 Centre for Tropical Medicine and Global Health, University of Oxford, Oxford, United Kingdom, 4 Division of National Malaria Programme, Ministry of Health, Nairobi, Kenya

* indimulib06@gmail.com

Abstract

Background
Health workers’ compliance with outpatient malaria case-management guidelines has been improving in Africa. This study examined the factors associated with the improvements.

Methods
Data from 11 national, cross-sectional health facility surveys undertaken from 2010–2016 were analysed. Association between 31 determinants and improvement trends in five outpatient compliance outcomes were examined using interactions between each determinant and time in multilevel logistic regression models and reported as an adjusted odds ratio of annual trends (T-aOR).

Results
Among 9,173 febrile patients seen at 1,208 health facilities and by 1,538 health workers, a higher annual improvement trend in composite “test and treat” performance was associated with malaria endemicity-lake endemic (T-aOR = 1.67 annually; p < 0.001) and highland epidemic (T-aOR = 1.35; p < 0.001) zones compared to low-risk zone; with facilities stocking rapid diagnostic tests only (T-aOR = 1.49; p < 0.001) compared to microscopy only services; with faith-based/non-governmental facilities compared to government-owned (T-aOR = 1.15; p = 0.036); with a daily caseload of >25 febrile patients (T-aOR = 1.49; p < 0.001) compared to microscopy only services; with faith-based/non-governmental facilities compared to government-owned (T-aOR = 1.15; p = 0.036); with a daily caseload of >25 febrile patients (T-aOR = 1.49; p < 0.001) compared to microscopy only services; and with under-five children compared to older patients (T-aOR = 1.07; p = 0.013). Other factors associated with the improvement trends in the “test and treat” policy components and arte-mether-lumefantrinine administration at the facility included the absence of previous RDT stock-outs, community health workers dispensing drugs, access to malaria case-
management and Integrated Management of Childhood Illness (IMCI) guidelines, health workers’ gender, correct health workers’ knowledge about the targeted malaria treatment policy, and patients’ main complaint of fever. The odds of compliance at the baseline were variable for some of the factors.

**Conclusions**

Targeting of low malaria risk areas, low caseload facilities, male and government health workers, continuous availability of RDTs, improving health workers’ knowledge about the policy considering age and fever, and dissemination of guidelines might improve compliance with malaria guidelines. For prompt treatment and administration of the first artemether-lumefantrine dose at the facility, task-shifting duties to community health workers can be considered.

**Introduction**

Malaria continues to be a major public health problem in Africa and case-management is a key component to reducing the malaria burden [1, 2]. The global shift from presumptive treatment of fevers to the 2010 “test and treat” policy recommending parasitological testing of all suspected malaria cases and targeted antimalarial treatment for only confirmed cases presented a major milestone in the history of malaria case-management [3, 4].

Health workers’ compliance with guidelines is one of the key aspects determining the cost-effectiveness of the “test and treat” policy implementation [5–7]. Numerous outpatient malaria case-management studies across Africa have shown that health workers’ clinical practices are often characterised by non-compliance with testing recommendations [8, 9], use of non-recommended antimalarials for confirmed cases [10, 11], irrational antimalarial treatments for test-negative patients [10, 12, 13] and missed opportunities for the administration of prompt antimalarial treatment at health facilities [8, 14–16].

Moreover, non-compliant practices have not only been observed in clinical settings where lack of “test and treat” commodities for malaria preclude compliance with guidelines [17], but also at facilities with adequate availability of malaria diagnostic and treatment commodities [14, 15, 18]. Besides the commodities, a variety of determinants may influence health workers’ compliance with guidelines [19–21]. According to Rowe et al. [19], these determinants can be grouped into two categories, interventional (e.g. training, guidelines, supervision) and non-interventional (e.g. patients’ age, gender, the severity of illness). The strongest study design for evaluating interventions to improve health workers’ compliance is randomized controlled trials as they can show causality, while observational studies can only establish associations. However, when a policy is implemented on a large scale under real-life conditions, the use of observational studies can be suitable and is often the only feasible option to identify both interventional and non-interventional determinants of performance [19]. Recent studies across Africa have suggested a variety of factors associated with health workers’ compliance with the test-based management of malaria [8, 22–24]. However, these studies were commonly undertaken at a single point in time [8, 22], focusing on only one of the outcomes (e.g. only testing) [23], and none examined determinants of the improvements in compliance with guidelines over time to assess the factors associated with long-term change in practices.
Improvements in the “test and treat” compliance have been observed on various scales across Africa [8, 12, 15, 25]. Such improvements have been well described in Kenya, where between 2010 and 2016, health workers’ compliance with all key outpatient case-management indicators significantly increased [23, 26, 27]. The differences in compliance trends across malaria epidemiological zones in Kenya have been previously reported [28]. In this paper, the effects of 31 interventional and non-interventional determinants that might be associated with the improvement trends in health workers’ compliance with malaria case-management guidelines at health facilities with available diagnostic and treatment commodities for malaria were examined.

Methods

Outpatient malaria case-management standards and implementation context

Kenya adopted the “test and treat” policy recommending universal parasitological testing of all patients with fever across all areas of malaria transmission with either malaria microscopy or rapid diagnostic tests (RDTs), and subsequent antimalarial treatment for only test positive patients in 2010 [29]. The recommended first-line treatment for uncomplicated malaria has been artemether-lumefantrine (AL) since 2006 [30, 31]. For prompt treatment and promotion of patients’ adherence to medicines, administration of the first AL dose is recommended at the health facility at the time when drugs are dispensed.

To support the countrywide translation of the 2010 malaria case-management policy into clinical practice, a series of routine programmatic activities have been implemented (Fig 1). Between April and September 2010, the first nationwide in-service training of frontline health workers on the new case-management policy was undertaken followed by the launch of the new guidelines in September 2010 [23, 29]. Subsequently, nationwide rounds of 3-day in-service malaria case-management training have been undertaken annually. The new malaria guidelines and accompanying job aids were distributed through routine commodity supply channels and during the in-service training. Moreover, in 2012, there was a national scale-up of RDTs to support the parasitological diagnosis of malaria and promote the appropriate use of antimalarial drugs. Lastly, strengthening of malaria-specific supervision using a structured checklist to assess health workers’ capacity and training in malaria case-management status and practices, followed by feedback and on-the-job training has been rolled out nationally since 2011.

![Fig 1. Timeline of key implementation activities of malaria diagnosis and treatment policy in Kenya.](https://doi.org/10.1371/journal.pone.0259020.g001)
Other contextual factors during this period include: first, central level stock-outs of AL and RDTs due to a fire at the Kenya Medical Supplies Agency (KEMSA) stores in 2013 and levy tax that delayed the delivery of commodities for ten months in 2014. Second, the pilot implementation of laboratory quality assurance and quality control for malaria microscopy and RDTs in low transmission counties that included on-job training and mentorship from June to December 2013 [32, 33]. Finally, in 2015, MalariaCare, a USAID partnership, began working in the lake endemic zone to improve the quality of malaria diagnosis using microscopy and RDTs, and clinical case-management of malaria and other febrile illnesses [34]. The implemented activities included case-management and laboratory training, on-site supervision, and mentoring (known as “outreach training and support supervision, OTSS”), electronic data collection and follow up evaluation, and implementation of the lessons learned. By 2016, two rounds of OTSS were conducted, reaching 98% coverage of the facilities in the region, and this might have contributed to the high compliance levels noted in the zone (Fig 1) [35, 36].

Data sources

The secondary analysis in this study utilised data from 11 national biannual cross-sectional, cluster sample health facility surveys undertaken between January 2010 and July 2016 (Fig 2). The primary monitoring indicator is a composite “test and treat” performance, measured at the patient level and comprised of malaria testing of febrile patients, AL treatment for test positive patients or no antimalarial for test negative patients. The sample size calculation details have been previously published [23, 26]. The sample size for each survey was calculated adjusting for the effect of clustering at the health facility level and the likelihood of practices at facilities without case-management commodities. For each survey, a proportionate stratified random sample of facilities was drawn from the Ministry of Health (MoH) master list of approximately 5,000 public health facilities taking into consideration the facility type, ownership and administrative boundaries to ensure national representativeness [37].

The number of assessed facilities ranged between 169 and 176 facilities per survey round. At each of the surveyed facilities, data collection methods included health facility assessments, interviews with health workers, and exit interviews with all eligible outpatients during one survey day when they were ready to leave the facility [23, 26, 28]. The patients’ exit interviews
included all non-referred and non-pregnant patients weighing >5 kgs across all age groups and presenting for an initial visit with fever or history of fever. Information was collected from patient-held cards about malaria tests requested, test results reported, treatment prescribed, and direct questioning about patients’ demographics, presenting symptoms, prior use of antimalarials, and drug dispensing and counselling practices during the facility visit. Each facility was assessed to determine the availability of medicines and diagnostics services (RDTs or microscopy). Additionally, febrile patients’ caseload on the survey day, ownership, retrospective stock-outs of malaria commodities, the health worker cadre dispensing medicines, and the availability of support tools like malaria treatment guidelines and job aids were also assessed. Finally, all health workers who provided clinical consultations in the outpatient departments were interviewed. Information on their demographic characteristics, outpatient responsibility, pre-service training, access to guidelines and job aids, in-service training, supervision, knowledge about malaria “test and treat” policy and their perceptions of malaria endemicity was collected. Health workers’ knowledge about the malaria “test and treat” policy was assessed using self-administered true or false statements reflecting the national recommendations about fever as malaria testing criteria and antimalarial treatment for only test positive patients as the targeted treatment recommendation. Data quality was assured through five days of training of the field workers, double-entry into a Microsoft Access database, and comparisons of data files using a verification program in Microsoft Access and referring to paper-based questionnaires (S1-S3 Appendices).

Outcomes and determinants

Five outcomes showing improvements in health workers’ compliance with national malaria case-management guidelines between 2010 and 2016 were selected (Fig 2). The outcomes reflected health workers’ decisions to test febrile patients for malaria, comply respectively with test positive and test negative results, deliver composite “test and treat” performance defined as a patient tested for malaria and prescribed AL if the test was positive or not prescribed an

Box 1. List of examined determinants

A) Malaria endemicity

1. Epidemiological zone (Lake endemic vs coast endemic vs highland epidemic vs semi-arid seasonal vs low)

B) Health facility level

1. Facility ownership (government vs faith-based/non-governmental organisation (FBO/NGO))
2. Level of outpatient care (dispensary vs health centre vs hospital)
3. Febrile patients’ caseload on the survey day (≤25 vs >25 patients)
4. Type of diagnostic test available at the facility (RDTs vs microscopy vs both)
5. Stock-outs of 7 or more continuous days of RDTs in the past 3 months (Yes vs No)
6. Stock-outs of 7 or more continuous days of AL in the past 3 months (Yes vs No)
7. Absence of malaria microscopy in the past 3 months (Yes vs No)
8. Availability of malaria guidelines (Yes vs No)
9. Displayed malaria case-management chart (Yes vs No)
10. Cadre dispensing drugs (CHW vs nurse/clinician vs pharmacist vs others)

C) Health worker level

1. Health workers’ age (continuous)
2. Gender (male vs female)
3. Outpatient responsibility (in-charge vs others)
4. Perception of malaria endemicity (high vs low)
5. Cadre (nurse vs clinical/medical officer vs others)
6. Malaria case-management in-service training (Yes vs No)
7. Access to current malaria case-management guidelines (Yes vs No)
8. Access to IMCI guidelines (Yes vs No)
9. Any supervisory visit received in past 3 months (Yes vs No)
10. Supervisory visit including any malaria case-management activity in the past 3 months (Yes vs No)
11. Supervisory visit with the observation of consultation in the past 3 months (Yes vs No)
12. Supervisory visit with feedback in the past 3 months (Yes vs No)
13. Correct knowledge of malaria testing policy (Yes vs No)
14. Correct knowledge of antimalarial treatment policy (Yes vs No)

D) Patient-level

1. Age (<5 years vs >5 years), (0–11 months, 12–59 months, 5–14 years, 15–45 years, >45 years) and as a continuous variable
2. Duration of illness (number of days)
3. Temperature (continuous and <37.5 vs ≥37.5˚ C)
4. Prior use of antimalarials for the same illness (Yes vs No)
5. Main complaints (fever, cough, diarrhoea, headache, running nose, rash, vomiting, and chills)
6. Case complexity (fever and other complaints vs fever only vs no fever)
antimalarial if the test was negative, and provide prompt treatment by administering the first AL dose at the facility.

With respect to determinants, Box 1 outlines malaria endemicity, ten health facility-, 14 health worker- and six patient-level determinants examined for the association with the 2010–2016 improvements in health workers’ compliance with each of the five outcomes. The malaria endemicity classifications have been previously described [28]. In summary, the classifications included: 1) Lake endemic–high transmission areas around Lake Victoria in western Kenya with stable malaria transmission all year round; 2) Coast endemic—low to moderate transmission areas along the Indian Ocean coast; 3) Highland epidemic–areas of the western highlands with unstable, year-to-year variation in transmission; 4) Semi-arid, seasonal transmission–arid and semi-arid areas of northern, eastern and south-eastern Kenya with acute seasonal and low transmission; and 5) Low risk—areas of central highlands including Nairobi with low transmission. The determinants were selected a priori based on the conceptual framework developed by Rowe et al. [19] and included factors previously reported in the literature and some additional ones (like health worker cadre dispensing medicines, health workers’ perceptions of malaria endemicity, case complexity and prior use of antimalarials) hypothesised to affect compliance.

**Statistical analysis**

Since the absence of commodities precludes compliance with guidelines, the analysis was restricted to patients who visited facilities with malaria diagnostic services and AL available on survey days. Across all surveys, 517 (30%) health facilities, 598 (28%) health workers and 4,281 (31.8%) febrile patient consultations were excluded from the analysis after the restriction.

Patient-level logistic regression models with random intercepts at the health facility level to adjust for clustering were used to assess the determinants of improvements in compliance. For each outcome, the probability $\mu_{ij}$ that the patient $i$ is correctly managed from a health facility $j$ was modelled, and hence $[\mu_{ij}/(1-\mu_{ij})]$ define the odds of health workers’ compliance. The annual trends in compliance with each binary outcome were first estimated using unadjusted multilevel logistic regression models with time in years as the only independent variable in the model (baseline model) and summarised as an odds ratio (OR) that represents the annual increase in the odds of compliance over time. The baseline model for the health workers’ compliance with each outcome was specified as:

$$\logit(\mu_{ij}) = \alpha + \beta t_j + \epsilon_{ij} + \mu_j$$

where $\alpha$ is the intercept; $t$ is the survey year; $\beta$ the annual time trends in health workers’ compliance at health facility $j$ and; $\epsilon_{ij}$ and $\mu_j$ the residuals at levels 1 and 2, respectively, and capture unobserved variation. A bivariable analysis of each outcome was then performed where the annual trends were fitted as the previous model but were a) adjusted for each covariate at baseline as follows;

$$\logit(\mu_{ij}) = \alpha + \beta 1 t_j + \beta 2 X_{ij} + \epsilon_{ij} + \mu_j$$

where $\beta 1$ is the time trends and $\beta 2$ is the covariates’ effect at the baseline, and b) each covariate was added as interaction with time (covariate * time) [38] as follows;

$$\logit(\mu_{ij}) = \alpha + \beta 1 t_j + \beta 2 X_{ij} + \beta 3 (X \ast t)_j + \epsilon_{ij} + \mu_j$$

where $\beta 3$ is the interaction between time∗covariate effect to evaluate the determinants of time trends in health workers’ compliance. Likelihood ratio tests comparing bivariable with base models at a significance level of a p-value (p) of <0.05 were used to perform the initial selection of covariates and interaction terms for multivariable analysis.
In the multivariable analysis for each outcome, any covariate or interaction term significant at \( p < 0.05 \) from the bivariable models were included. Covariates and interaction terms that turned non-significant at \( p < 0.05 \) (based on likelihood ratio test) were dropped from the models. Other potential determinants from the covariates and interaction terms that were non-significant in the bivariable analysis were tested one at a time and added to the model if they satisfied the \( p < 0.05 \) criterion in the likelihood ratio tests. At the same time, variables that did not lead to a significant change in log-likelihood tests were excluded from the models. The process of adding and dropping covariates and interaction terms was repeated until none of the variables in the model could be omitted without significantly increasing the model log-likelihood, and none of the excluded variables significantly reduced the model log-likelihood. Collinearity between covariates and interactions terms included in the multivariable models was automatically assessed using Stata and collinear variables were omitted when warranted.

The results of the final multivariable models are presented as the adjusted odds ratio (aOR, representing the baseline odds of compliance) and (T-aOR, the adjusted odds ratio of annual trends representing the multiplication factor for odds ratio for the annual change in compliance associated with a unit change in the covariate) with 95% CI. For instance, a T-aOR value of 5.0 for an interaction between age (\(<5 \text{ coded as } 0 \text{ vs } \geq 5 \text{ years as } 1\) and time means that the annual increment in the odds of compliance is five times higher for \( \geq 5\)-year olds compared to under-fives. The adjusted OR from the interaction terms between a covariate and time (T-aOR) were the main results for the determinants of improvement trends adjusting for main effects and covariates at baseline. No multiple comparisons adjustments were conducted [39, 40]. All analyses were conducted using Stata version 15 (StataCorp, College Station, TX, USA).

Ethics considerations
Ethical approval for the surveys was provided by the Kenyatta National Hospital/University of Nairobi-Ethics and Research Committee (KNH-ERC/R/108). Informed written consent was obtained for all participating health workers, patients, and caretakers of young children.

Results
Description of the study population
Frequency distributions of study patients by malaria endemicity zones and ten health facility-, 14 health worker- and six patient-level characteristics are shown for each of the 11 survey rounds in the S1 Table. In summary, a total of 9,173 febrile patients (survey range [SR]: 610–1,241) seen by 1,538 health workers (SR: 116–118) at 1,208 health facilities (SR: 89–143) were analysed. Median patients’ age ranged across surveys between five and eight years. The majority of the patients (>75%) had the main complaint of fever, followed by cough (SR: 42–51%) and headache (SR: 29–45%). Most patients visited government-owned facilities (SR: 75–93%) and dispensaries (SR: 35–63%). At the beginning of the surveys, most patients visited health facilities with only microscopy available, however, over time, this pattern declined (87 to 21%, \( p < 0.001 \)) while facilities with either only RDTs in stock (10 to 51%, \( p < 0.001 \) ) or both microscopy and RDTs available increased (4 to 28%, \( p < 0.001 \)). Across all the surveys, drugs were dispensed by nurses or clinical officers ranging between 35 to 55%. A majority of the patients were seen by male health workers (SR: 45–59%) and nurses (SR: 46–70%). The proportion of patients seen by trained health workers increased over time from 0 to 71% (\( p < 0.001 \)) and by supervised health workers from 49 to 70% (\( p = 0.019 \)). Moreover, health workers’ access to malaria treatment guidelines increased from none to 69% (\( p < 0.001 \)) and Integrated Management of Childhood Illness (IMCI) guidelines from 48 to 74% (\( p = 0.001 \)). Over three-quarters of the patients were seen by health workers who were knowledgeable about universal testing of
all febrile patients across all surveys while those with the correct knowledge of the malaria treatment policy increased from 47 to 95% (p<0.001) (S1 Table).

Determinants of improvement trends in compliance with overall “test and treat” performance

Overall, the odds of health workers’ compliance with testing and treating patients according to the malaria case-management guidelines increased between 2010 and 2016 by 26% annually (Fig 2, left-most set of bars; OR = 1.26 annually; 95% CI: 1.19–1.33). The results of the unadjusted bivariable analysis of determinants of the annual trends are shown in S2 Table. From the final multivariable model (Table 1), the baseline odds of composite “test and treat” performance are as follows:

Table 1: Determinants of improvement trends in compliance with composite malaria “test and treat” performance, 2010–2016—results from the final multivariable model.

| Factor                              | Baseline (2010), % (n/N) | Last survey (2016), % (n/N) | aOR (95% CI; p-value) | T-aOR ** (95% CI; p-value) | P-value for interaction *** |
|-------------------------------------|--------------------------|-----------------------------|-----------------------|---------------------------|---------------------------|
| Year                                | 20.9 (103/500)           | 25.0 (125/500)              | 0.90 (0.79–1.03; p = 0.117)* |                           |                           |
| Epidemiological zone                |                          |                             |                       |                           |                           |
| Low risk                            | 28.6 (52/182)            | 24.5 (24/98)                | Ref                   | Ref                       |                           |
| Lake endemic                        | 27.5 (112/407)           | 89.6 (206/230)              | 0.47 (0.25–0.87; p = 0.016) | 1.67 (1.43–1.95; p<0.001) |                           |
| Coast endemic                       | 25.0 (50/200)            | 75.0 (60/500)               | 1.16 (0.54–2.49; p = 0.714) | 1.18 (0.97–1.43; p = 0.098) |                           |
| Highland epidemic                   | 18.3 (38/208)            | 62.0 (75/121)               | 0.55 (0.29–1.03; p = 0.064) | 1.35 (1.16–1.58; p<0.001) |                           |
| Semi-arid seasonal                  | 40.2 (98/244)            | 49.0 (71/145)               | 1.87 (1.02–3.44; p = 0.044) | 0.97 (0.84–1.13; p<0.738) | <0.001                    |
| Facility ownership                  |                          |                             |                       |                           |                           |
| Government                          | 23.7 (219/926)           | 63.1 (361/572)              | Ref                   | Ref                       |                           |
| FBO/NGO                             | 41.6 (131/315)           | 73.5 (75/102)               | 1.24 (0.77–2.00; p = 0.371) | 1.15 (1.01–1.30; p = 0.036) | <0.001                    |
| Febrile patients’ caseload          |                          |                             |                       |                           |                           |
| ≤25 patients                        | 31.4 (277/881)           | 63.5 (408/643)              | Ref                   | Ref                       |                           |
| >25 patients                        | 20.3 (73/360)            | 90.3 (28/31)                | 0.40 (0.20–0.82; p = 0.012) | 1.46 (1.14–1.87; p = 0.003) | 0.010                     |
| Type of malaria diagnostic tests at the facility |                          |                             |                       |                           |                           |
| Microscopy                          | 30.2 (326/1078)          | 61.5 (88/143)               | Ref                   | Ref                       |                           |
| RDTs                                | 7.5 (9/120)              | 64.1 (218/143)              | 0.09 (0.05–0.18; p<0.001) | 1.49 (1.28–1.73; p<0.001) |                           |
| Both available                      | 34.9 (15/43)             | 68.1 (130/191)              | 1.64 (0.85–3.19; p = 0.143) | 0.94 (0.81–1.10; p = 0.467) | <0.001                    |
| Patient age                         |                          |                             |                       |                           |                           |
| ≥5 years                            | 36.3 (235/648)           | 67.7 (298/440)              | Ref                   | Ref                       |                           |
| <5 years                            | 19.4 (115/593)           | 59.0 (138/234)              | 0.66 (0.53–0.82; p<0.001) | 1.07 (1.02–1.14; p = 0.013) | 0.001                     |

*aOR=fixed effect representing the baseline odds ratio
**T-aOR = Ratio of annual change in the odds between the covariate levels and reference category adjusted for covariates at baseline
† fixed effects of time representing the annual change in the odds of compliance among older patients from the low malaria risk area seen at government-owned, less busy and microscopy only available facilities; The covariates adjusted for at baseline included health worker gender, HW perception of endemicity, supervision with feedback, correct knowledge about “test and treat” policy, temperature, patients’ main complaint of diarrhoea, headache, vomiting, running nose, cough and rash
***the overall p-value for the different time trends across factor categories from likelihood ratio tests

https://doi.org/10.1371/journal.pone.0259020.t001
compliance was lower for febrile patients from the lake endemic (aOR = 0.47) compared to low risk zone, those from busy facilities with a caseload of more than 25 febrile patients (aOR = 0.40) compared to less busy facilities, those from facilities with RDTs (aOR = 0.09) compared to microscopy services available and for children aged less than five years (aOR = 0.66) compared to older patients. The annual improvement trends were 67% and 35% higher in lake endemic (p < 0.001) and highland epidemic (p < 0.001) zones compared to low risk zone. Similarly, the improvements were 15% higher in patients who visited FBO/NGO compared to government-owned facilities (p = 0.036), 46% higher in busy facilities with a case-load of more than 25 febrile patients compared to less busy facilities (p = 0.003), and 49% higher in facilities with RDTs compared to microscopy available on the survey day (p < 0.001). Lastly, the improvement trends were 7% higher in under-fives compared to older patients (p = 0.013) (Table 1). None of the health worker level factors, including training, supervision, and access to guidelines, were associated with the improvement trends in overall malaria “test and treat” performance (S2 Table).

Determinants of improvement trends in compliance with individual “test and treat” outcomes

Between 2010 and 2016, the overall odds of health workers’ compliance with malaria testing of febrile patients increased by 14% annually (Fig 2, the second-left set of bars; OR = 1.14; 95% CI: 1.07–1.22) while compliance with malaria test results increased annually by 26% (Fig 2, middle set of bars; OR = 1.26; 95% CI: 1.10–1.45) and 81% (Fig 2, second-right set of bars; OR = 1.81; 95% CI: 1.60–2.05) for positive and negative cases, respectively. For the respective outcomes, the results from the unadjusted bivariable analysis of the determinants are presented in S3–S5 Tables.

From the final multivariable model (Table 2), the baseline odds of compliance with malaria testing were lower for febrile patients from facilities with RDTs (aOR = 0.11) compared to microscopy services available and for children aged less than five years (aOR = 0.56) compared to older patients. The annual improvement trends in testing recommendations were twice higher for patients from the lake endemic (p < 0.001) and 49% higher in the highland epidemic (p < 0.001) zones compared to those from the low risk zone. The annual increase in the odds of testing was also 35% higher in patients visiting facilities stocking only RDTs compared to those providing only malaria microscopy services (p = 0.001). Finally, patient age was also associated with improvements in malaria testing where under-fives compared to older patients had 9% higher annual odds of being tested (p = 0.022) (Table 2).

Only one factor was associated with improvement trends in AL treatment for test positive patients (Table 3). Malaria test positive patients seen by health workers who had access to the new malaria case-management guidelines had lower baseline odds of compliance (aOR = 0.16) and a 50% higher annual increase in the odds of AL treatment compared to those seen by health workers who did not have access to the guidelines (p = 0.027).

On the other hand, the improvement trend in health workers’ compliance with no antimalarial treatment for test negative patients was independently associated with six determinants from the final multivariable model (Table 3). The baseline odds of compliance with no antimalarial treatment for test negative patients were lower in lake endemic (aOR = 0.16) and highland epidemic (aOR = 0.20) zones compared to semi-arid seasonal transmission zone, at facilities with a caseload of >25 patients (aOR = 0.22), at facilities with RDT stock-outs (aOR = 0.23) and patients with the main complaint of fever (aOR = 0.26). Compared to patients from semi-arid seasonal transmission areas, patients from the lake endemic (p = 0.006), coast endemic (p = 0.005), and low risk (p = 0.001) zones had higher improvement
trends in compliance. At the health facility level, busy facilities with a caseload of >25 febrile patients had a twice higher annual increase in the odds of compliance compared to less busy facilities (p = 0.030). Similarly, patients seen at facilities without historical RDT stock-outs compared to those with stock-outs had a 51% higher annual increase in the odds of compliance (p = 0.006). At the health worker level, patients seen by females compared to male health workers had a 26% higher annual increase in compliance (p = 0.028). Whereas, when the health workers were knowledgeable about the targeted treatment policy, the annual increase in the odds of compliance was 53% higher (p < 0.001). At the patient level, patients with a main complaint of fever had a 34% higher annual increase in the odds of not being treated for malaria when they tested negative (p = 0.006) (Table 3).

Determinants of improvement trends in compliance with prompt AL administration at the health facility

The overall odds of administration of the first AL dose at the facility increased twice annually between 2010 and 2016 (Fig 2, right-most set of bars; OR = 2.00, 95% CI: 1.66–2.42). S6 Table presents the results of the unadjusted bivariable analysis of determinants of the improvement trend. From the final multivariable model (Table 4), three factors were significantly associated
Table 3. Determinants of improvement trends in compliance with malaria test results, 2010–2016—results from the final multivariable models.

| Factor                                      | Baseline (2010), % (n/N) | Last survey (2016), % (n/N) | aOR* (95% CI; p-value) | T-aOR** (95% CI; p-value) | P-value for interaction*** (factor<factor>time) |
|---------------------------------------------|--------------------------|-----------------------------|------------------------|---------------------------|-----------------------------------------------|
| 1. AL treatment for malaria test positive patients |                          |                             |                        |                           |                                               |
| Year                                        |                          |                             |                        |                           |                                               |
|                                             |                          |                             | 1.11 (0.88–1.40; p = 0.395) |                           |                                               |
| Access to MCM guidelines                    |                          |                             |                        |                           |                                               |
| No                                          | 91.3 (178/195)           | 98.5 (67/68)                | Ref                    | Ref                       |                                               |
| Yes                                         | 83.3 (5/6)               | 98.7 (150/152)              | 0.16 (0.04–0.66; p = 0.011) | 1.50 (1.04–2.15; p = 0.027) | 0.002                                         |
| 2. No antimalarial treatment for test negative patients |                          |                             |                        |                           |                                               |
| Year                                        |                          |                             |                        |                           |                                               |
|                                             |                          |                             | 0.50 (0.34–0.72; p < 0.001) |                           |                                               |
| Epidemiological zone                        |                          |                             |                        |                           |                                               |
| Semi-arid seasonal                          | 81.0 (34/42)             | 90.8 (59/65)                | Ref                    | Ref                       |                                               |
| Lake endemic                                | 35.6 (26/73)             | 89.3 (67/75)                | 0.16 (0.05–0.55; p = 0.004) | 1.56 (1.14–2.13; p = 0.006) |                                               |
| Coast endemic                               | 48.4 (15/31)             | 96.6 (28/29)                | 0.46 (0.08–2.58; p = 0.376) | 2.50 (1.32–4.72; p = 0.005) |                                               |
| Highland epidemic                           | 33.3 (21/63)             | 83.0 (44/53)                | 0.20 (0.06–0.70; p = 0.012) | 1.36 (1.00–1.86; p = 0.033) |                                               |
| Low risk                                    | 56.1 (23/41)             | 100 (21/21)                 | 0.31 (0.08–1.23; p = 0.096) | 2.04 (1.34–3.11; p = 0.001) | <0.001                                       |
| Caseload on the survey day                  |                          |                             |                        |                           |                                               |
| ≤ 25 patients                               | 62.3 (104/167)           | 89.7 (210/234)              | Ref                    | Ref                       |                                               |
| >25 patients                                | 40.4 (23/57)             | 100 (9/9)                   | 0.22 (0.05–0.88; p = 0.032) | 2.09 (1.08–4.08; p = 0.030) | 0.048                                         |
| Retrospective RDT stock-outs                |                          |                             |                        |                           |                                               |
| Yes                                         | 58.5 (120/205)           | 83.8 (62/74)                | Ref                    | Ref                       |                                               |
| No                                          | 36.8 (7/19)              | 92.6 (149/161)              | 0.23 (0.07–0.83; p = 0.025) | 1.51 (1.12–2.02; p = 0.006) | 0.022                                         |
| Health worker gender                        |                          |                             |                        |                           |                                               |
| Male                                        | 61.5 (80/130)            | 87.3 (111/127)              | Ref                    | Ref                       |                                               |
| Female                                      | 50.0 (47/94)             | 93.1 (108/116)              | 0.55 (0.27–1.13; p = 104) | 1.26 (1.03–1.55; p = 0.028) | 0.079                                         |
| Correct knowledge on targeted treatment policy |                      |                             |                        |                           |                                               |
| No                                          | 46.8 (51/109)            | 52.9 (9/17)                 | Ref                    | Ref                       |                                               |
| Yes                                         | 66.1 (76/115)            | 92.9 (210/226)              | 0.96 (0.44–2.07; p = 0.910) | 1.53 (1.21–1.92; p < 0.001) | <0.001                                       |
| Fever complaint                             |                          |                             |                        |                           |                                               |
| No                                          | 83.2 (108/131)           | 93.1 (27/29)                | Ref                    | Ref                       |                                               |
| Yes                                         | 79.0 (94/119)            | 89.7 (192/214)              | 0.26 (0.13–0.53; p < 0.001) | 1.34 (1.09–1.66; p = 0.006) | 0.001                                         |

*aOR = fixed effect representing the baseline odds ratio

**T-aOR = Ratio of annual change in the odds between the covariate levels and reference category adjusted for covariates at baseline; MCM-malaria case-management

* fixed effect of time representing the annual change in the odds of AL treatment among test positive patients seen by health workers without access to the guidelines; The covariates adjusted for at baseline in the final model for trends in AL treatment for test positives included in-service training and temperature

*b fixed effect for time representing the annual change in the odds of no antimalarial treatment for test negative patients without a main complaint of fever, from semi-arid seasonal transmission areas, seen at less busy facilities, those with retrospective RDTs stock-outs, and seen by male health workers and those not knowledgeable about the targeted treatment policy; The covariates adjusted for at baseline in the final model for trends in no antimalarial treatment for test negatives included the type of diagnostic test, AL stock-outs, facility level, RDT stock-outs, HW perception of endemicity, temperature, patients’ main complaint of headache, vomiting and cough

***the overall p-value for the different time trends across factor categories from likelihood ratio tests.

https://doi.org/10.1371/journal.pone.0259020.t003
with the improvement trends without significant differences in the baseline odds of compliance. The annual trends in the administration of the first AL dose at the facility were significantly higher in patients from the coast endemic region (p < 0.001) and lake endemic (p = 0.020) zones compared to patients from the highland epidemic zone. Moreover, patients who were seen in health facilities where CHWs dispensed medicines had a 90% higher increase in the annual odds of compliance compared to patients having medicines dispensed by higher-level cadres (p = 0.016). Lastly, patients who were seen by health workers who had access to the IMCI guidelines compared to those without access had a 39% higher annual increase in the odds of being given the first AL dose at the health facility (p = 0.026) (Table 4). None of the patient-level factors was significantly associated with the improvement trends in compliance with this task.

**Discussion**

This study is novel in applying regression models and Rowe’s framework [19] to assess the determinants of improvements in health workers’ performance over time using compliance to
outpatient malaria diagnosis and treatment guidelines trends. The findings indicate that even when malaria diagnostic tests and recommended antimalarials are available, malaria endemicity and other interventional and non-interventional factors are associated with health workers’ clinical behaviour when the case-management policy is routinely implemented on a large scale over time.

Controlling for other factors, malaria endemicity was independently associated with improvement trends in health workers’ compliance, confirming our previous report on the effect of malaria endemicity on compliance with malaria guidelines [28]. Greater improvements in “test and treat” compliance associated with higher malaria risk zones may be explained by the accumulation of experience with test positive results [41], health workers’ practices considering the pre-test and post-test probability of malaria [42] or the quality improvement activities implemented in these areas [34]. Future qualitative research would help to better understand the effects of endemicity on the compliance patterns observed. The priority for policy implementers should be tailoring of interventions and strategies to improve health worker performance according to the endemicity of the disease and specifically targeting health workers in areas of lower malaria risk.

At the health facility level, the type of diagnostic test, ownership, caseload, and cadre dispensing medicines were determinants of improvement trends in compliance. The type of diagnostic test available at the facility on the survey day, particularly the exclusive availability of RDTs compared to microscopy, was associated with higher improvement trends in testing and subsequently with composite “test and treat” performance. The finding is similar to the reports of interventional studies that indicated that the deployment of RDTs resulted in higher testing rates [43–45]. This is, however, in contrast with our first year (2010) report of higher compliance with testing in facilities with microscopy available compared to RDTs in Kenya [23]. Higher and wider availability of RDTs over time and increased health workers’ trust in the test results due to accumulated field experience [2, 13, 41] may explain the patterns observed. On the contrary, historical RDT stock-outs were associated with lower compliance with negative test results. Both findings support the national policy of deploying RDTs in facilities without diagnostic capabilities (where microscopy is not available) and ensuring the universal and continuous availability of RDTs [46, 47].

Government-owned facilities showed lower improvement trends in “test and treat” compliance compared to FBO/NGO facilities. The higher cost of laboratory services [48], wealthier patients [23], and higher motivation of health workers [49] are possible reasons explaining higher policy adoption in the FBO/NGO sector. Furthermore, at busier facilities, higher improvement trends in compliance with negative test results were found. The results concur with a better quality of care observed for children attending busier facilities in Benin [50] and contrast with a report from Angola [51]. Finally, when CHWs dispensed medicines, they were more likely to provide prompt treatment and administer the first AL dose at the facility over time. This might be because CHWs’ main responsibility is to dispense medicines while higher-level cadres such as pharmacists have broader responsibilities resulting in neglecting the dispensing and counselling tasks. Lay health workers have been shown to improve the quality of care [52–54] and task shifting of the medicine dispensing from often overwhelmed pharmacists to CHWs can be considered by malaria control managers [55].

Several significant associations between health workers’ characteristics and compliance with the guidelines were observed. Interestingly, access to the new malaria case-management guidelines was associated with improvement in AL treatment for test positive patients, a finding in contrast with studies reporting no association between provision of guidelines and recommended ACT treatment [22, 56] or no effect of guideline dissemination on broader health worker performance [57–59]. The finding is, however, in line with reviews suggesting that
context-specific dissemination of guidelines can improve care [60, 61]. In this context, health workers’ reference to malaria guidelines may have been of higher interest with respect to treatment than diagnostic changes. Access to IMCI guidelines was associated with improvements in the administration of the first AL dose at the facility. The possible explanation would be that IMCI guidelines put considerable emphasis on dispensing and counselling tasks [62–64].

Additionally, correct health workers’ knowledge about the treatment policy was a predictor of improvement trends in compliance with negative test results. A finding similar to other reports of higher knowledge scores resulting in higher health workers’ compliance [65, 66] and in contrast with other studies indicating that knowledge does not translate to better care [19, 58, 67–70]. The positive association of knowledge with the improvements may indicate that the effect of correct knowledge on compliance is sustained over time, or it is due to other unmeasured factors. Lastly, male health workers showed lower improvements in compliance with negative test results- this factor is rarely examined but contrasts with reports from Uganda reporting no gender association [22, 71, 72].

Conversely, the most widely used interventions to implement case-management policies, (i.e. training and supervision) were not associated with the improvement trends in health workers’ compliance. This contrasted reports from interventional studies that suggested an effect of training and supervision on improving health worker performance [44, 45, 57, 73–77]. The potential explanation for the lack of significant association with improvements over time may be the suboptimal quality of training and supervision implementation that affected the effectiveness of these strategies [78, 79] or possible contamination of patient observations as frontline health workers who attend the training are meant to mentor on-job other health workers at their facilities passing the correct information to untrained health workers [23]. Another reason could relate to the intention of in-service training to expand knowledge, while supervision may increase health worker motivation and translation of the knowledge into practice. However, this might be inadequate for a long-term effect on health worker performance as their influence decrease [80–82] or do not change over time [83]. This calls for further qualitative research to understand the details of the quality and content of training and supervision routinely delivered to health workers and interventional studies of the most cost-effective set of strategies to improve health worker performance further.

At the patient level, only two factors were associated with improvements, patient age and the main complaint of fever. Patient age was key in improvement in compliance with testing, which was higher in under-five children compared to older patients. This is likely to reflect the adoption of malaria testing after 2010 among under-fives, the patient population that was presumptively treated before 2010 [3]. Finally, patients’ main complaint of fever was associated with improvement in compliance with the negative test results. Over time, health workers might have acknowledged that fevers cannot be equated with malaria due to the decline in transmission in most areas hence better compliance when patients reported fever as the main complaint [84].

The study has some limitations. The sample sizes might have been small to allow for the detection of the effect of some factors. Moreover, health workers’ behaviour might be affected by a variety of factors, including contextual and latent ones like motivation, attitude, experience, and confidence, that could not be examined from the data and require further qualitative research. Also, we performed multiple comparisons of factors, and some of the results may have been significant by chance. Finally, the performance of some of the outcomes plateaued from the eighth round, suggesting a need for separately exploring the specific determinants of compliance during this recent period.
Conclusion

This study revealed a series of factors associated with improvement trends in health workers’ compliance with outpatient malaria case-management guidelines over time at health facilities with malaria “test and treat” commodities in Kenya. The improvements in clinical practices examined over six years were associated with high malaria risk areas, RDT availability, high patient caseloads, female and non-governmental health workers, dissemination of malaria and IMCI guidelines, under-five patients’ age, the main complaint of fever and health workers knowledge about the targeted treatment policy. Therefore, targeting of low malaria risk areas, facilities with low caseloads, male and government health workers, continuous availability of RDTs, improved health workers’ knowledge about the policy considering age and fever, and dissemination of malaria and IMCI guidelines might improve health workers’ compliance with malaria guidelines. For prompt treatment and administration of the first AL dose at the facility, task-shifting duties to CHWs can be considered. Further qualitative research to understand the details of the quality, content and delivery of training and supervision routinely delivered to health workers and interventional studies of the most cost-effective set of strategies to further improve outpatient malaria case-management performance are needed.

Supporting information

S1 Appendix. Exit interview form. (PDF)

S2 Appendix. Health facility assessment form. (PDF)

S3 Appendix. Health worker interview form. (PDF)

S1 Table. Description of patients by malaria endemicity and health facility-, health worker- and patient-level characteristics by survey round. (DOCX)

S2 Table. Bivariable analysis of determinants of improvement trends in compliance with overall “test and treat” performance, 2010–2016. *1-main effects estimate adjusting for time; 2- T-OR = unadjusted odds ratio from the covariate and time interaction; FBO/NGO- Faith-based organisation/Non-Governmental organisation; RDT-rapid diagnostics tests; AL-artemether-lumefantrine; IQR-interquartile range; HW-health worker; MCM-malaria case-management. (DOCX)

S3 Table. Bivariable analysis of determinants of improvement trends in compliance with malaria testing of febrile patients, 2010–2016. *1-main effects estimate adjusting for time; 2- T-OR = unadjusted odds ratio from the covariate and time interaction; FBO/NGO- Faith-based organisation/Non-Governmental organisation; RDT-rapid diagnostics tests; AL-artemether-lumefantrine; IQR-interquartile range; HW-health worker; MCM-malaria case-management. (DOCX)

S4 Table. Bivariable analysis of determinants of improvement trends in compliance with AL treatment for malaria test positive patients, 2010–2016. *1-main effects estimate adjusting for time; 2- T-OR = unadjusted odds ratio from the covariate and time interaction; FBO/NGO- Faith-based organisation/Non-Governmental organisation; RDT-rapid diagnostics tests; AL-artemether-lumefantrine; IQR-interquartile range; HW-health worker; MCM-malaria case-management. (DOCX)
tests; AL-artemether-lumefantrine; IQR-interquartile range; HW-health worker; MCM-
malaria case-management.

S5 Table. Bivariable analysis of determinants of improvement trends in compliance with
no antimalarial treatment for test negative patients, 2010–2016. *1-main effects estimate
adjusting for time; 2- T-OR = unadjusted odds ratio from the covariate and time interaction;
FBO/NGO- Faith-based organisation/Non-Governmental organisation; RDT-rapid diagnostics
tests; AL-artemether-lumefantrine; IQR-interquartile range; HW-health worker; MCM-
malaria case-management.

S6 Table. Bivariable analysis of determinants of improvement trends in compliance with
the administration of first AL dose at the facility, 2010–2016. *1-main effects estimate
adjusting for time; 2- T-OR = unadjusted odds ratio from the covariate and time interaction;
FBO/NGO- Faith-based organisation/Non-Governmental organisation; RDT-rapid diagnostics
tests; AL-artemether-lumefantrine; IQR-interquartile range; HW-health worker; MCM-
malaria case-management.

Acknowledgments
The authors of this report would like to thank the Kenya NMCP for permitting us to re-analyse
the national health facility survey data.

Author Contributions

Conceptualization: Beatrice Amboko, Philip Bejon, Robert W. Snow, Dejan Zurovac.

Data curation: Beatrice Amboko.

Formal analysis: Beatrice Amboko, Kasia Stepniewska, Lucas Malla.

Funding acquisition: Beatrice Machini, Robert W. Snow.

Methodology: Beatrice Amboko.

Supervision: Philip Bejon, Robert W. Snow, Dejan Zurovac.

Writing – original draft: Beatrice Amboko, Dejan Zurovac.

Writing – review & editing: Beatrice Amboko, Kasia Stepniewska, Lucas Malla, Beatrice
Machini, Philip Bejon, Robert W. Snow, Dejan Zurovac.

References

1. World Health Organization. Global Technical Strategy for malaria (GTS) 2016–2030. Geneva, Switzerland: World Health Organization; 2015.

2. World Health Organization. World Malaria Report 2019. Geneva, Switzerland: World Health Organization; 2019.

3. World Health Organization. Guidelines for the treatment of malaria. Geneva, Switzerland: World Health Organization; 2010.

4. World Health Organization. Guidelines for the treatment of malaria, 3rd Edition. 3rd ed. Geneva, Switzerland: World Health Organization; 2015.

5. Chanda P, Castillo-Riquelme M, Masiye F. Cost-effectiveness analysis of the available strategies for diagnosing malaria in outpatient clinics in Zambia. Cost Eff Resour Alloc. 2009; 7:5. https://doi.org/10.1186/1478-7547-7-5 PMID: 19356225
Determinants of the quality of outpatient malaria case-management

6. Lubell Y, Reyburn H, Mbakili H, Mwangi R, Chonya K, Whitty MJ, et al. The cost-effectiveness of parasitologic diagnosis for malaria-suspected patients in an era of combination therapy. Am J Trop Med Hyg. 2007;77.

7. Shillcutt S, Morel C, Goodman C, Coleman P, Bell D, Whitty C, et al. Cost-effectiveness of malaria diagnostic methods in sub-Saharan Africa in an era of combination therapy. Bull World Health Organ. 2008;86:101–10. https://doi.org/10.2471/blt.07.042259 PMID: 18297164

8. Plucinski MM, Ferreira M, Ferreira CM, Burns J, Gaparayi P, Joao L, et al. Evaluating malaria case management at public health facilities in two provinces in Angola. Malar J. 2017; 16:186. https://doi.org/10.1186/s12936-017-1843-7 PMID: 28468663

9. Plucinski MM, Gulivagouyi T, Camara A, Ndlopi M, Cisse M, Painter J, et al. How far are we from reaching universal malaria testing of all fever cases? Am J Trop Med Hyg. 2018; 99:670–9. https://doi.org/10.4269/ajtmh.18-0312 PMID: 29943717

10. Bruxvoort KJ, Leurent B, Chandler CIR, Ansah EK, Baiden F, Bjorkman A, et al. The impact of introducing malaria rapid diagnostic tests on fever case management: A synthesis of ten studies from the ACT Consortium. Am J Trop Med Hyg. 2017; 97:1170–9. https://doi.org/10.1093/ajtmh/pfx270 PMID: 28820705

11. O’Boyle S, Bruxvoort KJ, Ansah EK, Baiden F, Bjorkman A, et al. Patients with positive malaria tests not given artesinin-based combination therapies: a research synthesis describing under-prescription of antimalarial medicines in Africa. BMC Med. 2020; 18:17. https://doi.org/10.1186/s12916-019-1483-6 PMID: 31986199

12. Boyce MR, O’Meara WP. Use of malaria RDTs in various health contexts across sub-Saharan Africa: a systematic review. BMC Public Health. 2017; 17:470. https://doi.org/10.1186/s12889-017-4398-1 PMID: 28521798

13. Kabaghe AN, Visser BJ, Spijkjer R, Phiri KS, Grobusch MP, van Vugt M. Health workers’ compliance to rapid diagnostic tests (RDTs) to guide malaria treatment: a systematic review and meta-analysis. Malar J. 2016; 15:163. https://doi.org/10.1186/s12936-016-1218-5 PMID: 26979266

14. Abdelgader TM, Ibrahim AM, Elmardi KA, Githinji S, Zurovac D, Snow RW, et al. Progress towards implementation of ACT malaria case-management in public health facilities in the Republic of Sudan: a cluster-sample survey. BMC Public Health. 2012; 12:11. https://doi.org/10.1186/1471-2458-12-11 PMID: 22221821

15. Namuyinga RJ, Mwandama D, Moyo D, Gumbo A, Treoll P, Kobayashi M, et al. Health worker adherence to malaria treatment guidelines at outpatient health facilities in southern Malawi following implementation of universal access to diagnostic testing. Malar J. 2017; 16:40. https://doi.org/10.1186/s12936-017-1693-3 PMID: 28114942

16. Steinhardt LC, Chinkhumba J, Wolken A, Luka M, Luanga M, Sande J, et al. Quality of malaria case management in Malawi: results from a nationally representative health facility survey. Malar J. 2012; 11:e389. https://doi.org/10.1186/1475-2875-11-389 PMID: 2286497

17. PLoS Medicine Editors. Time for a “third wave” of malaria activism to tackle the drug stock-out crisis. PLoS Med. 2009; 6:e1000188. https://doi.org/10.1371/journal.pmed.1000188 PMID: 19936043

18. Mubi M, Kakoko D, Ngasala B, Premji Z, Peterson S, Bjorkman A, et al. Malaria diagnosis and treatment practices following introduction of rapid diagnostic tests in Kibaha District, Coast Region, Tanzania. Malar J. 2013; 12:293. https://doi.org/10.1186/1475-2875-12-293 PMID: 23977904

19. Rowe AK, Savigny D, Lanata CF, Victora CG. How can we achieve and maintain high-quality performance of health workers in low-resource settings? Lancet. 2005; 366:1026–35. https://doi.org/10.1016/S0140-6736(05)67028-6 PMID: 16168785

20. Dieleman M, Harmmeijer JW. Improving health worker performance: in search of promising practices. Geneva, Switzerland: World Health Organization. 2006:5–34.

21. World Health Organization. The world health report 2006: working together for health. Geneva, Switzerland: World Health Organization; 2006.

22. Steinhardt LC, Chinkhumba J, Wolken A, Luka M, Luanga M, Sande J. Patient, health worker and health facility level determinants of correct malaria case management at publicly funded health facilities in Malawi: results from a nationally representative health facility survey. Malar J. 2014; 13:64. https://doi.org/10.1186/1475-2875-13-64 PMID: 24555446

23. Nyandigisi A, Memusi D, Mbithi A, Ang’wa N, Shieshia M, Muturi A, et al. Malaria case-management following change of policy to universal parasitological diagnosis and targeted artemisinin-based combination therapy in Kenya. PLoS One. 2011; 6:e24781. https://doi.org/10.1371/journal.pone.0024781 PMID: 21935484

24. Ikeda DJ, Gosling R, Eliades MJ, Chung A, Murungu J, Agins BD. Bridging the quality gap in diagnosis and treatment of malaria. BMJ. 2020; 369:m1176. https://doi.org/10.1136/bmj.m1176 PMID: 32321709
25. Klootwijk L, Chirwa AE, Kabaghe AN, van Vugt M. Challenges affecting prompt access to adequate uncomplicated malaria case management in children in rural primary health facilities in Chikhwawa Malawi. BMC Health Serv Res. 2019; 19:735. https://doi.org/10.1186/s12913-019-4544-9 PMID: 31640676

26. Zurovac D, Gitini J, Memusi D, Kigen S, Machini B, Muturi A, et al. Major improvements in the quality of malaria case-management under the test and treat policy in Kenya. PLoS One. 2014; 9:e92782. https://doi.org/10.1371/journal.pone.0092782 PMID: 24663961

27. National Malaria Control Programme. Monitoring outpatient malaria case management under the 2010 diagnostic and treatment policy in Kenya-Progress January 2010 - June 2016. Malaria Control Program, Ministry of Health; 2016.

28. Amboko B, Stepniewska K, Macharia PM, Machini B, Bejon P, Snow RW, et al. Trends in health workers’ compliance with outpatient malaria case-management guidelines across malaria epidemiological zones in Kenya, 2010–2016. Malar J. 2020; 19:406. https://doi.org/10.1186/s12936-020-03479-z PMID: 33176783

29. Ministry of Public Health Sanitation/Ministry of Medical Services. National guidelines for diagnosis, treatment and prevention of malaria in Kenya. Nairobi, Kenya: Division of Malaria Control; 2010.

30. Amin AA, Zurovac D, Kangwana BB, Greenfield J, Otimen DN, Akhwale WS, et al. The challenges of changing national malaria drug policy to artemisinin-based combinations in Kenya. Malar J. 2007; 6:72. https://doi.org/10.1186/1475-2875-6-72 PMID: 17535417

31. Ministry of Health. National guidelines for diagnosis, treatment and prevention of malaria for health workers in Kenya. Nairobi, Kenya: Division of Malaria Control; 2006.

32. Odhiambo F, Buff AM, Moranga C, Moset CM, Wesoonga JO, Lwotter SA, et al. Factors associated with malaria microscopy diagnostic performance following a pilot quality-assurance programme in health facilities in malaria low-transmission areas of Kenya, 2014. Malar J. 2017; 16:371. https://doi.org/10.1186/s12936-017-1856-2 PMID: 28545579

33. Ministry of Health. Kenya Health Master Facility List 2017. Available from: http://kmhf.l.health.go.ke/#home. PMID: 29261450

34. Feise RJ. Do multiple outcome measures require p-value adjustment? BMC Med Res Methodol. 2002; 2:1–4. https://doi.org/10.1186/1471-2288-2-1 PMID: 11860604

35. Rothman KJ. No adjustments are needed for multiple comparisons. Epidemiology. 1990:43–6 PMID: 2081237

36. Graz B, Willcox M, Szeless T, Rougemont A. “Test and treat” or presumptive treatment for malaria in high transmission situations? A reflection on the latest WHO guidelines. Malar J. 2011; 10:136. https://doi.org/10.1186/1475-2875-10-136 PMID: 21599880

37. Chandler CI, Webb EL, Maiteki-Sebuguzi C, Naway G, Kajungu D, Khatib R, Kachur SP, et al. Increased use of malaria rapid diagnostic tests improves targeting of anti-malarial treatment in rural Tanzania: implications for nationwide rollout of malaria rapid diagnostic tests. Malar J. 2012; 11:221. https://doi.org/10.1186/1475-2875-11-221 PMID: 22747655
45. Mbacham WF, Mangham-Jefferies L, Cundill B, Achonduh OA, Chandler CIR, Ambebi la JN, et al. Basic or enhanced clinician training to improve adherence to malaria treatment guidelines: a cluster-randomised trial in two areas of Cameroon. Lancet Glob Health. 2014; 2:e346–e58. https://doi.org/10.1016/S2214-109X(14)70201-3 PMID: 25103303

46. Ministry of Health. Kenya National Malaria Strategy 2009–2017. Nairobi, Kenya: Division of Malaria Control; 2009.

47. Ministry of Health. National guidelines for parasitological diagnosis and entomological field methods for malaria. Nairobi, Kenya: Division of Malaria Control; 2013.

48. Batwala V, Magnussen P, Hansen KS, Nuwaha a F. Cost-effectiveness of malaria microscopy and rapid diagnostic tests versus presumptive diagnosis: implications for malaria control in Uganda. Malar J. 2011; 10:372. https://doi.org/10.1186/1475-2875-10-372 PMID: 22182735

49. Leonard KL, Masatu MC. Variations in the quality of care accessible to rural communities in Tanzania. Health Aff (Millwood). 2007; 26:w380–92. https://doi.org/10.1377/hlthaff.w3.2007 PMID: 17389635

50. Steinhardt LC, Onikpo F, Kouame J, Perrifield E, Lama M, Deming MS, et al. Predictors of health worker performance after Integrated Management of Childhood Illness training in Benin: a cohort study. BMC Health Serv Res. 2015; 15:276. https://doi.org/10.1186/s12913-015-0910-4 PMID: 26194895

51. Rowe AK, de Leon GF, Mihigo J, Santelli A, Miller N, Van-Dunem P. Quality of malaria case management at outpatient health facilities in Angola. Malar J. 2009; 8:275. https://doi.org/10.1186/1475-2875-8-275 PMID: 19954537

52. Lewin S, Munabi-Babigumira S, Glenton C, Daniels K, Bosch-Capblanch X, van Wyk BE, et al. Lay health workers in primary and community health care for maternal and child health and the management of infectious diseases. Cochrane Database Syst Rev. 2010; 2010:CD004015. https://doi.org/10.1002/14651858.CD004015.pub3 PMID: 20238326

53. Huicho L, Scherbier RW, Nkowane AM, Victora CG. How much does quality of child care vary between health workers with differing durations of training? An observational multicountry study. Lancet. 2008; 372:910–6. https://doi.org/10.1016/S0140-6736(08)61401-4 PMID: 18790314

54. Callaghan M, Ford N, Schneider H. A systematic review of task-shifting for HIV treatment and care in Africa. Hum Resour Health. 2010; 8:8. https://doi.org/10.1186/1478-4491-8-8 PMID: 20356363

55. Rao VB, Schellenberg D, Ghani AC. Overcoming health systems barriers to successful malaria treatment. Trends Parasitol. 2013; 29:164–80. https://doi.org/10.1016/j.pt.2013.01.005 PMID: 23415933

56. Zurovac D, Tibenderana JK, Nankabirwa J, Ssekittoleko J, Njogu-JN, Rwakimari JB, et al. Malaria case-management under artemether-lumefantrine treatment policy in Uganda. Malar J. 2008; 7:181. https://doi.org/10.1186/1475-2875-7-181 PMID: 18803833

57. Rowe AK, Rowe SY, Peters DH, Holloway KA, Chalker J, Ross-Degnan D. Effectiveness of strategies to improve health-care provider practices in Low-and Middle-Income Countries: a systematic review. Lancet Glob Health. 2018; 6:e1163–e75. https://doi.org/10.1016/S2214-109X(18)30398-X PMID: 30309799

58. Mangham-Jefferies L, Hanson K, Mbacham W, Onwujeoke O, Wiseman V. Mind the gap: knowledge and practice of providers treating uncomplicated malaria at public and mission health facilities, pharmacies and drug stores in Cameroon and Nigeria. Health Policy Plan. 2015; 30:1129–41. https://doi.org/10.1093/heapol/czu118 PMID: 25339637

59. Seleman i M, Masanja IM, Kajungu D, Amuri M, Njozi M, Khatib RA, et al. Health worker factors associated with prescribing of artemisinin combination therapy for uncomplicated malaria in rural Tanzania. Malar J. 2013; 12:334. https://doi.org/10.1186/1475-2875-12-334 PMID: 24053679

60. Grimshaw J, Thomas R, MacLennan G, Fraser C, Ramsay C, Vale L, et al. Effectiveness and efficiency of guideline dissemination and implementation strategies. Health Technol Assess. 2004; 8:iii-iv, 1–72. https://doi.org/10.3310/hta8060 PMID: 14960256

61. Grimshaw JM, Russell IT. Effect of clinical guidelines on medical practice: a systematic review of rigorous evaluations. Lancet. 1993; 342:1317–22. https://doi.org/10.1016/0140-6736(93)92244-n PMID: 7901634

62. Gove S. Integrated management of childhood illness by outpatient health workers: technical basis and overview. The WHO Working Group on Guidelines for Integrated Management of the Sick Child. Bull World Health Organ. 1997; 75 Suppl 1:7–24.

63. Tulloch J. Integrated approach to child health in developing countries. Lancet. 1999; 354 Suppl 2:SII6–SII20. https://doi.org/10.1016/s0140-6736(99)90252-0 PMID: 10507254

64. World Health Organization. IMCI: The Integrated approach. Geneva, Switzerland: World Health Organization; 1997.

65. Mohanan M, Vera-Hernández M, Das V, Giardili S, Goldhaber-Fiebert JD, Rabin TL, et al. The know-do gap in quality of health care for childhood diarrhea and pneumonia in rural India. JAMA Pediatr. 2015; 169:349–57. https://doi.org/10.1001/jamapediatrics.2014.3445 PMID: 25686357
66. Epstein A, Moucheraud C, Sarma H, Rahman M, Tariqjaman M, Ahmed T, et al. Does health worker performance affect clients' health behaviors? A multilevel analysis from Bangladesh. BMC Health Serv Res. 2019; 19:516. https://doi.org/10.1186/s12913-019-4205-z PMID: 31340809

67. Candrinho B, Plucinski MM, Colborn JM, da Silva M, Mathe G, Dimene M, et al. Quality of malaria services offered in public health facilities in three provinces of Mozambique: a cross-sectional study. Malar J. 2019; 18:162. https://doi.org/10.1186/s12936-019-2796-9 PMID: 31060065

68. Russell D, Dowding DW, McDonald MV, Adams V, Rosati RJ, Larson EL, et al. Factors for compliance with infection control practices in home healthcare: findings from a survey of nurses' knowledge and attitudes toward infection control. Am J Infect Control. 2018; 46:1211–7. https://doi.org/10.1016/j.ajic.2018.05.005 PMID: 29866633

69. Gage AD, Kruk ME, Girma T, Lemango ET. The know-do gap in sick child care in Ethiopia. PLoS One. 2018; 13:e0208898. https://doi.org/10.1371/journal.pone.0208898 PMID: 30540855

70. Rowe AK, Rowe S, Peters D, Holloway K, Chalker J, Ross-Degnan D. The effectiveness of strategies to improve health worker knowledge in low- and middle-income countries and the association between knowledge and clinical practice: a systematic review. 66th Annual Meeting of the American Society for Tropical Medicine and Hygiene; Baltimore, Maryland, USA; 2017;

71. Bawate C, Sylvia TC-C, Naaju B, Bwayo D. Factors affecting adherence to national malaria treatment guidelines in management of malaria among public healthcare workers in Kamuli District, Uganda. Malar J. 2016; 15:112. https://doi.org/10.1186/s12936-016-1153-5 PMID: 26911252

72. Kaula H, Kiconco S, Nuñez L. Cross-sectional study on the adherence to malaria guidelines in lakeshore facilities of Buyende and Kalibo districts, Uganda. Malar J. 2018; 17:432. https://doi.org/10.1186/s12936-018-2577-x PMID: 30454044

73. Burchett HE, Leurent B, Baiden F, Baltzell K, Björkman A, Bruxvoort K, et al. Improving prescribing practices with rapid diagnostic tests (RDTs): synthesis of 10 studies to explore reasons for variation in malaria RDT uptake and adherence. BMJ Open. 2017; 7:e012973. https://doi.org/10.1136/bmjopen-2016-012973 PMID: 28274962

74. Cundill B, Mbakilwa H, Chandler CI, Mtove G, Mtei F, Willetts A, et al. Prescriber and patient-oriented behavioural interventions to improve use of malaria rapid diagnostic tests in Tanzania: facility-based cluster randomised trial. BMC Med. 2015; 13:118. https://doi.org/10.1186/s12916-015-0346-z PMID: 26980737

75. Lourenco C, Kandula D, Haidula L, Ward A, Cohen JM. Strengthening malaria diagnosis and appropriate treatment in Namibia: a test of case management training interventions in Kavango Region. Malar J. 2014; 13:506. https://doi.org/10.1186/1475-2875-13-506 PMID: 25518938

76. Visser T, Bruxvoort K, Maloney K, Leslie T, Barat LM, Allan R, et al. Introducing malaria rapid diagnostic tests in private medicine retail outlets: A systematic literature review. PLoS One. 2017; 12:e0173093. https://doi.org/10.1371/journal.pone.0173093 PMID: 28253315

77. Nguyen DT, Leung KK, McIntyre L, Ghali WA, Sauve R. Does integrated management of childhood illness (IMCI) training improve the skills of health workers? A systematic review and meta-analysis. PLoS One. 2013; 8:e66030. https://doi.org/10.1371/journal.pone.0066030 PMID: 23776599

78. Leslie HH, Gage A, Nsona H, Hirschhorn LR, Kruk ME. Training and supervision did not meaningfully improve quality of care for pregnant women or sick children in sub-Saharan Africa. Health Aff (Millwood). 2016; 35:1716–24. https://doi.org/10.1377/hlthaff.2016.0261 PMID: 27605655

79. Wasunna B, Zurovac D, Bruce J, Jones C, Webster J, Snow RW. Health worker performance in the management of paediatric fevers following in-service training and exposure to job aids in Kenya. Malar J. 2010; 9:261. https://doi.org/10.1186/1475-2875-9-261 PMID: 20849650

80. Institute of Medicine. Improving quality of care in Low-and Middle-Income Countries: workshop summary. Washington, DC 2015.

81. Bosch-Capblanch X, Liqat S, Garner P. Managerial supervision to improve primary health care in low- and middle-income countries. Cochrane Database Syst Rev. 2011; 1:CD006413. https://doi.org/10.1002/14651858.CD006413.pub2 PMID: 21901704

82. Bosch-Capblanch X, Garner P. Primary health care supervision in developing countries. Trop Med Int Health. 2008; 13:369–83. https://doi.org/10.1111/j.1365-3156.2008.02012.x PMID: 18397400

83. Rowe AK, Osterholt DM, Kouame J, Piercefield E, Herman KM, Onikpo F, et al. Trends in health worker performance after implementing the Integrated Management of Childhood Illness strategy in Benin. Trop Med Int Health. 2012; 17:438–46. https://doi.org/10.1111/j.1365-3156.2012.02976.x PMID: 22950471

84. D’Acremont V, Lengeler C, Genton B. Reduction in the proportion of fevers associated with Plasmodium falciparum parasitaemia in Africa: a systematic review. Malar J. 2010; 9:240. https://doi.org/10.1186/1475-2875-9-240 PMID: 20727214