Predictors of presumptive treatment of uncomplicated malaria among children in private retail outlets in Kenya: mixed effects logistic regression modelling [version 1; peer review: awaiting peer review]

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Abstract

Background: The health seeking behavior in Kenya raises concerns in malaria case management at the private sector. Adherence to the national guidelines for the diagnosis, treatment and prevention of malaria is key in management of the disease. Presumptive treatment remains a major challenge in Kenya, especially in the private sector, with major gaps in literature identified on predictors of this treatment. Mixed-effects regression modelling considers county clustering, is more accurate in prediction and is more efficient and flexible.

Methods: The study design was a cross-sectional, nationally representative, retail outlet survey secondary data analysis. The study populations included the health care providers in the retail outlets sampled randomly in both the rural and urban settings in Kenya. The primary outcome of interest was the proportion of health care providers who treated patients presumptively. Multivariable analysis was conducted for the significant variables, adjusting for clustering at the county level to determine the predictors of presumptive treatment. The best fitting model was examined using the Akaike Information Criterion (AIC).

Results: Out of the 333 health care providers who treated patients, 190 (57%) treated patients presumptively. From the mixed effects logistic regression model, the predictors of presumptive treatment of uncomplicated malaria were case management training (AOR = 0.44; 95% CI = (0.18 – 1.09)), asked signs or symptoms (AOR = 0.19; 95% CI = (0.10 - 0.37)) and results presented (AOR = 0.08 95% CI = (0.03 - 0.19)).

Conclusions: Presumptive treatment of uncomplicated malaria remains a challenge in the private retail sector. Malaria case management training and health care providers asking of signs and symptoms and results presented predicts presumptive treatment. To
address the issue of presumptive treatment of Malaria, strengthening of malaria case management training is key for health care providers in the private sector.

**Keywords**
Presumptive Treatment, Uncomplicated Malaria among Children, Private Sector, Mixed Effects Models
Introduction
Malaria is a health problem across the globe; the World Health Organization (WHO) estimates that nearly one-half (3.4 billion) of the population in the world is at risk of the disease. Africa continues to have a disproportionately large share of the global malaria burden. According to the 2018 WHO Malaria Report, in 2017 the region reported 92% and 93% of malaria morbidity and mortality, respectively. In 2010, Kenya adopted the Test and Treat case management policy by WHO, which is in line with the malaria treatment guidelines in Kenya. Although the burden is high in Sub-Saharan Africa, Kenya has made major efforts to reduce and eliminate malaria. The Ministry of Health through the Division of National Malaria Programme has implemented comprehensive evidence-based strategies and policies to fight this disease. The key interventions used include the provision of mosquito nets and indoor residual spraying of households for vector control, case-management interventions & surveillance and monitoring and evaluation. Case management focuses on prompt diagnosis, effective treatment, capacity building among health workers and provision of quality diagnostics and effective medicines in all health facilities.

To ensure universal health coverage of these interventions, recognition of the private sector’s role in malaria is clearly stated as one of the strategies of case management for the Division of National Malaria Programme. This includes ensuring access to affordable malaria medicines, training of health workers among others. Though medical care is majorly sought in the public sector by the population, up to 25% of the population medical care is sought from the private sector. However, there were challenges in access to the private sector primarily due to price.

The Affordable Medicine Facility for malaria (AMFm) project, was implemented in nine countries as a pilot activity including Kenya between mid-2010 and 2012. The four major objectives of the AMFm was to increase Artemisinin-based combined therapies (ACTs) availability, affordability and use. The AMFm went through a transition of two years, finally adapting to the private sector co-pay where grant funds were dedicated at inicio to procure subsidized medicines and implement supporting interventions. The AMFm strategy has proved to be effective in the countries piloted. Though ACTs and rapid diagnostic tests (RDTs) have been made available in the private sector in Kenya, adherence to the national guidelines for malaria treatment is key by the health care providers. Several studies have shown that children are treated presumptively especially when they have fever cases.

Logistic regression is a statistical method of analysis that is used when the dependent (outcome) variable is binary (dichotomous). In this study, the outcome variable is presumptive treatment (Yes/No), which is a binary outcome variable. Mixed effects models, on the other hand, means that the predictor variables includes both the fixed and random effects whereby the random effects adjust for cluster correlations with multi-level data. The health care providers in this study are nested in the retail outlet which are nested in the counties. The predictor variables included the county as the random effect to adjust for inter-county correlations. This study used the application of mixed effects logistic regression modeling to predict treatment of children with uncomplicated malaria presumptively in the retail outlets.

The health seeking behavior in Kenya raises concerns in improvement in provision of health services in the private retail sector. About 25% of the population in Kenya seek medical care from the private retail sector. The AMFm has made ACTs available in the private retail sector through co-payment done at the manufacturer level to enable public and private buyers in approved countries purchase high-quality ACTs at a fraction of the market price. Though there is access to medicines at affordable prices as well as health worker capacity building on management of malaria, adherence to the national guidelines for the treatment of malaria is a key factor to be considered by the health care providers.

“Inappropriate” treatment practices (presumptive treatment) of uncomplicated malaria among children could be caused by several factors. This study examined these factors using a mixed effects logistic regression model. This study will inform strengthening of interventions in malaria management in the private sector. The study will also give insight for further research on malaria in the private retail sector. This study focused on application of mixed effects logistic regression modelling in establishing the predictors of treatment of children with uncomplicated malaria presumptively in the private retail sector in Kenya.

Methods
Study design and setting
This study design was a secondary data analysis from a cross-sectional, nationally representative, retail outlet survey that was measuring levels in key indicators on availability of ACTs and RDTs, and dispensing practices of ACTs in accordance with the diagnosis, treatment and prevention national treatment guidelines for malaria in Kenya.

This secondary analysis proposed in this study explored the predictors of ‘inappropriate’ treatment practices (presumptive treatment) of health care providers in the private retail outlets in Kenya.

Study population and eligibility of participants
The study populations included the health care providers who treated the patients in the retail outlets during the survey (September 2018), sampled randomly in both the rural and urban settings in Kenya.

The study included health care providers who treated patients in privately owned and predominantly dispensing retail outlets while health care providers from Public facilities, faith-based outlets and NGOs, non-functional outlets and pharmacies within a private facility were not included in this study.
Sample size determination
This study adopted the sample size in the primary study that was determined based on the Cochran’s formula:\(^1\):

\[
n = \frac{Z^2 \cdot p \cdot q}{d^2}
\]

Where:

\( n \) = the desired sample size
\( Z = \) standard normal deviate at required 95% confidence level = 1.96
\( p = \) Variability in the proportion of patients treated in the private sector assumed to be 50\%\(^1\)
\( q = 1 - p \)
\( d = \) margin of error = 0.05

To cater for non-response the sample was raised by 5%, hence the sample size was 405.

Sampling procedure
This study used the data for the health care providers who treated the patients during the primary study. In the primary study, a multistage random sampling method was used to obtain data in the retail outlets with each outlet having one health care provider surveyed. Specifically, all the 47 counties were included in the survey, but the sampling was done in two categories. In the first category, the 43 counties with less than 10 sub-counties had two sub-counties randomly sampled while in the second category, four counties with more than 10 sub-counties (namely Nairobi, Kiambu, Kakamega and Nakuru) had four sub-counties randomly sampled.

In the first stage for the first category, two sub-counties were randomly sampled. In the second stage, a rural and an urban area were randomly sampled from each sub-county. In the third stage, each of the rural/urban setting with two retail outlets was sampled; one registered and one unregistered. However, two registered retail outlets in the sub-county were selected. (If two or fewer, all were selected; if more than two, the researcher randomly selected two.) Two registered retail outlets in the Sub-county were selected to a maximum of two. (If two or fewer, all were sampled; if more than two, the researcher randomly sampled two.) A total of eight outlets were sampled in each of the counties for this category.

In the first stage for the second category, four sub-counties were randomly sampled. In the second stage, a rural and an urban area were randomly sampled from each sub-county (with the exception of Nairobi, where researchers went to one that is a relatively formal settlement and one that is a relatively informal settlement (slum). In the third stage, each of the rural/urban setting had two retail outlets sampled; one registered and one unregistered. However, two registered retail outlets in the sub-county were selected. (If two or fewer, all were sampled; if more than two, the researcher randomly selected two.) Two unregistered retail outlets in the Sub-county were selected to a maximum of 2 (If 2 or less, all were sampled; if more than two, researcher randomly sampled two). A total of 16 retail outlets were sampled in each of the counties for this category.

The list of unregistered retail outlets was obtained from the county pharmacist, the drug inspectors or the public health officer. Registered retail outlets were more likely to be around the municipal areas, unlike the unregistered ones. The registered retail outlets were selected from a list from the pharmacy and Poisons Board (PPB).

Data collection procedure
This study drew the data from the primary study that was conducted in September 2018 in the sampled private retail outlets in Kenya. The primary study accessed the availability of ACTs and RDTs and the dispensing practices of the health care providers in the private retail outlets. The data was valuable in this study since presumptive treatment was identified from the primary study report and the variables to investigate the predictors of this treatment were available for this study.

The data was requested from the Division of National Malaria Programme (DNMP) for secondary data analysis in this study. The variables not of interest from the primary data were dropped, leaving only the variables of interest to be used in this study. After the study conclusions for the primary study, the primary researcher had planned to store the data for a period of 5 years.

During the primary study, each survey team consisting of two persons visited a number of facilities as assigned. For the mystery shopper to yield positive results, only one of the data collectors obtained consent and administered the survey questionnaire while the other posed as the mystery shopper. One member of the team introduced him/herself to the outlet staff and seek audience with the superintendent. The superintendent of the retail outlets was told that the DNMP was monitoring national availability of case management for malaria commodities and malaria case management practices as part of the DNMP’s Monitoring and Evaluation activities. He/she was advised on the confidentiality of the results. The data collectors were given a letter from the MoH specifying the nature and purpose of the survey.

One method was through administration of a standardized retail outlets questionnaire where each retail outlet was assessed to determine the availability of non-expired, recommended and non-recommended ACTs and other anti-malarial drugs on the day of the survey. The presence of functional malaria microscopy service and availability of RDTs was assessed on the day of the survey and retrospectively over the last three months. Finally, the availability of weighing scales, ACT guidelines, and health workers’ exposure to malaria case-management training was also established. The retail outlets assessment data was collected using a combination of methods including direct observations of antimalarials in stock and interviewing superintendent of the retail outlets.

Secondly, the mystery shopper presented themselves to the retail outlets and requested for medicine based on a case scenario. After the encounter the information was recorded on a
standardized tool, designed to answer key counseling and dispensing of drugs tasks performed during this retail outlets visit.

Thirdly, the retail outlets superintendent and assistants who attended to the patients were interviewed on key aspects of in-service training, guidelines accessibility, supervision and practice at the retail outlets. The team thanked the outlet staff and departed.

**Study variables and methods of measurement**

The potential predictor variables accessed comprised of: zone, malaria risk, availability of rapid diagnostic tests, availability of artemisinin-based combination therapies, artemisinin-based combination therapies (acts) price, health care provider cadre, client asked signs/symptoms, health care provider case management training, client presented results, any supervision and access to national malaria guidelines. The outcome variable was presumptive treatment of uncomplicated malaria among children. Table 1 shows the measurement methods and study variables pertinent to this article assessed using the questionnaire, while Figure 1 shows the relationship between the predictor and outcome variables.

**Data management and statistical analysis**

Data cleaning, coding and analysis was done using STATA version 15 and R version 3.5.3 software. Exploratory data analysis was done to detect missing data, check for assumptions, and determine relationships between explanatory and outcome variables.

Descriptive statistics formed the basis of analysis for the variables of interest using frequencies. Specifically, the descriptive statistics determined were proportion of health care providers who treat patients presumptively, cadre, asked about any signs/symptoms, had gone through the case management training, had any supervision, had a case management supervision and had access to the national malaria guidelines. In addition, the proportion of the private retail outlets with RDTs and ACTs available was determined as well as the zone and the malaria risk. Finally, the median for the price of ACTs was since the data was skewed.

Bivariate analysis was performed using a mixed effects logistic regression at 95% CI to examine the association between the outcome and predictor variables which are categorical (zone, malaria risk, RDTs availability, ACTs availability, cadre, signs/symptoms asked, case management training, results presented, any supervision, case management supervision and access to national malaria guidelines) adjusting for county effects. Bivariate analysis is the analysis of two variables or an analysis that attributes to a two-way classification.

Multivariable logistic regression modelling was conducted to obtain the adjusted odds ratio, p-values, 95% CI and standard errors. The random effects were included to adjust for clustering.

| Variable (type) | Method of measurement |
|-----------------|-----------------------|
| Presumptive treatment of uncomplicated Malaria among children (nominal) | Binary form: Yes or No |
| Zone (nominal) | Accessed in two levels: Rural or Urban |
| Malaria risk (nominal) | Accessed in two levels: High or Low |
| Availability of Rapid Diagnostic Tests (nominal) | Binary form: Yes or No |
| Availability of Artemisinin-Based Combination Therapies (nominal) | Binary form: Yes or No |
| Artemisinin-Based Combination Therapies (ACTs) price (continuous) | Captured in Kenya Shillings |
| Health care provider cadre (nominal) | Accessed in 7 levels: Others, Nurse, Clinical officer, Laboratory Technologist, Pharmacy Assistant, Pharmaceutical Technologist & Pharmacist |
| Client asked signs/symptoms (nominal) | Binary form: Yes or No |
| Health care provider case management training (nominal) | Binary form: Yes or No |
| Client presented results (nominal) | Binary form: Yes or No |
| Any supervision (nominal) | Binary form: Yes or No |
| Access to national malaria guidelines (nominal) | Binary form: Yes or No |
at the county level to obtain adjusted odds ratios. The accuracy of the model was examined using the Akaike Information Criterion and the predictor variables for the best fitting model was used to predict the outcome of interest. Data were presented in tables clearly indicating the odds ratios, p-values, confidence intervals and standard errors.

**Ethical considerations**

Ethical approval for this study was obtained from the Kenyatta National Hospital/University of Nairobi – Ethics and Research Committee (KNH/UON/ ERC) – P457/06/2019. Permission to use the data for this study was obtained from the Division of National Malaria Programme (DNMP). During the primary study, an informed written consent was obtained from the respondents before they participated in the study.

**Results**

**Descriptive statistics of the study data**

The proportion of health care providers who treated patients presumptively was the first objective of this study. Out of the 333 health care providers who were interviewed, slightly more than a half, 190 (57%) treated patients presumptively (Table 2). Less than one-third, 70 (21%) and 44 (13%) had access to malaria guidelines and attended case management training, respectively. A majority (163, 47%) of the health care providers were pharmaceutical technologists. During treatment, 170 (51%) of the health care providers asked the signs and symptoms of the patients while 112 (34%) of the patients presented results.

In terms of the retail outlet characteristics, out of the 333 outlets where the health care providers were interviewed, almost all, 322 (97%) had availability of ACTs. Only 77 (23%) of the retail outlets had availability of RDTs.

The distribution of the retail outlet zone was almost equal, where 159 (48%) and 174 (52%) were located in the rural and urban areas, respectively. Finally, slightly more than one-third, 106 (32%) of the health workers accessed were from the high malaria risk area.

The de-identified raw dataset is available as Underlying data[17,18].

**Factors associated with presumptive treatment of uncomplicated malaria among children in the retail outlets**

The outcome variable of interest was presumptive treatment (Yes/No). The potential predictor variables were zone, RDT availability, ACT availability, drug price, cadre, health care provider asked signs or symptoms, case management training, results presented, any supervision, access to national malaria guidelines and malaria risk.

Out of the 10 variables, a health care provider who asked signs or symptoms, results were presented and had access to the national malaria case management guidelines were significantly associated with presumptive treatment of malaria at 95% CI adjusting for county effects.

Specifically, health care providers who asked signs or symptoms from the patient were negatively associated with presumptive treatment compared to those who did not (OR = 0.24; P<0.001, 95% CI = 0.13 - 0.45). In addition, health care providers who were presented with results from the patients were negatively associated with presumptive treatment compared to those who were not presented with results (OR = 0.08; P<0.001, 95% CI = 0.03 - 0.20). Finally, health care providers who had access to national malaria case management guidelines were negatively associated with presumptive treatment.
compared to those who have not (OR = 0.49; P-value = 0.038, 95% CI = (0.25 - 0.96).

There was not sufficient statistical evidence to indicate that there was a significant association between the other potential predictor variable and presumptive treatment of uncomplicated malaria among the health care providers. Table 3 shows the results of the factors associated with presumptive treatment of uncomplicated malaria among children in the retail outlets.

Table 2. Frequency distribution of the retail outlet and health care provider characteristics in Kenya (n = 333).

| Characteristic                              | Frequency (n = 333) | Percentage |
|---------------------------------------------|--------------------|------------|
| **Retail outlet**                           |                    |            |
| Zone                                        |                    |            |
| Rural                                       | 159                | 48%        |
| Urban                                       | 174                | 52%        |
| **Availability of RDTs**                    |                    |            |
| No                                          | 256                | 77%        |
| Yes                                         | 77                 | 23%        |
| **Availability of ACTs**                    |                    |            |
| No                                          | 11                 | 3%         |
| Yes                                         | 322                | 97%        |
| **Health care provider**                    |                    |            |
| Access to malaria case management guidelines|                    |            |
| No                                          | 263                | 79%        |
| Yes                                         | 70                 | 21%        |
| **Asked signs/symptoms**                   |                    |            |
| No                                          | 163                | 49%        |
| Yes                                         | 170                | 51%        |
| **Results presented**                       |                    |            |
| No                                          | 221                | 66%        |
| Yes                                         | 112                | 34%        |
| **Any supervision**                         |                    |            |
| No                                          | 172                | 52%        |
| Yes                                         | 161                | 48%        |
| **Presumptive treatment**                  |                    |            |
| No                                          | 143                | 43%        |
| Yes                                         | 190                | 57%        |
| **Case management training**               |                    |            |
| No                                          | 289                | 87%        |
| Yes                                         | 44                 | 13%        |
| **Cadre**                                   |                    |            |
| Others                                      | 43                 | 13%        |
| Nurse                                       | 24                 | 7%         |
| Clinical officer                            | 9                  | 3%         |
| Laboratory Technologist                     | 3                  | 1%         |
| Pharmacy Assistant                          | 57                 | 17%        |
| Pharmaceutical Technologist                 | 162                | 47%        |
| Pharmacist                                  | 35                 | 12%        |
| **Malaria Risk**                            |                    |            |
| Low                                         | 227                | 68%        |
| High                                        | 106                | 32%        |
Table 3. Bivariate analysis to test for factors associated with presumptive treatment of uncomplicated malaria in Kenya.

| Independent variable | Odds ratio (95% CI) | P-value |
|----------------------|---------------------|---------|
| Retail outlet        |                     |         |
| **Zone**             |                     |         |
| Urban (Ref)          | 1                   |         |
| Rural                | 1.46 (0.87 - 2.45)  | 0.151   |
| **RDTs available**   |                     |         |
| No (Ref)             | 1                   |         |
| Yes                  | 1.02 (0.53 - 1.98)  | 0.943   |
| **ACTs available**   |                     |         |
| No (Ref)             | 1                   |         |
| Yes                  | 0.71 (0.14 - 3.63)  | 0.680   |
| **Drug price**       | 1.00 (0.99 - 1.01)  | 0.742   |
| Health Care Provider |                     |         |
| **Cadre**            |                     |         |
| Others (Ref)         | 1                   |         |
| Nurse                | 0.88 (0.20 - 3.90)  | 0.846   |
| Clinical officer     | 0.53 (0.07 - 4.22)  |         |
| Laboratory Technologist | 1.70 (0.06 - 48.99) |         |
| Pharmacy Assistant   | 1.17 (0.32 - 4.24)  |         |
| Pharmaceutical Technologist | 0.90 (0.42 - 1.92) |         |
| Pharmacist           | 1.77 (0.72 - 4.36)  |         |
| **Asked any signs or symptoms** |             |         |
| No (Ref)             | 1                   |         |
| Yes                  | 0.24 (0.13 - 0.45)  | <0.001* |
| **Case management training** |       |         |
| No (Ref)             | 1                   |         |
| Yes                  | 0.55 (0.23 - 1.27)  | 0.159   |
| **Results presented** |                   |         |
| No (Ref)             | 1                   |         |
| Yes                  | 0.08 (0.03 - 0.20)  | <0.001* |
| **Any supervision**  |                     |         |
| No (Ref)             | 1                   |         |
| Yes                  | 0.99 (0.58 - 1.71)  | 0.979   |
| **Access to national malaria case management guidelines** |       |         |
| No (Ref)             | 1                   |         |
| Yes                  | 0.49 (0.25 - 0.96)  | 0.038*  |
| **Malaria risk**     |                     |         |
| Low (Ref)            | 1                   |         |
| High                 | 0.84 (0.30 - 2.33)  | 0.734   |

*p<0.05.
Predictors of presumptive treatment of uncomplicated malaria among children in the retail outlets using mixed effects logistic regression

A mixed effects logistic regression analyses was conducted and a liberal p-value of <0.2 was used to select the potential variables that were used to predict presumptive treatment of uncomplicated malaria. The mixed effects logistic regression found that a health care provider who asked patients signs or symptoms and results were presented were predictors that were statistically significant at 95% CI. The county variance was 0.99, which indicated that there was evidence for variance of the different counties. A health care provider who asked the patient any signs or symptoms was 80% less likely to treat the patient presumptively to those who did not adjusting for the variability in the counties (AOR = 0.20; P<0.001, 95% CI = (0.10 - 0.39). In addition, health care providers who had results presented by the patient were 91% less likely to treat a patient presumptively compared to one the one whom he results were not presented adjusting for county effects (AOR = 0.09; P-value = <0.001, 95% CI = (0.04 - 0.20). Table 4 shows the results for the mixed effects logistics regression analysis.

The model with the best fit based on the Akaike Information Criterion (AIC) was the one with health care provider who has undergone a malaria case management training, who asked the patient for the signs and symptoms and for whom results were presented (Table 5). The built model will therefore be:

\[
\text{Logit } [p_j] = 2.24 - 1.67 X_1 - 0.83 X_2 - 2.49 X_3 + u_j,
\]

where \(u_j \sim N(0, \delta_g^2)\)

The probability of treating a patient presumptively = \(\logit^{-1}(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + u_j)\)

Where \(u_j = 1.96 \delta_g\)

Therefore, the probability (Treating a patient presumptively) of any hypothetical county = \(\logit^{-1}(2.24 - 1.67 X_1 - 0.83 X_2 - 2.49 X_3 + 1.96 (1.013))\)

Considering the different value of the predictor variables i.e. Yes = 1 or No = 0, Table 6 below illustrates the different probabilities. The mixed effects logistic regression for the best-fitted model was conducted (Table 6).

Finally, the probability of a health care provider treating a patient presumptively if the patient presented results, were asked about signs and symptoms and the health care provider has been trained was 0.32. However, when the health care provider has

| Table 4. Multivariable analysis to test for presumptive treatment of uncomplicated malaria. |
| --- |
| **MELOGIT** |
| **Fixed effects** | AOR (95% CI) | Coeff (SE) | P-value |
| **Zone** | | | |
| Urban (Ref) | 1 | | |
| Rural | 1.39 (0.79 - 2.44) | 0.33 (0.29) | 0.255 |
| **Asked any signs or symptoms** | | | |
| No (Ref) | 1 | | |
| Yes | 0.20 (0.10 - 0.39) | -1.63 (0.35) | <0.001 * |
| **Case management training** | | | |
| No (Ref) | 1 | | |
| Yes | 0.44 (0.17 - 1.12) | -0.82 (0.47) | 0.084 |
| **Results presented** | | | |
| No (Ref) | 1 | | |
| Yes | 0.09 (0.04 - 0.20) | -2.46 (0.43) | <0.001 * |
| **Access to national malaria case management guidelines** | | | |
| No (Ref) | 1 | | |
| Yes | 0.75 (0.37 - 1.54) | -0.29 (0.37) | 0.434 |
| **Random effect** | | | |
| County | (0.9991) | | |

*p<0.05.
not gone for a case management training but the results were presented and the health care provider asked for the signs and symptoms, the probability of treating a patient presumptively is 0.85 (Table 7).

**Discussion**

The proportion of health care providers who treat uncomplicated malaria presumptively was 57% out of the 333 health care providers. A study conducted in Tanzania found that 51% of the patients testing negative were treated presumptively for uncomplicated malaria. Another study conducted in the Coastal area of Kenya found that presumptive treatment of patients ranged from 0 to 13.9% in the private sectors. In Nigeria a study conducted found that presumptive treatment among health care providers was higher in the private sector (95%) than the public sector (23%). These studies have shown that presumptive treatment in the private sector is being practiced. The study conducted in Tanzania had a percentage of health care providers who treat patients presumptively almost equal (51%) to that in this study (57%).

The potential factors associated with presumptive treatment were as follows: zone, RDT availability, ACT availability, drug price, cadre, health care provider asked signs or symptoms, case management training, results presented, any supervision, access to national malaria guidelines and malaria risk. However, the factors that were associated with presumptive treatment of uncomplicated malaria considering the county effect were zone, signs/symptoms asked, case management training, results presented and access to malaria case management guidelines. Several other studies have investigated the factors associated with presumptive treatment of uncomplicated malaria.

### Table 5. Candidate models to test for the best model fit.

| Predictor variables included | MELOGIT AIC value |
|-----------------------------|-------------------|
| Zone; access to guidelines; asked signs or symptoms; presented results; case management training | 356.9 |
| Access to guidelines; asked signs or symptoms; presented results; case management training | 356.3 |
| Zone; asked signs or symptoms; presented results; case management training | 355.6 |
| Zone; access to guidelines; asked signs or symptoms; presented results | 358.0 |
| Asked signs or symptoms; presented results; case management training | 354.9* |
| Asked signs or symptoms; presented results | 356.1 |

*The smaller the AIC value, the better the model.

AIC, Akaike Information Criterion.

### Table 6. Mixed effects logistic regression for the best model fit.

|                      | AOR (95% CI) | Coeff (SE) | P-value |
|----------------------|--------------|------------|---------|
| Intercept            | 9.44 (4.69 – 19.02) | 2.24 (0.34) | <0.001  |
| **Fixed effects**    |              |            |         |
| *Asked any signs or symptoms (X<sub>1</sub>)* |             |            |         |
| No (Ref)             | 1            |            |         |
| Yes                  | 0.19 (0.10 - 0.37) | -1.67 (0.34) | <0.001  |
| **Case management training (X<sub>2</sub>)** |             |            |         |
| No (Ref)             | 1            |            |         |
| Yes                  | 0.44 (0.18 – 1.09) | -0.83 (0.46) | 0.073   |
| **Results presented (X<sub>3</sub>)** |             |            |         |
| No (Ref)             | 1            |            |         |
| Yes                  | 0.08 (0.03 - 0.19) | -2.49 (0.43) | <0.001  |
| **Random effect**    |              |            |         |
| County               | Variance = 1.027 | Standard deviation= 1.013 |         |
A study that was conducted in Kenya assessed the association between presumptive treatment and case management training among health care providers in the private retail sector. The study showed that malaria case management training was significantly associated with presumptive treatment\textsuperscript{23}. These results are in line with that of this study as malaria case management training was significantly associated with presumptive treatment taking into account the county effects. A cluster randomized trial conducted in Ghana found that there was a significant association between availability of RDTs and presumptive treatment of uncomplicated malaria\textsuperscript{24}. The results contradict those of this study since the data did not provide enough evidence to indicate the association between availability of RDTs and presumptive treatment of uncomplicated malaria taking into account the county effect.

Availability of antimalarial drugs was significantly associated with presumptive treatment of uncomplicated malaria in a study that was conducted in Nigeria\textsuperscript{22}. However, in this study, the data did not provide sufficient evidence to indicate that there was an association.

Both the test for association and model building for this study was done using the mixed effects logistic regression models. The random effect which was the county was taken into account due to the county clustering. This method has been proved to be more accurate for prediction compared to the ordinary logistic regression models\textsuperscript{25}. This study applied the mixed effects logistic regression model with the best fitted model used as the AIC. Generally, comparing the AIC value, the mixed effects logistic regression model had a better fit compared to the ordinary logistic regression model. The mixed effects models have also been proven to be more efficient and flexible\textsuperscript{26}.

Table 7. Probabilities of the predicted model for presumptive treatment of uncomplicated malaria.

| Predictor variable | Equation | Probability |
|--------------------|----------|-------------|
| Asked signs/symptoms = 1 | \[ P (1) = \text{logit}^{-1}(2.24 \cdot 1.67(1) - 0.83(1) - 2.49(1) + 1.96(1.013)) \] | 0.32 |
| Results presented = 1 | \[ P (1) = \text{logit}^{-1}(2.24 \cdot 1.67(0) - 0.83(1) - 2.49(1) + 1.96(1.013)) \] | 0.71 |
| Case management training = 1 | \[ P (1) = \text{logit}^{-1}(2.24 \cdot 1.67(1) - 0.83(0) - 2.49(1) + 1.96(1.013)) \] | 0.52 |
| Asked signs/symptoms = 0 | \[ P (1) = \text{logit}^{-1}(2.24 \cdot 1.67(1) - 0.83(0) - 2.49(0) + 1.96(1.013)) \] | 0.85 |
| Results presented = 1 | \[ P (1) = \text{logit}^{-1}(2.24 \cdot 1.67(0) - 0.83(0) - 2.49(0) + 1.96(1.013)) \] | 0.99 |
| Case management training = 0 | \[ P (1) = \text{logit}^{-1}(2.24 \cdot 1.67(0) - 0.83(0) - 2.49(0) + 1.96(1.013)) \] | 0.99 |

Based on the AIC values for the different candidate models to predict presumptive treatment of uncomplicated malaria among children in the private retail outlet, if the test was presented, if the health care provider asked the signs and symptoms and had undergone case management training were the predictor variables that fitted the best model. The model further predicted the probability of a health care provider to treat a patient presumptively based on the three factors. For a health care provider who has undergone a malaria case management training, who asked the patient for the signs and symptoms and for whom results were presented, the probability is 0.32. For one who has gone through a malaria case management training, for whom results were presented but did not ask for signs or symptoms of malaria the probability is 0.71. For a health care provider who had no results presented, the probability was 0.52. If the test results were presented, and the health care provider asked for the signs and symptoms but had not undergone a case management training, the probability of treating a patient presumptively was 0.85. These results show that all the three predictors are crucial for a health care provider. However, malaria case management training plays a key role in treatment of malaria at the private retail sector.

In conclusion, the health care providers practices and knowledge in case management of malaria is key in diagnosis, treatment and prevention of malaria in Kenya. Presumptive treatment is due to misdiagnosis of a patient, which may lead to drug resistance.

**Conclusion**

Health seeking behavior in the private retail sector raises concerns in the provision of health care services in the private sector. Much has been done in the public sector but there is a need
to also strengthen interventions in the private sector in realization of Universal Health Care in Kenya to reach the Sustainable Development Goals (SDGs). Presumptive treatment of uncomplicated malaria among children in Kenya has been an issue which depends on the health care providers as well as the retail outlet factors. Adherence to the national malaria case management guidelines in key in ensuring quality of treatment to the malaria patients. Interventions in place to curb presumptive treatment include provision of malaria case management guidelines, case management training, supervision and availability of RDTs to ensure testing before treatment. On the other hand, availability of ACTs due to the AMFM subsidies could possibly influence presumptive treatment of uncomplicated malaria.

The results from this study show that case management training, asking about signs/symptoms and having results presented predict presumptive treatment of uncomplicated malaria. A mixed effects logistic regression model was used to adjust for the county clustering effect. This model provides more accurate prediction compared to an ordinary logistic regression model measured by the AIC values. Apart from asking the signs and symptoms or results presented, case management training for the health care providers play a key role in management of malaria by health care providers in the private retail outlets.

Malaria case management training touches on testing and asking of patients for signs/symptoms before diagnosis and treatment of a patient, However, this study gives and insight for policy makers to emphasize on testing and asking signs/symptoms when training health care providers on malaria case management.

**Recommendations**

Based on the discussion and conclusion drawn, this study recommends:

1. The Division of National Malaria Programme (DNMP) and other partners should focus on malaria case management in the private sector to improve the quality of treatment.
2. Further research to look into the factors that may predict presumptive treatment since the data in this study did not provide evidence to indicate the other potential factors predictability.
3. There is need to strengthen interventions in the private sector in realization of Universal Health Care in Kenya.

**Data availability**

**Underlying data**

Figshare: PPTUM_Kenya.xlsx. https://doi.org/10.6084/m9.figshare.12783128.v217.

This file contains the de-identified dataset used in the present study.

Figshare: PPTUMK_DD. https://doi.org/10.6084/m9.figshare.12783188.v214.

This file contains the data dictionary for the de-identified dataset.

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

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**References**

1. World Health Organization: World Malaria Report 2015. World Health, 2015. Reference Source
2. WHO: WORLD MALARIA REPORT 2018. 2018. Reference Source
3. World Health Organization: World malaria Report 2012. World Health Organization, 2012. Reference Source
4. National Malaria Control Program [Ministry of Health]: Kenya Malaria Strategy 2009 - 2018 (Revised 2014). 2014; 76. Reference Source
5. Kenya National Bureau of Statistics: Malaria Indicator Survey 2015. Minist. Heal. Kenya, 2016. 2. Reference Source
6. O’Connell KA, Gatakaa H, Poyer S, et al.: Got ACTs? Availability, price, market share and provider knowledge of anti-malarial medicines in public and private sector outlets in six malaria-endemic countries. Malar J. 2011; 10: 326. PubMed Abstract | Publisher Full Text | Free Full Text
7. AMFM: Independent Evaluation of Phase 1 of the Affordable Medicines Facility - malaria (AMFM), Multi-Country Independent Evaluation Report: Final Report. Calverton, Maryl. London ICF Int. London Sch. Hyg. Trop. Med., 2012. Reference Source
8. Juma E, Zurovac D: Changes in health workers’ malaria diagnosis and treatment practices in Kenya. Malar J. 2011; 10: 1. PubMed Abstract | Publisher Full Text | Free Full Text
9. Mosha JF, Conteh L, Tediosi F, et al.: Cost implications of improving malaria diagnosis: Findings from North-Eastern Tanzania. PLoS One. 2010; 5(1): e6707. PubMed Abstract | Publisher Full Text | Free Full Text
10. D’Alessandro U, Ubben D, Hamed K, et al.: Malaria in infants aged less than six months - Is it an area of unmet medical need? Malar J. 2012; 11: 400. PubMed Abstract | Publisher Full Text | Free Full Text
11. Bilal JA, Gasim GI, Abdien MT, et al.: Poor adherence to the malaria management protocol among health workers attending under-five year old febrile children at Omdurman Hospital, Sudan. Malar J. 2015; 14: 34. PubMed Abstract | Publisher Full Text | Free Full Text
12. Ansumana R, Jacobsen KH, Gbakima AA, et al.: Presumptive self-diagnosis of malaria and other febrile illnesses in Sierra Leone. P.Med J. 2013; 15:
13. Scott AJ, Hosmer DW, Lemeshow S: *Applied Logistic Regression*. Biometrics. 2006.
14. Maxwell SE, Maxwell SE: *Mixed-Effects Models*. In: *Designing Experiments and Analyzing Data*. 2017.
15. Yuan M, Lin Y: Model selection and estimation in regression with grouped variables. *J R Stat Soc Ser B Stat Methodol*. 2006; 68(1): 49–67.
16. Mugenda O, Mugenda AG: *Research Methods – Quantitative & Qualitative Approaches*. African Cent Technol Stud Nairobi Kenya. 2003.
17. Kemunto D: *PPTUM_Kenya.xlsx*. figshare. Dataset. 2020. http://www.doi.org/10.6084/m9.ﬁgshare.12783128.v2
18. Kemunto D: *PPTUMK_DD*. figshare. Online resource. 2020. http://www.doi.org/10.6084/m9.ﬁgshare.12783188.v2
19. Dohoo IR, Martin SW, Stryhn H: *Methods in epidemiologic research*. 2012.
20. Reyburn H, Mtaklila H, Mwangi R, et al.: Rapid diagnostic tests compared with malaria microscopy for guiding outpatient treatment of febrile illness in Tanzania: Randomised trial. *BMJ*. 2007; 334(7590): 403.
21. Poyer S, Musuva A, Njoki N, et al.: Fever case management at private health facilities and private pharmacies on the Kenyan coast: Analysis of data from two rounds of client exit interviews and mystery client visits. *Malar J*. 2018; 17(1): 112.
22. Bamiselu OF, Ajayi I, Fawole O, et al.: Adherence to malaria diagnosis and treatment guidelines among healthcare workers in Ogun State, Nigeria. *BMC Public Health*. 2016; 16(1): 828.
23. Kangwana BP, Kedenge SV, Noor AM, et al.: The effect of an anti-malarial subsidy programme on the quality of service provision of artemisinin-based combination therapy in Kenya: A cluster-randomized, controlled trial. *Malar J*. 2013; 12: 81.
24. Ansah EK, Narh-Bana S, Affran-Bonful H, et al.: The impact of providing rapid diagnostic malaria tests on fever management in the private retail sector in Ghana: A cluster randomized trial. *BMJ*. 2015; 350: h1019.
25. Balazsi L, Matyas L, Wansbeek T: Fixed effects models. In: *Advanced Studies in Theoretical and Applied Econometrics*. 2017; 50: 1–34.
26. Bagiella E, Sloan RP, Heitjan DF: Mixed-effects models in psychophysiology. *Psychophysiology*. 2000; 37(1): 13–20.
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