Predictors of Malaria Rapid Diagnostic Tests' Utilisation Among Healthcare Workers in Zamfara State.

Usman Rabi[1]*, Ahmad A. Umar[2], Saheed Gidado[1,3] , A.A Gobir[2], , Izuchukwu F. Obi[1, 5], IkeOluwapo Ajayi[4], Olufemi Ajumobi[1,3]

1. Nigeria Field Epidemiology and Laboratory Training Programme, Abuja, Nigeria
2. Department of Community Medicine, Ahmadu Bello University, Zaria, Nigeria
3. African Field Epidemiology Network, Abuja, Nigeria
4. Department of Epidemiology and Medical Statistics, University of Ibadan, Ibadan, Nigeria
5. Department of Community Medicine, University of Nigeria Teaching Hospital Enugu, Nigeria

*Corresponding author:

E-mail; rabiusman360@yahoo.com(RU)

Abstract

Introduction: Early diagnosis and prompt and effective treatment is one of the pillars of malaria control Malaria case management guidelines recommend diagnostic testing before treatment using malaria Rapid Diagnostic Test (mRDT) or microscopy and this was adopted in Nigeria in 2010. However, despite the deployment of mRDT, the use of mRDTs by health workers varies by settings. This study set out to assess factors influencing utilisation of mRDT among healthcare workers in Zamfara State, Nigeria.

Methods: A cross-sectional study was carried out among 306 healthcare workers selected using multistage sampling from six Local Government Areas between January and February 2017. Mixed method was used for data collection. A pre-tested self-administered questionnaire was

25 used to collect information on knowledge, use of mRDT and factors influencing utilization. An

26 observational checklist was used to assess the availability of mRDT in the six months prior to

27 this study. Data were analyzed using descriptive statistics such as means and proportions.

28 Association between mRDT use and independent variables was tested using Chi square while

29 multiple regression was used to determine predictors of use at 5% level of significance.

30 **Results:** Mean age of respondents was 36.0 ± 9.4years. Overall, 198 (64.7%) of health workers

31 had good knowledge of mRDT; malaria RDT was available in 33 (61.1%) facilities. Routine use

32 of mRDT was reported by 253 (82.7%) healthcare workers. This comprised 89 (35.2%)

33 laboratory scientists/technicians, 89 (35.2%) community health extension workers/community

34 health officers; 59 (23.3%) nurses and 16 (6.3%) doctors. Predictors of mRDT utilisation were

35 good knowledge of mRDT (adjusted OR (aOR):3.3, CI: 1.6-6.7), trust in mRDT results (aOR:

36 4.0, CI: 1.9 - 8.2), having being trained on mRDT (aOR: 2.7, CI: 1.2 - 6.6), and provision of free

37 mRDT (aOR: 2.3, CI: 1.0 - 5.0).

38 **Conclusion:** This study demonstrated that healthcare worker utilisation of mRDT was associated

39 with health worker and health system-related factors that are potentially modifiable. There is

40 need to sustain training of healthcare workers on benefits of using mRDT and provision of free

41 mRDT in health facilities.

42 **Keywords:** Malaria rapid diagnostic test, knowledge, utilisation, healthcare worker, Nigeria

43

44

45

46

Introduction

Malaria remains a major public health problem in many countries of the world. Despite the progressive reduction in malaria cases and deaths, it is estimated that an estimated 216 million cases of malaria occurred worldwide in 2016 with 90% from the African region.[1] Fifteen countries accounted for 80% of the 445,000 malaria deaths worldwide; these countries are all in sub-Saharan Africa which include Nigeria[1].

In 2016, Nigeria accounted for more than 50% of all malaria cases in sub-Saharan Africa[1]; the disease is responsible for two-thirds of outpatient visits to health facilities, one-third of childhood deaths, one-quarter of deaths in children under one year and 11% maternal deaths. The financial loss due to malaria annually is estimated to be about 132 billion naira in form of treatment costs, prevention and loss of man-hours among others; yet, it is a treatable and preventable disease[2]. Malaria prevalence in Zamfara State has remained consistently high, 69.9% [3] with less than one percent of children with fever being tested for malaria[4].

The WHO in 2010, recommended confirmation of malaria in febrile illness prior to treatment with artemisinin combination therapy[5]. Attaining the objective of test and treat for all suspected malaria cases using RDT or microscopy[6] make it imperative for all health workers to have access to, and appropriately utilize malaria diagnostic tools. Although microscopy is recognized as the gold standard in malaria diagnosis, it has been limited in availability, often of poor quality, time-consuming, labor-intensive, and costly[7,8] especially in resource-poor settings. Lack of equipment, reagents, and expertise for malaria microscopy in the majority of peripheral health centers and the constant power supply has equally limited its use. More so, presumptive diagnosis based on malaria symptoms has proven to be unspecific[9–11]. These shortcomings of microscopy and

70   presumptive diagnosis have favored the deployment and use of mRDTs which have been found

71   to be cost-effective[12–14] and allow diagnosis even in health settings lacking any laboratory

72   facility. Malaria RDT use is expected to not only improve malaria management but also limit

73   malaria treatment costs[15]. Deployment to mRDT to health facilities commenced in Nigeria in the

74   year 2007.

75   Factors such as heavy workload, lack of trust, cost, training on the use of RDTs have been

76   considered to influence RDT use[16–21]. A study reported a high proportion (61.5%) of healthcare

77   workers perceived mRDTs as unreliable, one-third (30.8%) of healthcare workers had supply

78   issues with mRDT, 15.4% of them reported a preference for other methods of malaria diagnosis

79   and one-fifth (26%) of healthcare workers were ignorant about mRDT.[16] These factors are

80   generic and may vary in different settings.

81   There is a paucity of data concerning the mRDT use and factors influencing utilisation among

82   healthcare workers in Zamfara State. Lack of malaria testing could impair the ability of health

83   workers to make informed and prompt treatment decision based on parasitological diagnosis[5].

84   This study aimed to investigate the knowledge of mRDT, mRDT availability and use as well as

85   factors influencing mRDT utilisation in health facilities in Zamfara State.

86

87

88

89

90

91

92

Methods

93

Study area

94

95 The study was conducted in Zamfara State, North West Nigeria**.** The State has a projected

96 population of 4,466,775 (based on the 2006 Census population with an annual growth rate of

97 3.2%). The climate of Zamfara is tropical with a temperature rising up to 38 °C (100.4 °F) and

98 above between March to May. The state experiences malaria transmission all year-round with

99 peak transmission during the rainy season between May and September. The State operates a

100 three-tier healthcare delivery services namely primary, secondary (General Hospitals) and

101 tertiary spread across urban and rural areas. The State has a total of 712 health facilities

102 distributed across 14 Local Government Areas (LGAs). These health facilities are as follows; 71

103 Primary Health Centres, 607 Health Clinics, 10 private hospitals, 22 General Hospitals, 1

104 Specialist Hospital and 1 Federal Medical Center. The State has a total of 3,458 healthcare

105 workers working in these health facilities. Majority of the facilities in the State offer malaria

106 diagnosis and treatment services[22]. Generally, trained staff of public primary health centers offer

107 malaria diagnosis using mRDT while trained laboratory scientists at public general hospitals

108 (secondary care level) offer both malaria microscopy and mRDT services. The State has

109 benefitted from several Malaria intervention programs over the years such as Partnership for

110 Reviving Routine Immunization in Northern Nigeria- Maternal and Neonatal Child Health

111 (PRRINN/MNCH), Malaria Action Program for States (MAPS) and of recent, the STOP/Malaria

112 Frontline project to improve the effectiveness of malaria control in Zamfara State. A cross-

113 sectional study was carried out among health workers. in public health facilities in the state

114 between January and February 2017.

115 **Sample size and sampling technique**

116 A sample size of 306 was calculated using sample size formula for single proportion;

117 $$n = \frac{Z_\alpha{}^2\,pq}{d^2}$$

118

119 Where:

120 the p= proportion of health workers that use malaria RDT to diagnose malaria in public health

121 facilities, (0.85)[23]

122 q= 1-p= 1-0.852= 0.148

123 d= level of precision, 0.05

124 α = level of significance, 5%

125 $Z_{\alpha=}$ standard normal deviate, 1.96

126 A three-stage sampling technique was used to select study respondents. Two (2) LGAs were

127 randomly selected by balloting from each of the three senatorial zones of the State giving a total

128 of 6 LGAs namely; Kaura Namoda and Zurmi LGAs (Zamfara North zone), Gusau and Bungudu

129 LGAs (Zamfara Central zone), Anka and Talata Mafara LGAs (Zamfara West zone). List of all

130 public health facilities from the selected LGAs based on the level of care was stratified into

131 primary and secondary facilities. Eight Primary Health Care centers (PHCs) were selected from

132 each of the selected LGA by balloting giving a total of 48 PHCs while the General hospital in

133 each of the LGA selected was purposively selected for the study. However, where there was

134 more than one General Hospital in a selected LGA, one was selected by balloting. This gave an

135 overall total of 54 health facilities selected for the study. A sampling frame of all healthcare

136   workers was developed using the facility's nominal roll. Health workers were selected by

137   stratified sampling proportionate to size until required sample size was obtained.

Data collection

139   Six trained research assistants distributed the questionnaires. Semi-structured self- administered

140   questionnaires were used to obtain information on respondents' socio-demographic

141   characteristics, knowledge of mRDT, malaria diagnostic methods used in health facilities,

142   utilization of malaria RDT among health care workers, training on malaria case management,

143   supervision on malaria RDT use and factors affecting malaria RDT utilization. The research

144   assistants administered health facility observational checklists to assess the availability of

145   mRDTs at the facilities within the last six months.

Data processing and analysis

147   Questionnaires were manually checked for completeness and consistency with corrections made

148   daily. Data were entered, cleaned and analyzed using Epi-info Version 7. Data were summarized

149   using descriptive statistics such as means and standard deviations for quantitative variables such

150   as age, years of practice and knowledge score while frequencies and proportions were generated

151   for categorical variables (the cadre of health worker, the proportion of febrile patients who get

152   tested using mRDT, mRDT availability, and mRDT use). Results of the analysis were presented

153   in tables and charts. Healthcare workers' mRDT knowledge scores were calculated thus; 8

154   questions evaluated knowledge of mRDT, each correct answer was given a score of 1 and an

155   incorrect answer was given a score of 0. Total scores were computed for each respondent and

156   converted into percentages. A score of less than 50% was graded as poor knowledge, between

157   50% and 75% as fair knowledge and greater than 75% as good knowledge. Bivariate analysis

158   was used to test the association between categorical dependent and independent variables. Those

159   significant at p-value ≤ 5% were put in the logistic regression model to control for confounders

160   to determine predictors of mRDTs by healthcare workers. Odds Ratios and 95% Confidence

161   Intervals (CIs) were presented.

162   **Ethical considerations**

163   This research was granted ethical approval by the Ethics and Research Committee of Zamfara

164   State Ministry of Health (Reference number- ZSHREC/03/10/2016). Participation was voluntary

165   and written informed consent was obtained from all respondents. The participants were not at

166   any point in time exposed to harm and were free to opt out at any time during the interview.

167   Confidentiality of collected information was maintained by using unique non-personal identifier

168   codes for the respondents. The completed questionnaire was kept under lock and key.

169   # Results

170   **Characteristics of respondents**

171   Overall, 306 healthcare workers participated in the study and their mean age was 36.0yrs, SD:

172   9.4yrs. Most, 128 (41.8%), of the respondents were aged 25 to 34years. They were mostly males,

173   204 (66.7%). CHEWs represented 105 (34.3%) of respondents and 21 (6.9%) were doctors. Most

174   were married (78.1%, n = 239). The average duration of practice was 11.0 ± 9.1yrs (Table 1).

175

176

177

178

179 **Table 1: Frequency ddistribution of socio-demographic characteristics of the respondents**

180 **(N = 306)**

181

Characteristics	Frequency (%)
Age group (in years)	
<25	22 (7.2)
25-34	128 (41.8)
35-44	90 (29.4)
45-54	54 (17.7)
≥55	12 (3.9)
Sex	
Male	204 (66.7)
The cadre of healthcare worker	
Doctor	21 (6.9)
Nurse/Midwife	83 (27.1)
Laboratory Scientist/Technician	97 (31.0)
CHEW/CHO	105 (34.3)
Marital Status	
Single	63 (20.6)
Married	239 (78.1)
Widowed	4 (1.3)
Duration of practice (years)	
1-5	95 (31.1)
6-10	95 (31.1)
11-15	47 (15.4)
16-20	23 (7.5)
21-25	8 (2.6)
>25	38 (12.4)

182

183

184

185

186

187

188   **Health workers' knowledge of mRDT**

189   Among the 306 health workers, 245 (80.1%) knew the meaning of mRDT, while 236 (77.0 %)

190   knew what mRDT assesses. All the respondents, 306 (100%) knew that blood was used for the

191   test. Two hundred and eighty-two (92.0%) knew how to carry out mRDT. Mean knowledge

192   score for respondents was 82.0 (standard deviation (SD): 15.8). Overall, more than half of

193   respondents (64.7%, n = 198) had good knowledge of mRDT. According to cadre, 71.1% of

194   laboratory scientists/technicians, 63.8% of CHEWs/CHOs, 61.9% of doctors and 59.0% nurses

195   had good knowledge of malaria RDT. (Table 2).

196

197

198

199

200

201

202

203

204

205

206

Table 2: Level of knowledge of malaria Rapid Diagnostic Test by Professional Cadre of Respondents in Selected Health Facilities, Zamfara State

Professional cadre	Knowledge grade						Total
	Good N = 198		Fair N = 99		Poor N = 9		
	Frequency	%	Frequency	%	Frequency	%	N = 306
Doctors	13	61.9	4	19.1	4	19.1	21
Nurse/Midwife	49	59.0	32	38.6	2	2.4	83
CHEW/CHO	67	63.8	36	34.3	2	1.9	105
Lab. Scientist/Technician	69	71.1	27	27.8	1	1.0	97

222 **Availability and use of mRDT among healthcare workers**

223 Thirty-three (61.1%) out of the 54 of health facilities had mRDT in stock. Overall, 253 (82.7%)

224 of the healthcare workers reported using malaria RDT routinely before making a diagnosis of

225 malaria. This comprised 89 (35.2%) laboratory scientists/technicians, 89 (35.2%) community

226 health extension workers/community health officers; 59 (23.3%) nurses and 16 (6.3%) doctors.

227 Nurses/Midwives (OR: 2.7, 95% CI: 1.5 − 5.0) and Laboratory scientists/technicians (OR: 3.1,

228 95% CI: 1.4 − 6.8) were significantly more likely to use mRDT compared to doctors and

229 CHEWs/CHOs (Table 3).

230

231

232

233

234

235

236

237

238

239

240 **Table 3: Utilisation OF Malaria Rapid Diagnostic Test Among Healthcare Workers in**

241 **Selected Health Facilities, Zamfara State (N=253)**

Professional cadre	n (%)	OR (95%CI)	p-value
Doctor	16 (6.3)	1.5 (0.5 - 4.4)	0.606
Nurse/Midwife	59 (23.3)	2.7 (1.5 - 5.0)	0.002
CHEW/CHO	89 (35.2)	0.8 (0.4 - 1.5)	0.592
Lab. Scientist/Technician	89 (35.2)	3.1 (1.4 - 6.8)	0.007

242

243

244

245

246

247

248

249

250

251

Factors influencing mRDT use

Healthcare workers with good knowledge of mRDT were 2.7 times more likely to use it (p = 0.002). Those who have had training in malaria case management had 2.4 times odds of using mRDT (p = 0.003). Healthcare workers in facilities that do mRDT for free were 2.8 times more likely to use it (p = 0.036) compared to facilities where patients have to pay for it. Healthcare workers who have trust in mRDT, have had training on mRDT and those who have received supportive supervision ((p = 0.002) were 3 times more likely to use mRDT compared to those who did not have training and did not receive supportive supervision. Predictors of mRDT utilisation include health workers' having good knowledge of mRDT (aOR: 3.3, 95% CI: 1.6 – 6.7), trust in mRDT results, (aOR: 4.0, 95% CI: 2.0 – 8.3), training on mRDT (aOR: 2.8, 95% CI: 1.2 – 6.7) and provision of free mRDT (aOR: 2.3, 95% CI: 1.0 – 5.0), Table 4.

Table 4: Association between respondents' factors, health system factors, and utilization of malaria Rapid Diagnostic Test,
Zamfara

Characteristic	Crude OR	p-value	aOR	p-value
Age (in years)				
<36	1.5 (0.5 – 1.7)	0.9798		
>36				
Sex				
Male	2.5 (1.4 – 4.5)	0.0046		
Professional cadre				
Doctor	1.5 (0.5 – 4.4)	0.6062		
Nurse/Midwife	2.7 (1.5 – 5.0)	0.0019		
CHEW/CHO	0.8 (0.4 – 1.5)	0.5916		
Lab. Scientist/Technician	3.1 (1.4 – 6.8)	0.0070		
Duration of practice (in years)				
<15	1.0 (0.5 – 1.8)	0.9496		
≥15				
Knowledge of mRDT				
Good knowledge	2.7 (1.5 – 4.9)	0.0020	3.3 (1.7 – 6.7)	<0.001
Poor knowledge				
Training on Malaria case management				
Trained	2.4 (1.7 – 6.0)	0.0003		
Not trained				
Trust in mRDT result				
Trust results	3.2 (1.7 – 6.0)	0.0070	4.0 (2.0 – 8.3)	<0.001
Do not trust results				
Had training on mRDT in the last 6 months				
Trained	3.4 (1.7 – 6.6)	0.0003	2.8 (1.2 – 6.7)	0.040
Not trained				
Received supportive supervision in the last 6 months				
Supervised	3.2 (1.8 – 5.9)	0.0002		
Not supervised				
mRDT availability				
Available	1.7 (0.6 – 4.8)	0.7917		
Not available				
Cost of mRDT				
Free	2.8 (1.2 – 6.6)	0.0363	2.3 (1.0 – 5.0)	0.040
Not free				

Discussion

The study showed that healthcare workers have good knowledge of mRDT similar to a study conducted in Southeast Nigeria where 61.1% of respondents knew about mRDT.[24] The proportion of healthcare workers who knew the meaning of mRDT was found to be higher than that in a study carried out in the six geo-political zones of Nigeria where 70% reported knowing the meaning of mRDT[21]. This is probably because of investment by government and non-governmental organizations in awareness creation on parasitological testing through training on mRDT[21] in Zamfara state.

Majority of healthcare workers used malaria RDT routinely before making a diagnosis of malaria. This finding is similar to a study in Ogun State[25] and systematic review of mRDT use in sub-Saharan Africa that reported a high percentage of healthcare workers used mRDT prior to administration of ACTs. However, a previous study found that doctors and laboratory technicians more likely to use mRDT compared to nurses and CHEWs/CHOs[24]. High use of mRDT among laboratory scientists is not surprising as their primary responsibility is to carry out tests.

It is widely established that the key factor in improving diagnosis of malaria is the availability of mRDTs in health facilities.[26] This study found that rapid diagnostic test kits were available in more than half of health facilities, higher than what was reported in a study in Enugu State where 31% of health facilities had mRDT[17] and another study in Ogun State that reported mRDT was available in 50.7% of health facilities[25]. This, however, is less than the WHO average availability target in public and private health facilities as availability is said to be inadequate if it falls below 80%. This finding underscores the need to scale-up mRDTs availability in health

288   facilities in the State since currently, mRDTs are supplied free of charge by the government to

289   only public health facilities. Widespread provision of malaria RDTs will play a significant role in

290   reducing the persistent problem of malaria over-diagnosis and contribute to reduced risk of

291   malaria under-treatment. Factors that were found to influence mRDT use in this study are similar

292   to those found in previous studies that have reported that trust, training, and cost of mRDT affect

293   its use[16–21]. Positive influence of healthcare workers' trust in mRDT use in this study differs from

294   a previous study that reported low use of mRDT despite availability because they do not trust the

295   results[24]. This is probably because the study was conducted during the early stage of introducing

296   mRDT into the country compared to the present day where awareness and training on mRDT

297   have improved.

298   Another factor influencing mRDT utilization found in this study was training. This is similar to

299   previous studies that showed that training of healthcare workers on mRDT improves healthcare

300   workers' performance with an increased likelihood of adherence to malaria treatment

301   guidelines.[28–30] This study also found that healthcare workers are more likely to use mRDT if the

302   cost is free. This is similar to a previous study that reported a large improvement in the

303   proportion of patients appropriately treated at a low cost with the introduction of mRDTs[5]. A

304   possible reason for this is the fact that patients won't incur any cost if they are asked to do mRDT

305   since it is free. This, in turn, will encourage its use in health facilities, thereby, increasing the

306   proportion of patients with the parasitological diagnosis.

307   **Limitations**
308   The questionnaire captured self-reported information, hence relied primarily on respondents

309   providing the right information. There might have been some reporting bias with probably the

310   tendency to overestimate utilization of mRDTs in this study since this is a desirable outcome.

311 However, this was minimized by ensuring that participants were assured of a high degree of

312 confidentiality.

Conclusion

314 The high proportion of health workers with good knowledge of mRDT in Zamfara state is

315 commendable and could be reflection of the training that has been held in the state by multiple

316 agents in the past. This also influenced the high use of the diagnostic kit. The drivers of mRDT

317 use in this study (knowledge, trust, training, and provision of free mRDTs) are plausible and a

318 good index to inform intensified efforts at capacity building of healthcare workers. The

319 government and collaborating partners with interest in malaria control should, therefore, sustain

320 the training of healthcare workers on mRDT and supply of free mRDTs in the health facilities in

321 Zamfara state and the country as a whole.

Acknowledgements

331   **Author's contributions:** RU and SG conceptualised the study. AAU and OA contributed to

332   design of the study and the data tools. RU designed the study, performed the field work, data

333   analysis and interpretation and wrote the draft manuscript. AAU, AAG, IFO, IA and OA

334   contributed to data interpretation and provided technical inputs during the manuscript writing.

335   **Competing interests:** The authors have declared that no competing interests exist.

336

337

References

1. WHO. World Malaria Report 2017 [Internet]. World Health Organization. 2017. 186 p. Available from: http://apps.who.int/iris/bitstream/handle/10665/259492/9789241565523-eng.pdf;jsessionid=3B05B30235850B2B29A7FFFDD8A874D8?sequence=1

2. Plan S. Federal Ministry of Health , National Malaria Control Programme , Abuja , Nigeria . Strategic Plan 2009-2013 A Road Map for Malaria Control in Nigeria DRAFT 16 June 2008. 2013;(June 2008):1–39.

3. Nigeria Malaria Indicator Survey 2015 - Key Indicators Report [PR70] - PR70.pdf [Internet]. 2015. Available from: http://dhsprogram.com/pubs/pdf/PR70/PR70.pdf

4. NPC, ICF. Nigeria Demographic and Health Survey 2013. Natl Popul Comm [Internet]. 2014 [cited 2016 Oct 25];566. Available from: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Nigeria+Demographic+and+Health+Survey#0%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Nigeria+demographic+and+health+survey+1999#0

5. Ajumobi O, Sabitu K, Ajayi I, Nguku P, Ufere J, Wasswa P, et al. Demand-related factors influencing caregivers' awareness of malaria tests and health workers' testing practices, in Makarfi, Nigeria. Malar J [Internet]. 2017;16(1):1–9. Available from: https://doi.org/10.1186/s12936-017-2138-8

6. FMOH. National malaria strategic plan 2014–2020. . Abuja, Nigeria: Federal Ministry of Health; 2014.

7. Hamer DH, Ndhlovu M, Zurovac D, Fox M, Yeboah-Antwi K, Chanda P, et al. Improved diagnostic testing and malaria treatment practices in Zambia. JAMA. May 23. 2007;297(20):2227–2231.

8. Bruxvoort K, Kalolella A, Nchimbi H, Festo C, Taylor M, Thomson R, et al. Getting antimalarials on target : impact of national roll-out of malaria rapid diagnostic tests on health facility treatment in three regions of Tanzania. 2013;18(10):1269–82.

9. Mens P, Spieker N, Omar S, Heijnen M, Schallig H, Kager PA. Is molecular biology the best alternative for diagnosis of malaria to microscopy? A comparison between microscopy, antigen detection and molecular tests in rural Kenya and urban Tanzania. Trop Med Int Heal. 12(2):238–244.

10. Chandramohan D, Jaffar S, Greenwood B. Use of clinical algorithms for diagnosing malaria. Trop Med Int Heal. 2002 Jan. 2002;7(1):45–52.

11. Källander K, Nsungwa-Sabiiti J, Peterson S. Symptom overlap for malaria and pneumonia--policy implications for home management strategies. Acta Trop. 2004;90(2):211–4.

12. Lubell Y, Reyburn H, Mbakilwa H, Mwangi R, Chonya S, Whitty CJM, et al. The impact

375   of response to the results of diagnostic tests for malaria: cost-benefit analysis. BMJ.

376   13.   Shillcutt S, Morel C, Goodman C, Coleman P, Bell D, Whitty CJM, et al. Cost-
377   effectiveness of malaria diagnostic methods in sub-Saharan Africa in an era of
378   combination therapy. Bull World Health Organ. 28 Novembe. 86(2).

379   14.   Uzochukwu BSC, Obikeze EN, Onwujekwe OE, Onoka C a, Griffiths UK. Cost-
380   effectiveness analysis of rapid diagnostic test, microscopy and syndromic approach in the
381   diagnosis of malaria in Nigeria: implications for scaling-up deployment of ACT. Malar J.
382   2009;8:265.

383   15.   Bisoffi Z, Gobbi F, Angheben A, Ende J Van den. The Role of Rapid Diagnostic Tests in
384   Managing Malaria. PLoS Med [Internet]. 2009;6(4). Available from:
385   http://www.plosmedicine.org

386   16.   Onwujekwe O, Uzochukwu B, Dike N, Uguru N, Nwobi E, Shu E. Malaria treatment
387   perceptions, practices and influences on provider behaviour: comparing hospitals and non-
388   hospitals in south-east Nigeria. Malar J. 2009;8:246.

389   17.   Uzochukwu BSC, Chiegboka LO, Enwereuzo C, Okorafor D, Onwujekwe OE, Uguru NP,
390   et al. Examining appropriate diagnosis and treatment of malaria: availability and use of
391   rapid diagnostic tests and artemisinin-based combination therapy in public and private
392   health facilities in southeast Nigeria. BMC Public Health. 2010;10(486).

393   18.   Ansah EK, Narh-Bana S, Epokor M, Akanpigbiam S, Quartey AA, Gyapong J, et al.
394   Rapid testing for malaria in settings where microscopy is available and peripheral clinics
395   where only presumptive treatment is available: a randomised controlled trial in Ghana.
396   BMJ [Internet]. 2010;340(mar05_1):c930. Available from:
397   http://www.bmj.com/content/340/bmj.c930

398   19.   Chandler CIR, Whitty CJM, Ansah EK. How can malaria rapid diagnostic tests achieve
399   their potential? A qualitative study of a trial at health facilities in Ghana. Malar J
400   [Internet]. 2010;9:95. Available from:
401   http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2859355&tool=pmcentrez&re
402   ndertype=abstract

403   20.   Mubi M, Kakoko D, Ngasala B, Premji Z, Peterson S, Björkman A, et al. Malaria
404   diagnosis and treatment practices following introduction of rapid diagnostic tests in
405   Kibaha District, Coast Region, Tanzania. Malar J. 2013;12(293).

406   21.   Mokuolu OA, Okafor HU, FA O, CO A, KU E, TO F, et al. Status of the use and
407   compliance with malaria rapid diagnostic tests in formal private health facilities in
408   Nigeria. Malar J. 2016;15:4.

409   22.   Reviewed ZAMFARA STATE 2015 ANNUAL OPERATIONAL PLAN FOR
410   MALARIA CONTROL.

411   23.   Bamiselu OF, Ajayi I, Fawole O, Dairo D, Ajumobi O, Oladimeji A, et al. Adherence to
412   malaria diagnosis and treatment guidelines among healthcare workers in Ogun State ,

413   Nigeria. BMC Public Health [Internet]. 2016;1–10. Available from:
414   http://dx.doi.org/10.1186/s12889-016-3495-x

415 24. Uzochukwu BSC, Chiegboka LO, Enwereuzo C, Nwosu U, Okorafor D, Onwujekwe OE,
416   et al. Examining appropriate diagnosis and treatment of malaria : availability and use of
417   rapid diagnostic tests and artemisinin-based combination therapy in public and private
418   health facilities in south east Nigeria. 2010;1–9.

419 25. Bamiselu OF, Ajayi I, Fawole O, Dairo D, Ajumobi O, Oladimeji A, et al. Adherence to
420   malaria diagnosis and treatment guidelines among healthcare workers in Ogun State,
421   Nigeria. BMC Public Health. 2016;16(1).

422 26. Bawate C, Callender-Carter ST, Nsajju B, Bwayo D. Factors affecting adherence to
423   national malaria treatment guidelines in management of malaria among public healthcare
424   workers in Kamuli District, Uganda. Malar J [Internet]. 2016;15(1):112. Available from:
425   http://www.scopus.com/inward/record.url?eid=2-s2.0-
426   84959185453&partnerID=tZOtx3y1

427 27. Albertini A. Preliminary enquiry into the availability , price and quality of malaria rapid
428   diagnostic tests in the private health sector of ... 2011;(November 2014).

429 28. Moonasar D, Goga AE, Frean J, Kruger P, Chandramohan D. An exploratory study of
430   factors that affect the performance and usage of rapid diagnostic tests for malaria in the
431   Limpopo Province ,. 2007;5:1–5.

432 29. Harvey SA, Jennings L, Chinyama M, Masaninga F, Mulholland K, Bell DR. Improving
433   community health worker use of malaria rapid. 2008;12(group 1):1–12.

434 30. Counihan H, Harvey SA, Sekeseke-chinyama M, Hamainza B, Banda R, Malambo T, et
435   al. Community Health Workers Use Malaria Rapid Diagnostic Tests (RDTs) Safely and
436   Accurately : Results of a Longitudinal Study in Zambia. 2012;87(1):57–63.

437