PAPUA NEW GUINEA & THE GLOBAL FUND
MALARIA CONTROL PROGRAMME EVALUATION

REPORT ON

THE PAPUA NEW GUINEA NATIONAL MALARIA CONTROL PROGRAM: HEALTH FACILITY SURVEYS 2010-2016

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EXECUTIVE SUMMARY

Papua New Guinea (PNG) implemented a revised 'test and treat' national malaria treatment protocol (NMTP) in late 2011. The new protocol stipulates that all fever or suspected malaria cases be tested for malaria infection by microscopy or rapid diagnostic test (RDT) and introduced artemether-lumefantrine (AL) as the first-line treatment for uncomplicated malaria infections. The new NMTP represented a substantial change from the former 'presumptive' treatment guidelines in which older (now obsolete) anti-malarials were routinely prescribed to all children with fever as well as all adults where microscopy was not available.

The Papua New Guinea Institute of Medical Research (PNGIMR) completed repeat, cross-sectional, country-wide health facility surveys (HFS) in 2010, 2011, 2012, 2014 and 2016 to evaluate the outcome of the change in NMTP on resource availability and health worker practice. Each survey was conducted in up to six randomly selected primary health care facilities in each province in PNG. Across the five HFS, an audit of health facility medicines and supplies was completed in 379 primary health care facilities, 965 health worker interviews were completed, the treatment of 2789 febrile patients was observed and exit interviews were conducted with 3108 febrile patients. Primary outcome indicators and the respective findings are detailed in Figures 1-4.

Figure 1. Proportion of health facilities with working microscopy or with malaria Rapid Diagnostic Tests (RDT) in stock

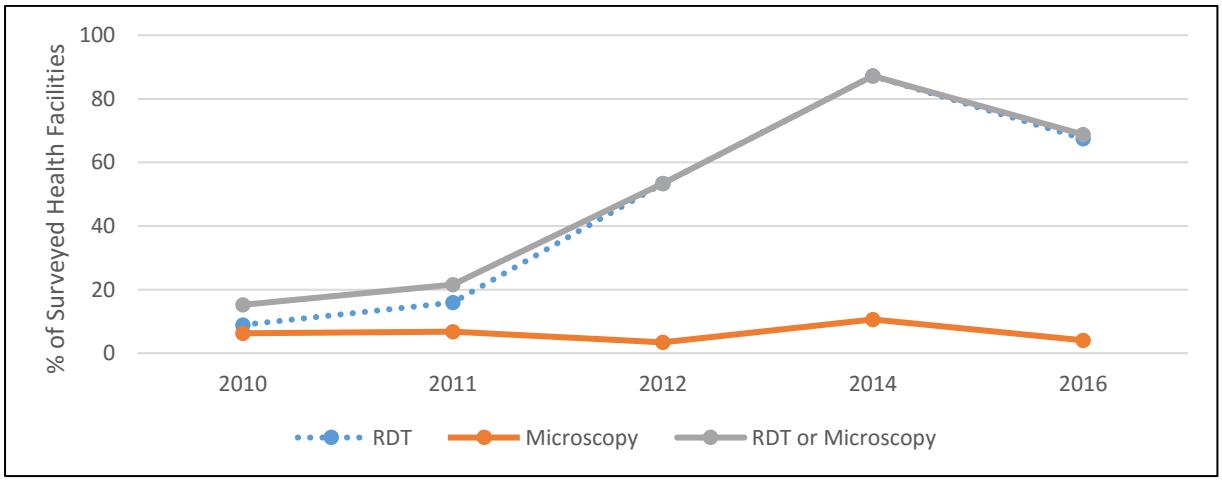


Figure 2. Proportion of health facilities with artemether-lumefantrine (AL) in stock for all age groups (all doses) or with any AL in stock (any doses)

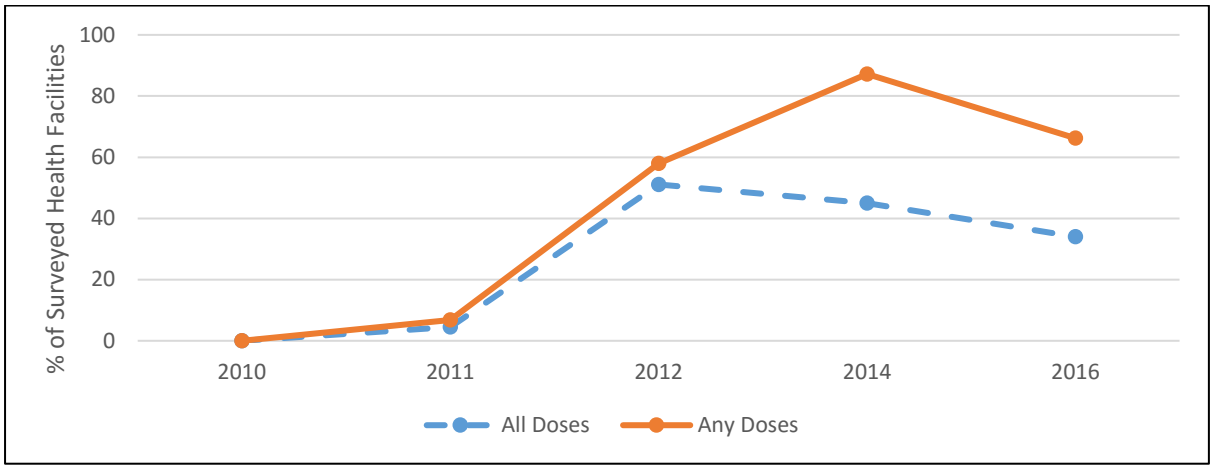


Figure 3. Proportion of health care providers trained in the new treatment guidelines and use of RDTs

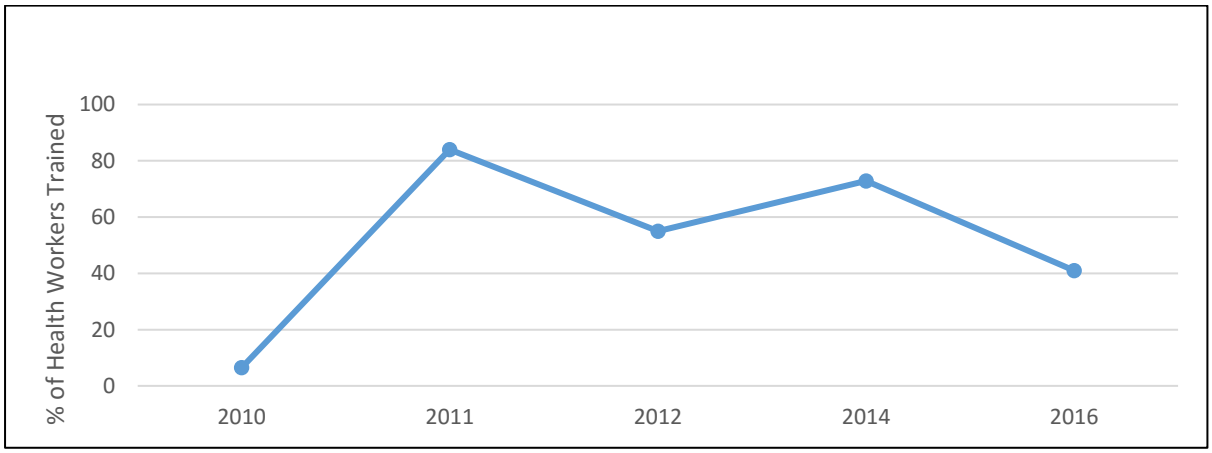
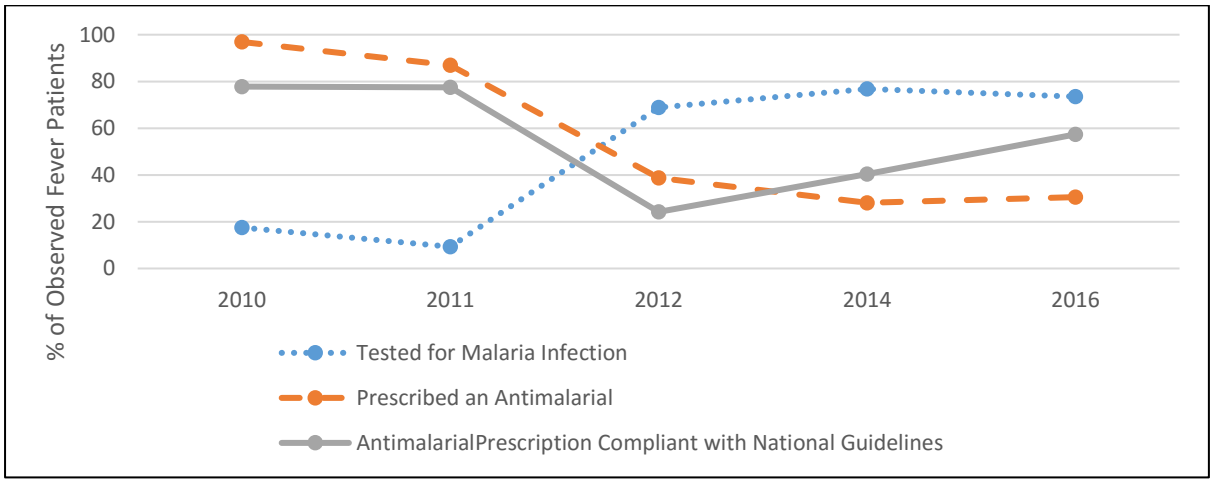


Figure 4. Proportion of fever cases presenting to health facilities diagnosed and treated according to national guidelines



Nb. The former (now obsolete) malaria treatment guidelines were still in use during the 2010 and 2011 HFS

As demonstrated in Figures 1-4, the availability of RDTs and AL peaked in 2014 and has subsequently declined suggesting continuity of supply may be an issue. The number of health workers trained in the NMTP peaked in 2011 (Figure 3), the year in which the majority of training took place, and has decreased substantially since that time. However, as shown in Figure 4, major changes in health worker practice have taken place since 2011 – especially in regards to the greater use of diagnostic testing and reduced antimalarial prescription – and have been maintained ever since. The time trend data also suggest that health worker compliance with the new NMTP has continuously improved since its implementation, but has yet to reach the level of compliance observed in the final years of the former protocol (Figure 4).

Among other findings (not reported above, but described within this report), training opportunities for health workers in malaria case management (and likely febrile case management more broadly) have been limited since 2010. Regular supervision (at least once per six months) remains an exception for the majority of primary health care workers.

Health worker's treatment counselling practice is often poor (especially with regard to side effects of primaquine) and many health workers fail to wear gloves when administering an RDT posing a significant risk to their personal safety (the availability of gloves was not assessed during the surveys and may have been a factor).

Approximately 35-40% of aid posts are out of operation at any one point in time. The loss of treatment coverage associated with aid post closure is offset in part by the operation of community-based volunteer schemes of which close to one-third of health centres reportedly supervised.

The exit interview data indicate that the median waiting time, from time of first symptom to seeking assistance at the health facility, was between 20-24 hours between 2010 and 2014. However, this time increased to 48 hours by 2016. Further investigation may be needed to determine the accuracy of this finding, although it is possible that a consequence of a declining malaria prevalence is greater ambivalence in terms of seeking help for a febrile illness.

Finally, the median cost of seeking treatment has not changed since 2012, and is double that of 2010, despite the free health care policy. Transport costs associated with attending a health facility are typically more expensive than the cost of treatment itself (for those patients who report incurring a transport cost).

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1. INTRODUCTION

The Government of Papua New Guinea (PNG), with support from the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM), implemented a revised 'test and treat' national malaria treatment protocol (NMTP) in late 2011. Consistent with WHO recommendations [1], the new protocol stipulates that all fever or suspected malaria cases be tested for malaria infection by microscopy or RDT, introduced artemether-lumefantrine (AL) as the new first-line treatment for uncomplicated *Plasmodium falciparum* malaria and AL plus primaquine (PQ) as the new first-line treatment for uncomplicated *Plasmodium vivax* malaria and for mixed malaria infections [2]. The new NMTP represented a substantial change in both diagnostic and prescription practice. Under the former 'presumptive' treatment practice anti-malarials were routinely prescribed to all children with fever as well as all adults where microscopy was not available. First line treatments included amodiaquine plus sulphadoxine-pyrimethamine (SP) or chloroquine plus SP for the treatment of uncomplicated malaria.

The Papua New Guinea Institute of Medical Research (PNGIMR) was contracted to provide a range of monitoring and evaluation (M&E) activities in support of the PNG National Malaria Control Program. One component of the PNGIMR M&E plan, described in full elsewhere [3], included repeat, cross-sectional countrywide health facility surveys (HFS) designed to assess the availability of diagnostic tools, medicines and human resources as well as the quality of malaria case management. Five HFS have been completed to date: two in the two-year period prior to the implementation of the new NMTP (2010 and 2011) and three post-implementation of the new NMTP (2012, 2014 and 2016)[1]. This report presents time-trend analyses on key indicators from across all five HFS as well as selected findings from the 2016 HFS. The main outcome measures of the HFS include:

1. Proportion of health facilities with working microscopy or with malaria Rapid Diagnostic Tests (RDT) in stock
2. Proportion of health facilities with the new first-line anti-malarials (ACTs) in stock (for all age groups)
3. Proportion of health care providers trained in malaria case management (new treatment guidelines and use of RDTs)
4. Proportion of fever cases presenting to health facilities diagnosed and treated according to national guidelines

[1] At present, there are no plans to conduct additional HFS (the current PNGIMR M&E plan expires in December 2017).

2. METHODS

2.1. Study Sites

All HFS were carried out country-wide in areas with endemic or potentially epidemic malaria[2]. The study sample for each HFS consisted of two Urban Clinics (UC), Health Centres (HC) or Sub-Health Centres (SC) (collectively referred to as HC in this report) and up to four Aid Posts (AP) selected from each province using a simple random sampling procedure. The sampling frame for each HFS included all HC operational in March 2010 inclusive of government and mission administered health facilities (N = 689). Aid Posts were randomly selected on site at participating (i.e. randomly selected and consenting) HC. The sampling frame for aid posts was all operational aid posts under the supervision of the HC at the time of survey[3]. All health facilities subsequently included in the survey are listed in Appendix 1.

2.2. Survey Procedure

Each HFS was carried out from June to November in the respective survey year and was conducted by three trained field teams, each comprising two-to-three members, working simultaneously at different sites. The training program for field staff spanned 10 days and consisted of lectures on the project background, malaria facts and effects, survey methodology, and intensive instruction and practice on the survey instruments. Members of each survey team spent between three to five days at each participating HC and up to one day at each participating AP. Four distinct survey instruments were utilised (when possible) at each site: 1) a health facility checklist completed with the officer in charge of the health facility; 2) an interviewer administered questionnaire completed with clinical staff at each participating health facility; 3) an interviewer administered questionnaire completed with fever or suspected/confirmed malaria patients at the end of their clinical consultation; and 4) a clinical assessment instrument which involved non-participant observation of the clinical case management of fever or suspected malaria patients. The health facility checklist was only completed once at each site whilst the remaining three instruments were completed as many times as possible. The clinician

[2] The 2014 HFS was an exception. Due to financial and logistical constraints, the 2014 HFS was only completed in 10/20 provinces. This included all four provinces in the Momase region and two provinces each from the remaining regions.

[3] Reliable records of the number of aid posts in operation are not available. Not all participating HC had operational aidposts under their supervision so the target of surveying four aid posts per province was not always achieved.

and patient questionnaires were available in English or *Tok Pisin* versions. Completed survey instruments were reviewed by a senior scientist during the course of data collection as a quality control measure and supervisory field visits were conducted with each team to ensure research protocols were adhered to.

Prior to any health facility visit, the respective provincial and district health authorities were informed of the study objectives, sites, and timetable. The provincial health authority was also asked to commission a health officer to accompany the field team. Upon arriving at each HC or AP, the field team conducted a *tok save* (information session) with the officer in charge and, following this, with the health facility staff. Once permission to proceed had been obtained, the team leader established in consultation with the officer in charge an acceptable process for survey completion. Oral informed consent was sought from the officer in charge at all participating health facilities and from all participating clinicians and patients prior to interview or clinical observation. A health facility was excluded from participation if voluntary consent by the officer in charge was not obtained (nil occurrence). Individual health workers or patients were excluded from the study if they asked for something in exchange for their participation or if voluntary consent was not obtained. The surveys were approved and granted ethical clearance by the Medical Research Advisory Committee of PNG (MRAC No. 10.12; 26 Feb 2010 & MRAC No. 15.21; 26 Oct 2015).

2.3. Survey Instruments

2.3.1. Health facility checklist

This instrument assessed the human resource capacity and the availability of supplies relevant to the treatment and management of malaria. Key questions included the number of clinical staff employed, the number of clinical staff trained in the new NMTP, the quantity of RDTs and artemether/lumefantrine (AL) in stock, the quantity of functional microscopes and availability of essential microscopy supplies, and the availability of a range of anti-malarial medications. Recorded numbers of clinical staff and staff trained in the new NMTP were based on figures provided by the officer in charge. All reported RDT stock, microscopes, including microscopy supplies essential to operation – Giemsa stain, slides and (in the case of electric microscopes) power supply – anti-malarials, and other reported medical equipment or supplies were observed by the respective PNGIMR field team leaders.

2.3.2. Health worker interview

This questionnaire contained a range of open and closed questions designed to elicit information regarding staff education, work experience and supervision as well as the type and utility of any malaria-related training he/she may have received (inclusive of NMTP training). This questionnaire also examined the knowledge, attitudes and practice of health workers relevant to malaria case management and, if applicable, their experiences implementing the new NMTP.

2.3.3. Non-participant observation

A checklist designed to assess the quality of malaria case management. The PNGIMR field team used this checklist to assess whether specified actions did or did not occur and to record the content of specific actions (e.g. whether an RDT was conducted or a referral was made and, if yes, what was the outcome?).

2.3.4. Patient interview

This questionnaire contained a range of open and closed questions designed to elicit information regarding the patient's treatment experience, his or her retention of clinical instruction (e.g. diagnosis, treatment counselling advice), treatment accessibility and cost, and pre-treatment behaviour.

2.4. Data Analysis

All data were double entered into DMSys version 5.1. Data analysis was performed using Stata SE version 14.1. Univariate analysis was performed to describe the characteristics of the various samples and for calculating 95% confidence intervals (CIs) on selected measures. Differences on repeat measures across time were examined by chi-square or two-tailed *t*-tests as appropriate. Where appropriate, the calculation of CIs was adjusted for possible clustering at the health facility level by using the Stata 'svy' command set in which health facilities were defined as the primary sampling unit.

From the 2012 HFS onwards, an antimalarial prescription was considered compliant with protocol if: AL was prescribed to *P. falciparum* cases; AL + PQ was prescribed to *P. vivax* or mixed malaria infection cases; or if AL or AL + PQ was prescribed to any malaria 'positive' case in which the species type was not identified. The response options for each 'attitudinal' statement were 'agree', 'disagree' and 'don't know'. 'Don't know' responses were categorised as 'incorrect' in the analysis.

3. RESULTS

3.1. Health Facility Checklist

3.1.1. Sample size

Table 1 presents the number of health facilities surveyed per year, by type and region. As shown, between 47 to 88 health facilities were included in each survey approximately evenly split by type (aid post vs. health centre) and region (with the notable exception of the abbreviated HFS in 2014).

Table 1. Number of surveyed health facilities by year, health facility type and region

Year	Type	Region				Total
		Southern	Highlands	Momase	Islands	
2010	Health Centres	13	10	8	10	**41**
	Aid Posts	12	7	8	11	**38**
	Overall (%)	25 (31.6)	17 (21.5)	16 (20.3)	21 (26.6)	**79 (100)**
2011	Health Centres	15	11	9	11	**46**
	Aid Posts	11	6	10	12	**39**
	Overall (%)	26 (29.5)	17 (19.3)	19 (21.6)	26 (29.5)	**88 (100)**
2012	Health Centres	15	10	8	7	**40**
	Aid Posts	16	12	10	10	**48**
	Overall (%)	31 (36.9)	22 (26.2)	18 (21.4)	17 (20.2)	**88 (100)**
2014[a]	Health Centres	6	6	9	4	**25**
	Aid Posts	3	4	13	2	**22**
	Overall (%)	9 (19.1)	10 (21.3)	22 (46.8)	6 (12.8)	**47 (100)**
2016	Health Centres	12	11	9	8	**40**
	Aid Posts	6	8	11	12	**37**
	Overall (%)	18 (23.4)	19 (24.7)	20 (26.0)	20 (26.0)	**77 (100)**
Total	**Health Centres**	**61**	**48**	**43**	**40**	**192**
	Aid Posts	**48**	**37**	**52**	**50**	**187**
	Overall (%)	**109 (28.8)**	**85 (22.4)**	**95 (25.1)**	**90 (23.7)**	**379 (100)**

a. An abbreviated HFS was conducted in 2014 (limited to 10 provinces only).

3.1.2. Availability of RDTs and working microscopy: Outcome indicator one

The availability of RDTs increased across all survey years and health facility types until 2016 when the first decrease in availability since 2010 was recorded (Table 2). The reduction in overall RDT availability between 2014 and 2016 reached statistical significance (87.2% vs. 67.5%; $x^2(1) = 6.0$, p = 0.014). Table 2 also demonstrates a consistently low percentage in the availability of working microscopy across all survey years and health facility types.

Table 2. Percentage of health facilities with unexpired RDT in stock, working microscopy available, or either unexpired RDT/working microscopy

Year	Diagnostic Test	Health Centres		Aid Posts		Overall	
		%	(95% CI)	%	(95% CI)	%	(95% CI)
2010	RDT	17.1	(8.1, 32.5)	0	-	8.9	(4.2, 17.7)
	Microscopy[a]	12.2	(5.0, 26.9)	0	-	6.3	(2.6, 14.6)
	RDT or microscopy	29.3	(17.0, 45.5)	0	-	15.2	(8.7, 25.1)
2011	RDT	23.9	(13.5, 38.9)	7.1	(2.2, 20.1)	15.9	(9.6, 25.3)
	Microscopy[a]	13.0	(5.8, 26.8)	0	-	6.8	(3.1, 14.6)
	RDT or microscopy	34.8	(22.1, 50.0)	7.1	(2.2, 20.1)	21.6	(14.1, 31.6)
2012	RDT	90.0	(75.4, 96.4)	22.9	(12.9, 37.4)	53.4	(42.8, 63.7)
	Microscopy[a]	5.0	(1.2, 18.9)	2.1	(0.3, 14.2)	3.4	(1.1, 10.3)
	RDT or microscopy	90.0	(75.4, 96.4)	22.9	(12.9, 37.4)	53.4	(42.8, 63.7)
2014	RDT	84.0	(62.5, 94.3)	90.9	(67.4, 98.0)	87.2	(73.7, 94.3)
	Microscopy[a]	20.0	(8.0, 41.8)	0	-	10.6	(4.4, 23.8)
	RDT or microscopy	84.0	(62.5, 94.3)	90.9	(67.4, 98.0)	87.2	(73.7, 94.3)
2016	RDT	70.0	(53.5, 82.6)	64.9	(47.6, 78.9)	67.5	(56.1, 77.2)
	Microscopy[a]	7.5	(2.3, 21.7)	0	-	4.0	(1.3, 11.8)
	RDT or microscopy	72.5	(56.1, 84.5)	64.9	(47.6, 78.9)	68.8	(57.4, 78.3)

a= Working microscopy was defined as the presence of a functional microscope, all essential supplies – Giemsa stain, slides and (in the case of electric microscopes) power – and a trained RLA or MLA in employment. b= Working microscopy was not expected in aid post settings (i.e. '0' was the expected result).

3.1.3. Availability of artemether-lumefantrine (AL): Outcome indicator two

Consistent with the trend for RDT availability, an increase in AL availability across all surveyed health facilities is evident between 2010 and 2014 followed by a statistically significant decrease between 2014 and 2016 (87.2% vs. 66.2% (any doses); $x^2(1) = 6.7$, p = 0.010; Table 3). Table 3 further suggests comparable AL availability in aid posts and health centres from 2014 onwards.

Table 3. Percentage of health facilities with artemether-lumefantrine (AL) in stock[a]

Year	AL Dose	Health Centres		Aid Posts		Overall	
		%	(95% CI)	%	(95% CI)	%	(95% CI)
2010	Infant (5-15kg)	0	-	0	-	0	-
	Child (15-25kg)	0	-	0	-	0	-
	Youth (25-35kg)	0	-	0	-	0	-
	Adult (35+ kg)	0	-	0	-	0	-
	All doses[b]	0	-	0	-	0	-
	Any doses[c]	0	-	0	-	0	-
2011	Infant (5-15kg)	13.0	(2.9, 23.2)	0	-	6.8	(2.5, 14.3)
	Child (15-25kg)	13.0	(2.9,23.2)	0	-	6.8	(1.4,12.2)
	Youth (25-35kg)	13.0	(2.9,23.2)	0	-	6.8	(1.4,12.2)
	Adult (35+ kg)	8.7	(0.2,17.2)	0	-	4.5	(1.4,12.2)
	All doses[b]	8.7	(0.2,17.2)	0	-	4.5	(0.01,9.0)
	Any doses[c]	13.0	(2.9,23.2)	0	-	6.8	(1.4,12.2)
2012	Infant (5-15kg)	95.1	(83.5, 99.4)	21.3	(10.7, 35.7)	55.7	(44.7, 56.3)
	Child (15-25kg)	92.7	(80.1, 98.5)	23.4	(12.3, 38.0)	55.7	(44.7, 56.3)
	Youth (25-35kg)	92.7	(80.1, 98.5)	19.2	(9.1, 33.3)	53.4	(42.5, 64.1)
	Adult (35+ kg)	92.7	(80.1, 98.5)	23.4	(12.3, 38.0)	55.7	(44.7, 56.3)
	All doses[b]	87.8	(73.8, 95.9)	19.2	(9.1, 33.3)	51.1	(40.2, 61.9)
	Any doses[c]	97.5	(83.1, 99.7)	25.0	(14.5, 39.6)	58.0	(47.2, 68.0)
2014	Infant (5-15kg)	68.0	(48.3,87.7)	77.3	(58.3,96.3)	72.3	(59.1,85.6)
	Child (15-25kg)	72.0	(53.1,90.9)	68.2	(47.0,89.3)	70.2	(56.6,87.0)
	Youth (25-35kg)	48.0	(27,69.0)	81.8	(64.3,99.3)	64.0	(50.0,78.1)
	Adult (35+ kg)	60.0	(39.4,80.6)	77.3	(58.3,96.3)	68.1	(54.3,81.9)
	All doses[b]	36.0	(15.8,56.2)	54.6	(31.9,77.1)	45.0	(29.9,59.4)
	Any doses[c]	84.0	(68.6,99.4)	90.9	(77.9,1.0)	87.2	(77.3,97.1)
2016	Infant (5-15kg)	55.0	(39,71.1)	46.0	(29.1,63.0)	51.0	(39.2,62.1)
	Child (15-25kg)	57.5	(41.1,74.5)	51.4	(34.5,68.2)	55.0	(43.2,65.9)
	Youth (25-35kg)	60.0	(44.176.0)	43.2	(26.5,60.0)	52.0	(40.5,63.3)
	Adult (35+ kg)	55.0	(39.0,71.1)	37.8	(21.4,54.2)	47.0	(35.4,58.2)
	All doses[b]	40.0	(24.1,56.0)	27.0	(12.0,42.0)	34.0	(23.0,45.0)
	Any doses[c]	75.0	(61.0,89.0)	56.8	(40.0,73,5)	66.2	(55.4,77.0)

a. The quantity of each medication was not accounted for in this analysis; rather, the data represent the percentage of health facilities that had at least one blister pack of the respective anti-malarial in stock.b. at least one blister pack in all age categories was present at the health facility. c. at least one blister pack from any age category was present at the health facility.

3.1.4. Health worker training: Outcome indicator three

The highest (peak) percentage of trained health workers was evident in the 2011 survey (the initial, and often only, NMTP training was provided in late 2010/early 2011) at 84.0% decreasing to 41.0% by 2016 (Table 4). The lowest percentage was observed during 2010, although the majority of the 2010 HFS was completed before the formal NMTP training program commenced.

Table 4. The number and percentage of clinical staff employed in the surveyed health facilities who had been reportedly trained in the new NMTP

Year	Position	Employed	Trained in new NMTP	
		n	n	%
2010	MD	3	0	0
	HEO	16	1	6.3
	Nurse	144	9	6.3
	CHW	263	19	7.2
	RLA/MLA	17	0	0
	Total	**443**	**29**	**6.5**
2011	MD	3	3	100
	HEO	25	22	88
	Nurse	179	153	85.5
	CHW	300	246	82
	RLA/MLA	14	12	85.7
	Total	**521**	**436**	**84.0**
2012	MD	7	4	57.1
	HEO	19	17	89.5
	Nurse	308	111	36.0
	CHW	308	218	71.0
	RLA/MLA	12	10	83.3
	Total	**654**	**360**	**55.0**
2014	MD	0	0	0
	HEO	13	13	100
	Nurse	66	44	67.0
	CHW	131	95	72.5
	RLA/MLA	8	7	87.5
	Total	**218**	**159**	**72.9**
2016	MD	9	1	11.1
	HEO	23	5	21.7
	Nurse	125	64	51.2
	CHW	266	104	39.1
	RLA/MLA	9	3	33.3
	Total	**432**	**177**	**41.0**

NMTP=National Malaria Treatment Protocol; MD=Medical Doctor; HEO=Health Extension Officer; CHW=Community Health Worker; RLA/MLA=Rural/Medical Laboratory Assistant

3.1.5. Availability of other antimalarial medications

Table 5 presents the percentage of health facilities with the various antimalarial combinations stipulated in the new NMTP in stock in the 2016 HFS. As shown, AL was the most widely available antimalarial and dihydroartemisinin-piperaquine (DP) the least available (66.2% & 10.5%, respectively). AL was the only recommended antimalarial available in more than 50% of surveyed health facilities ; however, AL+PQ and artemether or artesunate injections (AI)+AL and AI+AL+PQ were available in 57.5%, 65.0% and 55.0% of surveyed health centres, respectively.

Table 5. Percentage of health facilities with the required anti-malarial medication for implementation of the new national malaria treatment protocol (2016 HFS only).

Medication[a]	**Health Centre**		**Aid Post**		**Overall**	
	%	(95% CI)	%	(95% CI)	%	(95% CI)
AL[b,c]	75.0	(61.0,89.0)	56.8	(40.0, 73.5)	66.2	(55.4, 77.0)
AL + PQ[d]	57.5	(41.3, 72.3)	27.0	(14.8, 44.2)	42.9	(32.1, 54.3)
DP[e]	20.5	(10.3, 36.8)	0	-	10.5	(3.5, 17.6)
AI + AL[f]	65.0	(48.5. 78.6)	24.3	(12.8, 41.4)	45.5	(34.5, 56.9)
AI + AL + PQ[g]	55.0	(38.9, 70.1)	13.5	(5.5, 29.6)	35.1	(25.1, 46.6)
QI + QT + DX[h]	45.0	(29.9, 61.1)	5.4	(1.3, 20.3)	26.0	(17.3, 37.1)

a= The quantity of each medication was not accounted for in this analysis; rather, the data represent the percentage of health facilities that had at least one vial or container (inclusive of a single, opened container) of the respective anti-malarial in stock. b= Measured as the presence of blister packs in all four weight categories. c= First line treatment for uncomplicated *P.falciparum* infection. d= First line treatment for uncomplicated *P.vivax* infection. e= Second line treatment for uncomplicated malaria infection. f= First line treatment for severe *P.falciparum* infection. g= First line treatment for severe *P.vivax* infection. h= Second line treatment for severe malaria infection. AL= artemether-lumefantrine, PQ= primaquine, DP= dihydroartemisinin-piperaquine, AI= artemether or artesunate injection, QI= quinine injection, QT= quinine tablets, DX= doxycycline.

Table 6 lists the percentage of health facilities with specified antimalarials in stock by survey year. This Table demonstrates a substantial decrease in stocks of Amodiaquine, artemether tablets (monotherapy) and Chloroquine between 2010 and 2016 (89.9% to 16.9%, 53.2% to 10.4% & 88.6% to 14.3%, respectively).

Table 6. Percentage of surveyed health facilities with specified anti-malarial medications in stock

Medication	2010		2011		2012		2014		2016	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
Amodiaquine	89.9	(81.0, 95.5)	98.9	(93.8, 99.9)	89.8	(81.5, 95.2)	38.3	(23.8, 52.7)	16.9	(8.3, 25.4)
Artemisinin-naphthoquine	2.5	(0.3, 8.9)	1.2	(<0.1, 6.2)	6.8	(2.5, 14.3)	2.17	(<0.1, 6.5)	6.5	(0.9, 12.1)
Artemether injections	49.4	(37.9, 60.1)	60.2	(49.2, 70.5)	59.1	(48.1, 69.5)	74.5	(61.5, 87.4)	41.6	(30.3, 52.8)
Artemether tablets	53.2	(41.6, 64.5)	46.6	(35.9, 57.5)	54.6	(43.9, 64.8)	19.2	(7.5, 30.8)	10.4	(3.4, 17.3)
Artesunate injections	24.1	(15.1, 35)	12.5	(6.4, 21.3)	21.6	(13.5, 31.6)	34.1	(20.0, 48.1)	49.4	(37.9, 60.8)
Artesunate suppositories	2.5	(0.3, 8.9)	0	-	12.5	(6.4, 21.3)	51.1	(36.2, 66.0)	53.3	(41.8, 64.6)
Chloroquine	88.6	(79.5, 94.7)	90.8	(82.7, 95.9)	88.6	(80.1, 94.4)	42.6	(27.9, 57.2)	14.3	(6.3, 22.3)
Dihydroartemisinin-piperaquine	2.5	(0.3, 8.8)	1.1	(<0.1, 6.2)	2.3	(<0.1, 8.0)	14.9	(4.3, 25.5)	10.5	(3.5, 17.6)
Doxycycline	70.9	(59.6, 80.6)	88.5	(79.9, 94.3)	85.2	(76.1, 91.9)	78.3	(66.0, 90.6)	74.0	(64.0, 84.0)
Sulphadoxine/Pyrimethamine	86.1	(76.5, 92.8)	82.8	(73.2, 90.0)	92.1	(84.3, 96.7)	89.4	(80.2, 99.0)	77.9	(68.4, 87.1)
Atovaquone-proguanil	3.9	(0.8, 11)	3.5	(<0.1, 9.7)	0	-	2.13	(<0.1, 6.4)	13.2	(5.4, 2.1)
Primaquine	73.1	(61.8, 82.5)	79.6	(69.6, 87.4)	81.8	(72.2, 89.2)	87.2	(77.3, 97.1)	61.0	(49.9, 72.2)
Quinine injections	62.0	(50.4, 72.7)	53.4	(42.5, 64.1)	54.6	(43.6, 65.2)	68.1	(54.2, 81.9)	41.6	(30.3, 52.8)
Quinine tablets	82.3	(72.1, 90.0)	76.1	(65.9, 84.6)	80.7	(70.9, 88.3)	80.9	(69.2, 92.5)	33.7	(22.9, 45.0)

3.1.6. Availability of malaria job aids and equipment

Tables 7 and 8 present the percentage of health facilities by HFS year with specified malaria-related job aids and medical equipment and resources in stock. As shown in Table 7, the percentage of health facilities with the specified job aids increased substantially between 2011 and 2012. RDT user guides and the malaria treatment protocol wall charts were observed in between approximately 40-60% of surveyed health facilities since 2012. The presence of malaria-related flipcharts and posters peaked in 2012 where they were observed in between 40.2% to 52.9% of surveyed health facilities and has decreased since.

Thermometers, adult body weight scales and adult and child treatment manuals were present in the vast majority of surveyed health facilities across all HFS (Table 8). The percentage of health facilities with infant body weight scales and a wallchart of the 10-step IMCI checklist also remained stable across HFS, although at a lower frequency (observed in approximately 55% to 65% of health facilities at each HFS). Infant blood pressure machines were rarely observed in surveyed health facilities at any time point (ranging between 2.1% in 2014 and 13.3% in 2016), although a general increase in the availability of adult blood pressure machines was observed between 2010 and 2016 (55.7% to 75.0%) and adult blood pressure machines were always observed in at least half of surveyed facilities.

Table 7. Percentage of surveyed health facilities with specified National Malaria Treatment Protocol 'job aids' in stock[a]

Resource	2011		2012		2014		2016	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
RDT User Guide (wall chart)	37.5	(27.4, 48.5)	56.8	(45.8, 67.3)	57.5	(43.0, 72.1)	59.7	(49.0, 71.0)
PNG Malaria Treatment Protocol (wall chart)	7.8	(3.3, 15.7)	47.7	(37.0, 58.6)	43.5	(29.0, 58.3)	50.6	(39.2, 62.1)
Preventing Malaria in PNG (flip chart)	8.1	(3.3, 15.9)	40.2	(29.9, 51.3)	19.6	(07.6, 31.5)	28.6	(18.3, 39.0)
Talking about Malaria Treatment (poster)	9.1	(4.0, 17.1)	47.1	(36.3, 58.1)	43.5	(29.0, 58.4)	42.1	(31.0, 53.5)
Talking about Mosquito Nets (poster)	6.8	(2.5, 14.3)	50.6	(39.6, 61.5)	41.3	(26.5, 56.1)	33.7	(27.0, 48.7)
Talking about Malaria Testing (poster)	6.8	(2.5, 14.3)	52.9	(41.9, 63.7)	41.3	(26.5, 56.1)	41.6	(30.3, 52.8)

a. Listed resources were not assessed in the 2010 survey.

Table 8. Percentage of surveyed health facilities with specified medical equipment and resources in stock

Resource[a]	2010		2011		2012		2014		2016	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
Thermometer	97.5	(91.2, 99.7)	94.3	(87.2, 98.1)	97.7	(92.0, 99.7)	91.5	(83.2,99.7)	92.1	(83.3, 96.5)
Body weight scale (infant)	60.8	(49.1, 72.6)	65.9	(55.0, 75.7)	61.4	(50.4, 71.6)	66.0	(52.0, 80.0)	65.8	(54.9, 76.7)
Body weight scale (adult)	84.8	(75.0, 91.9)	94.3	(87.1, 98.1)	88.6	(80.1, 94.4)	93.6	(81.3, 98.0)	88.2	(78.5, 93.8)
BP[b] machine (infant)	11.4	(5.3, 20.5)	4.6	(1.3, 11.2)	2.3	(<0.1, 8.0)	2.1	(0.3, 6.4)	13.3	(5.5, 21.2)
BP machine (adult)	55.7	(44.1, 66.9)	58.0	(47.0, 68.4)	50.0	(39.1, 60.9)	80.9	(69.2, 92.5)	75.0	(65.0, 85.0)
10 step IMCI checklist[c]	54.4	(42.8, 65.7)	60.2	(49.2, 70.5)	60.2	(48.9, 70.8)	61.2	(46.7, 74.8)	54.7	(43.1, 65.8)
Treatment manual (child)	94.9	(87.5, 98.6)	93.2	(85.7, 97.5)	93.2	(85.7, 97.5)	95.7	(89.8, 99.9)	89.6	(82.6, 96.6)
Treatment manual (adult)[d]	-	-	85.2	(76.1, 91.2)	78.8	(68.6, 86.9)	78.7	(66.6, 90.9)	83.1	(74.6, 91.7)

a. Thermometers, body weight scales and BP machines had to be in working order. b. BP = blood pressure. c. Only IMCI wall charts were counted. d. The adult treatment manual was not included in the 2010 survey

3.1.7. Aid post supervision

Table 9 presents the number of surveyed health centres that had one or more aid posts under their supervision as well as the total number of supervised aid posts and their operational status. The mean number of aid posts under supervision (at those health centres supervising at least one) between 2011 and 2016 was 4.0, 4.2, 4.6 and 4.7, respectively (data not depicted in Table 9). Between 61.7% to 80.8% of supervised aid posts at surveyed health centres were reportedly open at the time of each HFS.

Table 9. Operational status of aid posts under the supervision of surveyed health centres

Aid Posts	**Survey Year**			
	2011	2012	2014	2016
No. of health facilities supervising 1+ aid posts	37	46	16	32
Total No. of aid posts under supervision	149	194	73	150
- No. open (%)	92 (61.7)	126 (64.9)	59 (80.8)	96 (64.0)
- No. closed for less than one month (%)	5 (3.4)	27 (13.9)	0 (0)	13 (8.7)
- No. closed for greater than one month (%)	52 (34.9)	41 (21.2)	14 (19.2)	41 (27.3)

3.1.8. Village health volunteers

Between 15.6% to 39.5% of surveyed health centres reported supporting some form of village health volunteer (VHV) program (Table 10). These programs included training and/or supervision of community members to provide basic health services to their respective communities in all (2011 and 2014) or the vast majority (2012 and 2016) of cases. The VHV schemes included support for trained community members to prescribe antimalarials in between 27.3% to 60.0% of cases. These trained community members did not (2011) or rarely (2012) prescribed AL or administered RDTs in 2011 and 2012; however, 100% reportedly prescribed AL or administered RDTs in the 2014 HFS as did 60% and 80%, respectively, in the 2016 HFS. In 2016 (the only year in which this question was asked), the officer in charge of each surveyed health centre reported that the VHV scheme reduced the number of malaria patients presenting to the respective health facility in 75% of cases.

Table 10. Percentage of surveyed health centres supporting a village health volunteer (VHV) program (and specifications of VHV program)

Question	% (95% CI) of Participants' Responding 'Yes'			
	2011	2012	2014	2016
Does this health facility support a VHV or Marisin Meri/Man program?[a]	36.6 (21.2, 52.0)	39.5 (24.3, 54.8)	15.6 (2.3, 28.9)	35.9 (20.1, 51.7)
Does this program include the training and/or supervision of community members to provide basic health care services in their local community?[b]	100 (-)	82.4 (56.6, 96.2)	100 (-)	78.6 (49.2, 95.3)
Have you trained/supervised any community members in the last 12 months?	-	-	-	35.7 (12.8, 64.9)
Do these trained community members prescribe anti-malarials?[c]	40.0 (16.3, 67.7)	57.1 (23.0, 72.2)	60.0 (14.7, 94.7)	27.3 (0.6, 61.0)
Do these trained community members prescribe artemether-lumefantrine or some other form of artemisinin combination therapy?[d]	0	12.5 (0.3, 52.7)	100 (-)	60.0 (14.7, 94.7)
Do these trained community members administer malaria RDTs?[d]	0	12.5 (0.3, 52.7)	100 (-)	80.0 (28.4, 99.5)
In your opinion, has this community program reduced the number of malaria patients presenting to your health facility?	-	-	-	75.0(19.4, 99.4)

a. Analysis limited to health centres only. b. Analysis limited to health centres who reported supporting a VHV program. c. Analysis limited to health centres who reported training community members to provide basic health care services. d. Analysis limited to health centres who reported a VHV prescribing antimalarials.

3.2. Health Worker Interviews

3.2.1. Sample size

A total of 965 health worker interviews were completed across the five HFS, ranging from 114 in 2014 to 225 in 2010 (Table 11). Fewer interviews were completed with health workers based at aid posts as fewer staff are employed in these facilities relative to health centres.

Table 11. Number of health workers surveyed by year, health facility type and region

Year	Type	Region				Total
		Southern	Highlands	Momase	Islands	
2010	Health Centres	52	53	33	46	**184**
	Aid Posts	15	7	8	11	**41**
	Overall (%)	67 (29.8)	60 (26.7)	41 (18.2)	57 (25.3)	**225 (100)**
2011	Health Centres	48	36	36	46	**163**
	Aid Posts	12	8	10	15	**45**
	Overall (%)	60 (28.4)	44 (20.9)	46 (21.8)	61 (28.9)	**211 (100)**
2012	Health Centres	60	46	35	28	**169**
	Aid Posts	18	14	10	10	**52**
	Overall (%)	78 (35.3)	60 (27.1)	45 (20.4)	38 (17.2)	**221 (100)**
2014	Health Centres	12	18	44	16	**90**
	Aid Posts	3	4	15	2	**24**
	Overall (%)	15 (13.2)	22 (19.3)	59 (51.8)	18 (15.8)	**114 (100)**
2016	Health Centres	50	43	35	26	**154**
	Aid Posts	8	8	12	12	**40**
	Overall (%)	58 (29.9)	51 (26.3)	47 (24.2)	38 (19.6)	**194 (100)**
Total	**Health Centres**	**222**	**196**	**183**	**162**	**763**
	Aid Posts	**56**	**41**	**55**	**50**	**202**
	Overall (%)	**278 (28.8)**	**237 (24.6)**	**238 (24.6)**	**212 (22.0)**	**965 (100)**

As shown in Table 12, the majority of interviews in each HFS were completed with community health workers. The majority of interviewees were female in four out of five HFS, the mean interviewee age ranged between 39.6 to 41.8 years and the mean number of years of clinical experience ranged between 16.9 and 19.2.

Table 12. Selected characteristics of the health worker interview sample by year

Characteristic		Year				
		2010	2011	2012	2014	2016
Qualification n (%)	CHW	151 (68)	134 (64.4)	157 (71.0)	67 (58.8)	132 (68.0)
	NO	62 (28)	59 (28.4)	55 (24.9)	39 (34.2)	50 (25.8)
	HEO	9 (4)	12 (5.8)	5 (2.26)	7 (6.1)	11 (5.7)
	Other	1 (<1)	3 (1.4)	4 (1.8)	1 (0.8)	1 (0.5)
Female n (%)		108 (48)	118 (56.7)	122 (55.2)	61 (53.5)	108 (54.9)
Years age mean (sd)		39.6 (0.6)	40.3 (0.7)	39.6 (0.7)	41.8 (1.0)	40.7 (0.8)
Years clin. exper. mean (sd)		16.9 (0.8)	17.4 (0.8)	17.1 (0.8)	19.2 (1.0)	18.0 (0.9)

CHW=Community Health Worker; NO=Nursing Officer; HEO=Health Extension Officer; RLA/MLA=Rural Laboratory Assistant/Medical Laboratory Assistant; clin. exper. = clinical experience

3.2.2. Training and clinical supervision

Table 13 presents the percentage of surveyed health workers, by HFS year, who reported receiving malaria-related training or clinical supervision. As shown, the percentage of health workers who reported having received training in the new NMTP increased from 8.9% in 2010 to 71.6% in 2011 (the national NMTP training program was implemented across 2010/2011). However, the percentage of health workers reporting having received NMTP training had decreased to 39.2% in the 2016 HFS. The reduction between 2011 and 2016 reached a level of statistical significance ($x^2(3) = 56.2$, p = <0.001). Few interviewees in any year reported receiving any other form of malaria related training (other than NMTP specific training), ranging from 1.4% in 2012 to 5.3% in 2016. Between 11.4% (2014) and 25.7% (2010) of health worker interviewees reported receiving some form of supervision in the six months prior to survey. Among those interviewees who reported a supervisory session in the past six months, between 40.0% (2014) and 88.1% (2010) reported that at least one session included supervised observation of febrile case management.

Table 13. Percentage of surveyed health workers who reported receiving malaria-related training since 2010 or clinical supervision in the past 6 months

Question	% (95% CI) of Participants' Responding 'Yes'				
Have you received…	2010	2011	2012	2014	2016
any training on new NMTP	8.9 (2.1, 12.7)	71.6 (65.4, 77.9)	68.8 (62.6, 74.9)	68.8 (60.0, 77.5)	39.2 (32.1, 46.2)
any other malaria training since 2010	4.2 (1.5, 6.9)	3.0 (0.1, 5.4)	1.4 (<0.1, 2.9)	4.4 (0.1, 8.3)	5.3 (2.1, 8.5)
any supervision in past 6 months	25.7 (19.9, 31.5)	19.5 (13.9, 25.1)	16.3 (11.4, 21.2)	11.4 (5.5, 17.3)	23.0 (17.0, 29.1)
supervision incl. MCM observation[a]	88.1 (73.7, 95.1)	57.1 (26.9, 82.9)	86.4 (65.1, 95.6)	40 (3.8, 91.9)	79.3 (60.3, 90.6)

a. Limited to participants who reported having received supervision in past 6 months

3.2.3. Health worker attitudes towards malaria case management

Health worker interviewees were presented with nine statements designed to measure attitudinal support for the new NMTP. Table 14 lists the nine statements, the 'correct' response (i.e. a response considered supportive of the new NMTP) for each statement and the percentage of participants who responded correctly in each HFS. The highest percentage by HFS year for each statement is indicated in bold. As shown, the highest number of correct responses was provided in 2014 on six out of the nine statements, one in 2010 and two in 2014. The variation in the percentage of health workers providing a correct response across survey years reached a level of statistical significance (p<0.05) on seven/nine statements (the two exceptions being 'It is important to distinguish between vivax and falciparum infection when treating uncomplicated malaria' and 'Malaria patients are less likely to complete their medication if the importance of doing so is not clearly communicated to them'). However, a fluctuating trend in the percentage of correct responses across survey years was the norm in these seven cases (i.e. there was no example of a consist increase or descrease by survey year).

Response patterns of note included the consistently low (<50% in 4/5 HFS) percentage of interviewees disagreeing with the statement that ' in most cases, chlorioquine is an effective treatment for uncomplicated malaria infection' as well as the substantial increase in interviewees disagreeing with the statement that 'fever patients who test negative for malaria infection should still be provided with antimalarial medication as a precautionary measure'. The former response pattern suggests a continuing belief in the effectiveness of chloroquine as a treatment for unomplicated malaria (despite high levels of drug resistance in PNG) whilst the latter response pattern suggests a growing confidence in the accuracy of RDT results.

The mean number of correct statements in 2010, 2011, 2012, 2014 and 2016 were 5.9 (SD 1.3), 5.9 (SD 1.3), 6.3 (SD 1.6), 7.1 (SD 1.4) and 6.7 (1.7), respectively (data not shown). The difference in mean number of correct statements between 2010 (5.9) and 2016 (6.7) reached a level of statistical significance (t(405) = -5.64, p<0.001).

Table 14. Percentage of health worker interviewees providing the correct response to each of nine malaria case management-related attitudinal statements

Statement	'Correct' Response	% (95% CI) of Participants' Providing Correct Response by Survey Year				
		2010	2011	2012	2014	2016
All patients who present with fever or suspected malaria should be tested for malaria infection by microscopy or RDT	Agree	89.3 (85.2, 93.4)	94.6 (91.5, 97.8)	90.1 (86.1, 94.0)	**97.3** (94.4, >99.9)	93.2 (89.5, 96.8)
In most cases, chloroquine is an effective treatment for uncomplicated malaria infection	Disagree	32.4 (26.3, 38.6)	36.1 (29.5, 42.7)	42.5 (36.0, 49.1)	**56.1** (46.9, 65.4)	49.5 (42.3, 56.6)
Advising patients how best to avoid mosquito bites is a good use of clinical time	Agree	**85.7** (81.1, 90.3)	69.8 (63.4, 76.1)	79.2 (73.8, 84.6)	77.2 (69.4, 85.0)	67.4 (60.6, 74.1)
In most cases, clinical diagnosis is just as accurate as microscopy or RDT in detecting malaria infection	Disagree	58.2 (51.7, 64.7)	55.7 (48.8, 62.6)	63.4 (56.9, 69.8)	**78.1** (70.4, 85.8)	67.2 (60.4, 74.0)
Fever patients who test negative for malaria infection should still be provided with antimalarial medication as a precautionary measure	Disagree	24.0 (18.4, 29.6)	37.3 (30.6, 43.9)	63.4 (56.9, 69.8)	**73.7** (65.5, 81.9)	72.8 (66.5, 79.3)
It is important to distinguish between vivax and falciparum infection when treating uncomplicated malaria	Agree	81.7 (76.6, 86.8)	76.0 (70.1, 81.9)	77.4 (71.2, 82.9)	**86.7** (80.4, 93.1)	80.5 (74.8, 86.2)
Telling patients when to take their medication is less important if written instructions are provided	Disagree	71.4 (65.5, 77.4)	72.9 (65.7, 78.2)	80.5 (75.3, 85.8)	**84.2** (77.4, 91.0)	77.4 (71.4, 83.4)
In most cases, combination therapy is the most effective treatment for malaria infection	Agree	54.9 (48.3, 61.4)	64.4 (57.8, 71.0)	52.0 (45.4, 58.7)	66.7 (57.9, 75.5)	**70.4** (63.8, 76.9)
Malaria patients are less likely to complete their medication if the importance of doing so is not clearly communicated to them	Agree	88.0 (83.7, 92.3)	87.8 (83.3, 92.3)	86.4 (81.9, 91.0)	90.4 (84.8, 95.9)	**90.5** (86.3, 94.7)

3.2.4. Health worker knowledge of malaria case management practice

Health worker interviewees who reported having administered an RDT, prescribed AL or advised a patient to sleep under a LLIN were asked a series of questions designed to test their knowledge in these respective areas. Table 16 (overpage) lists the number of health workers asked each question, the questions and the percentage of participants who responded correctly in each HFS. The highest percentage by HFS year for each question is indicated in bold. The variation in the percentage of health workers providing a correct response across survey years reached a level of statistical significance (p<0.05) on all five RDT questions, one AL question (What should patient do if vomit <one hour of consuming first dose of AL?) and two LLIN questions ('How often should you wash an LLIN?' and 'How many years does insecticide in LLIN remain effective, assuming good care?'). However, as with the 'attitudinal' data presented in Table 14, there was little consistency across survey years in terms of the direction of change (a general upward trend in the percentage of participants providing correct responses to the RDT questions was evident as was a downward trend in the percentage of participanst providing correct responses to the LLIN questions).

Response patterns of note include the consistently low percentage of interviewees correctly identifying what type of food AL should be consumed with or what side effect of PQ indicates a G6PD deficiency.

The mean number of correct responses (out of five) by question type and survey year are presented in Table 15. The difference in mean number of correct answers between 2010 and 2016 reached a level of statistical significance for the RDT questions, but not the LLIN questions (3.6 vs. 4.4, t(301) = -5.12, p<0.001; and 3.2 vs. 3.0, t(273) = 1.62, p-0.107, respectively). The difference in mean number of correct answers between 2012 and 2016 for the AL questions also reached statistical significance (2.4 vs. 2.7, t(266) = -2.04, p=0.042).

Table 15. Mean (SD) number of correct responses (out of five) by question type and survey year

Question Type	**Survey Year**				
	2010	2011	2012	2014	2016
RDT	3.6 (1.4)	3.7 (1.4)	4.4 (1.0)	4.5 (0.9)	4.4 (1.1)
AL	-	-	2.4 (1.2)	2.8 (1.2)	2.7 (1.4)
LLIN	3.2 (1.3)	3.0 (1.1)	3.0 (1.1)	2.8 (1.2)	3.0 (1.2)

Table 16. Percentage of health worker interviewees providing the correct response to 15 malaria case management related test questions

Question	% (95% CI) of Health Workers' Providing Correct Response by Survey Year				
	2010	2011	2012	2014	2016
RDT Knowledge. No. health workers tested[a]:	126	112	158	108	180
Please indicate where blood & buffer are applied on pictured RDT test?	76.8 (62.3, 84.3)	78.2 (70.3, 86.0)	96.2 (93.2, 99.2)	96.3 (92.7, 99.9)	**97.2** (94.8, 99.6)
How long after applying buffer should you wait before reading RDT result?	68.3 (60.0, 76.6)	73.9 (65.6, 82.2)	86.0 (80.6, 91.5)	**86.1** (79.5, 92.7)	83.9 (78.5, 89.3)
Which of the pictured test results indicates malaria infection?	88.8 (83.2, 94.4)	91.0 (82.6, 96.4)	**96.8** (94.1, 99.6)	95.4 (91.3, 99.4)	93.3 (89.7, 97.0)
Which of the pictured test results indicates no malaria (negative) infection?	66.9 (58.5, 75.3)	64.9 (55.8, 73.9)	80.4 (74.1, 86.6)	**88.0** (81.7, 94.2)	84.4 (79.1, 89.8)
Which of the pictured test results indicates an invalid result?	63.7 (55.1, 72.3)	65.6 (58.7, 76.4)	79.1 (72.7, 85.5)	**82.4** (75.1, 89.7)	77.8 (71.6, 83.9)
AL Knowledge. No. health workers tested[a]:	0	0	103	102	168
How many hours after taking a first dose of AL should second dose be taken?	-	-	76.5 (68.1, 84.8)	**88.2** (81.9, 94.6)	82.1 (76.3, 88.0)
What should patient do if vomit <one hour of consuming first dose of AL?	-	-	57.8 (48.1, 67.6)	**76.5** (68.1, 84.8)	65.5 (58.2, 72.7)
With what type of food should AL be consumed?	-	-	24.5 (16.0, 33.0)	**39.2** (29.6, 48.9)	38.1 (30.7, 45.5)
AL is not recommended for treatment with which group of women?	-	-	**69.9** (60.9, 78.9)	62.8 (53.2, 72.3)	69.6 (62.6, 76.7)
What side effect of PQ indicates a G6PD deficiency?	-	-	5.9 (1.2, 10.5)	9.8 (3.9, 15.7)	**15.0** (9.5, 20.4)
LLIN Knowledge. No. health workers tested[a]:	101	172	178	101	178
Who should sleep under a mosquito net at night?	80.0 (72.0, 88.0)	80.0 (72.0, 88.0)	81.9 (76.2, 87.6)	85.0 (77.9, 92.1)	**90.5** (86.1, 94.8)
If not enough mosquito nets in house, who should be prioritised for net use?	94.0 (89.3, 98.7)	94.0 (89.3, 98.7)	**96.6** (93.9, 99.3)	91.1 (85.4, 96.7)	93.8 (90.2, 97.4)
How often should you wash an LLIN?	**40.2** (30.3, 50.1)	**40.2** (30.3, 50.1)	36.2 (29.0, 43.3)	32.7 (23.4, 42.0)	27.5 (20.9, 34.2)
What should you wash an LLIN with?	**57.0** (47.1, 66.9)	**57.0** (47.1, 66.9)	46.6 (39.1, 54.0)	40.6 (30.9, 50.3)	41.8 (34.5, 49.1)
How many years does insecticide in LLIN remain effective (assum. good care)?	**53.0** (43.0, 63.1)	**53.0** (43.0, 63.1)	35.8 (28.6, 42.9)	30.7 (21.5, 39.8)	44.9 (37.6, 52.3)

a. Only those health workers who reported to have a) administered an RDT, b) prescribed AL or c) advised a patient to sleep under an LLIN were asked the respective test questions

3.3. Clinical Observations

3.3.1. Sample size

A total of 2789 clinical observations were completed across the five HFS, ranging from 408 in 2014 to 832 in 2016 (Table 17). Few clinical observations were completed at aid posts as the research teams spent the least amount of time in these facilities and the patient load is substantially less than that of a health centre.

Table 17. Number of clinical observations by year, health facility type and region[a]

Year	Type	Region				Total
		Southern	Highlands	Momase	Islands	
2010	Health Centres	121	106	116	104	**447**
	Aid Posts	5	4	6	4	**19**
	Overall (%)	126 (27.0)	110 (23.6)	122 (26.2)	108 (23.2)	**466**
2011	Health Centres	145	110	192	165	**612**
	Aid Posts	3	1	14	4	**22**
	Overall (%)	148 (23.3)	111 (17.5)	206 (32.5)	169 (26.7)	**634**
2012	Health Centres	132	114	127	66	**439**
	Aid Posts	5	0	0	1	**6**
	Overall (%)	137 (30.8)	114 (25.6)	127 (28.5)	67 (15.1)	**445**
2014	Health Centres	60	68	162	105	**395**
	Aid Posts	**0**	0	6	7	**13**
	Overall (%)	60 (14.7)	68 (16.7)	168 (41.2)	112 (27.5)	**408**
2016	Health Centres	281	166	224	161	**832**
	Aid Posts	1	0	3	0	**4**
	Overall (%)	282 (33.7)	166 (19.9)	227 (27.2)	161 (19.3)	**836**
Total	**Health Centres**	**739**	**564**	**821**	**601**	**2725**
	Aid Posts	**14**	**5**	**29**	**16**	**64**
	Overall (%)	**753 (27.0)**	**569 (20.4)**	**850 (30.5)**	**617 (22.1)**	**2789**

a. Listed totals include new fever cases only; treatment review patients were excluded from analysis.

3.3.2. Health worker diagnostic & prescription practices: Outcome indicator four

Table 18 presents the percentage of febrile patients tested for malaria infection by RDT or microscopy by survey year, the percentage prescribed an antimalarial and the percentage of antimalarial prescriptions that were compliant with national guidelines current at the time of survey. The analysis was limited to patients who were sent home at the end of the clinical consultation (to exclude cases of severe malaria). Clinical observations completed at the aid post level were excluded from analysis.

As shown in Table 18, the percentage of febrile patients tested for malaria infection by RDT or microscopy increased from 17.5% in 2010 to 73.5% in 2016. The most substantial increase in the use of RDT or microscopy was evident in the first HFS post NMTP implementation (2012), plateauing at approximately 75% in the two HFS thereafter. Conversely, a substantial decrease in antimalarial prescription was observed across the same period from 96.9% in 2010 to 30.5% in 2016. Again, the most substantial decrease was evident in the first HFS post NMTP implementation plateauing at approximately 30% thereafter. The findings pertaining to antimalarial prescription compliance followed a different pattern. Compliance was highest in the first HFS (2010) where 77.8% of antimalarial prescriptions conformed to the standard treatment guidelines current at that time, was lowest in the first HFS following the implementation of the new NMTP (24.2% in 2012) and has consistently increased since (reaching 57.4% by 2016), although not to the levels observed pre implementation of the new NMTP.

Table 19 presents antimalarial prescription practices by diagnostic test result for the three HFS completed post implementation of the NMTP. As shown, a substantial and statistically significant reduction in the prescription of antimalarials to febrile patients who were either not tested for malaria infection by RDT or microscopy or who tested negative for malaria infection (48.9% to 25.5% & 19.9% to 5.7%, respectively) was evident in the three HFS post NMTP implementation. 100% of patients who tested positive for malaria infection by RDT or microscopy were prescribed an antimalarial in all three HFS. Table 19 also shows a statistically significant increase in the percentage of antimalarial prescriptions compliant with the new NMTP guidelines among febrile patients who were either not tested for malaria infection by RDT or microscopy or who tested negative for malaria infection but were provided an antimalarial prescription anyway (6.2% to 16.7% & 2.1% to 45.8%, respectively). An increase in the percentage of antimalarial prescriptions compliant with national guidelines was also evident among those patients with test confirmed malaria (67.3% to 72.3%), although this failed to reach statistical significance.

Out of a total of 279 non-compliant antimalarial prescriptions, 76.0% (212/279) were due to the exclusive use of non-recommended antimalarials (e.g. chloroquine), 11.1% (31/279) were due to a failure to combine PQ with an AL prescription when treating a non-*P. falciparum* malaria infection, 3.6% (10/279) were for combining PQ with AL when treating a *P. falciparum* infection and a further 9.3% (26/279) were for combining a recommended antimalarial with an obsolete antimalarial. A full description of the types of antimalarial prescription and compliance status by diagnostic test result is presented in Table 20.

Table 18. Malaria diagnosis and antimalarial prescription practices

Practice Indicator	Survey Year % (95% CI)					*p*
	2010 (n=423)	2011 (n=582)	2012 (n=426)	2014 (n=388)	2016 (n=801)	
Febrile patients tested for malaria infection by RDT or microscopy	17.5 (8.7, 32.0)	9.3 (4.9, 16.9)	68.8 (55.2, 81.6)	76.8 (58.7, 88.5)	73.5 (64.1, 81.2)	<0.001
Febrile patients prescribed an antimalarial	96.9 (93.8, 98.5)	86.9 (78.8, 92.3)	38.7 (27.4, 51.4)	28.1 (19.1, 39.3)	30.5 (23.1, 39.0)	<0.001
Antimalarial prescriptions compliant with national guidelines[a, b]	77.8 (66.4, 86.2)	77.5 (65.9, 85.9)	24.2 (11.8, 43.4)	40.4 (26.7, 55.7)	57.4 (39.4, 73.6)	<0.001

a. Analysis limited to patients who received an antimalarial prescription. b 2010 and 2011 analyses based on former NMTP. 2012, 2014 & 2016 analyses based on current NMTP.

Table 19. Antimalarial prescription practices by diagnostic test result

Diagnostic Test Result	No.			Antimalarial Prescription							
				Any Prescription				Compliant Prescription[a]			
	2012	2014	2016	2012	2014	2016	*p*	2012	2014	2016	*p*
Not tested	133	90	212	48.9%	21.1%	25.5%	<0.001	6.2%	0%	16.7%	0.016
Malaria +	52	67	166	100%	100%	100%	-	67.3%	64.2%	72.3%	0.636
Malaria -	241	231	423	19.9%	10.0%	5.7%	<0.001	2.1%	4.4%	45.8%	<0.001

a. Analysis limited to patients who received an antimalarial prescription

Table 20. Compliance status and type of antimalarial prescription by diagnostic test result

Diagnostic Test Result				Prescription				
		Rating	N	2012	N	2014	N	2016
No test		Compliant	4	AL	0		9	AL
		Noncompliant	60	CQ+SP(x36), AQ+SP(x13), AQ(x7), SP(x1), Q+SP(x1), PQ+A+SP(x1), AL+A+SP(x1)	17	SP(x3), CQ+SP(x10), CQ (x1), A (x2), AT (x1)	45	SP (x21), AQ (x8), PQ (x6), CQ+SP (x3), A+SP (x3), Q (x2), A (x1), CQ (x1)
Malaria +	Undefined	Compliant	3	AL	1	AL	0	
		Noncompliant	0		1	Q	1	AL+AT (x1)
	P.falciparum	Compliant	18	AL	17	AL	54	AL
		Noncompliant	1	AL+PQ	5	AL+PQ(x3), A+PQ(x1), A(x1)	12	AL+PQ (x6), AL+SP (x3), AL+PQ+SP (x1), A+SP (x1), A (x1)
	P.vivax, non-P.f	Compliant	7	AL+PQ	3	AL+PQ	0	
		Noncompliant	2	AL	7	AL	0	
	Mixed infection	Compliant	8	AL+PQ	23	AL+PQ	60	AL+PQ
		Noncompliant	14	AL(x13), AL+PQ+AQ	12	AL(x6), AL+A(x3), A(x3), Q(x1)	19	Al (x4), AL+AT+PQ (x3), AL+PQ+SP (x2), A+SP (x2), A (x2), AL+SP (x1), AL+AT (x1), AL+DQ (x1), AT+SP+PQ (x1), AT+SP (x1), PQ (x1)
Malaria -		Compliant	1	AL	1	AL	11	AL
		Noncompliant	46	CQ+SP(x19), AQ+SP(x14), AQ(x5), A+SP(x3), A(x2), SP(x1), CQ+SP+PQ(x1), AT+SP(x1)	25	SP(x7), CQ+SP(x5), AQ+SP(x3), PQ(x3), A(x2), Q(x2), A+SP(x1), CQ+Q(x1), AT(x1)	12	SP (x5), A+SP (x3), AT+SP (x1), A (x1), AQ (x1), CQ (x1)

A=artemether tablets; AL= artemether-lumefantrine; AT=artesunate tablets; AQ=amodiaquine; CQ=chloroquine; Q=quinine tablets; PQ=primaquine; SP=sulfadoxine-pyrimethamine, DQ=doxycycline

3.3.3. Treatment counselling

Table 21 presents the percentage of patients prescribed AL in the 2012, 2014 and 2016 HFS who received specified treatment counselling instructions. As shown, health workers provided general advice on the AL dosage regimen (e.g. two doses a day for three days), encouragement to complete the full course of medication and specific advice to take the second dose of AL eight hours after the first to the majority of patients prescribed AL across all three HFS. Comparatively few patients were instructed to take AL with milk or fatty food or to repeat the initial dose of AL if the patient vomits within one hour of taking it, although a statistically significant increase in the former was observed between 2012 and 2016 (8.3% to 26.3%). A total of 224 patients were prescribed primaquine across the five HFS. In only two cases was the health worker observed to have provided 'adverse effect' advice (data not shown).

3.3.4. RDT practice

Table 22 presents the percentage of observed RDTs in the 2012, 2014 and 2016 HFS in which health workers adhered to the specified RDT administration procedures. As shown, health workers adhered to five out of the eight procedures in the vast majority of all RDTs observed being administered. These included: using a current (non-expired) RDT test, using an alcohol swab, drawing blood from the finger or heel, applying blood to the RDT test prior to buffer and applying the blood and buffer in the appropriate sections of the RDT. Health workers did not wear gloves and/or did not write the patient's name on the test during the majority of observed RDTs across all three surveys. In the 2012 and 2014 HFS, when the ICTcombo RDT was in wide use, 63.9% and 63.7% of observed RDTS were read at the recommended time (15 minutes for ICTcombo). In the 2016 HFS, when the CAREstart RDT was in wide use, 35.8% of observed RDTs were read at the recommended time (20 minutes for CAREstart).

Table 21. Percentage of patients prescribed artemether lumefantrine who received specified treatment counselling instructions

Instruction	Survey Year % (95% CI)			*p*
Was the patient/caregiver…	2012 (n=91)	2014 (n=68)	2016 (n=194)	
Given an explanation about the AL dosage regimen?	95.3 (88.0, 98.2)	100 (-)	95.8 (86.7, 98.8)	0.215
Advised to complete all doses of AL?	92.9 (86.5, 96.4)	97.0 (77.6, 99.7)	85.8 (69.9, 94.0)	0.019
Advised to take second dose of AL after 8 hours?	80 (53.2, 93.4)	83.6 (74.8, 89.7)	77.4 (59.4, 88.9)	0.548
Advised to take AL with milk or fatty food?	8.3 (1.9, 29.8)	23.9 (9.4, 48.8)	26.3 (10.0, 53.4)	0.003
Advised what to do if vomiting occurs?	3.6 (0.8, 14.1)	10.5 (4.3, 23.4)	5.8 (2.0, 15.9)	0.207

Table 22. Percentage of observed RDTs in which the health worker adhered to specified RDT administration procedures

RDT Procedures	Survey Year % (95% CI)			*p*
	2012 (n=382)	2014 (n=335)	2016 (n=620)	
RDT test still current (used prior to expiry date)	89.1 (64.4, 97.4)	98.8 (93.6, 99.8)	84.9 (68.0, 93.7)	<0.001
Provider put on a new pair of gloves	45.0 (33.0, 57.5)	34.6 (20.1, 52.6)	31.7 (20.5, 45.4)	<0.001
Patient name written on test	36.0 (21.4, 53.6)	31.0 (15.5, 52.5)	34.9 (24.4, 47.1)	0.356
Patient's finger cleaned with alcohol swab	99.2 (97.6, 99.7)	97.0 (83.7, 99.5)	99.5 (97.9, 99.9)	0.002
Blood drawn from patient's finger (or heel if baby)	95.5 (88.3, 98.4)	96.7 (86.1, 99.3)	100 (-)	<0.001
Blood applied to RDT test prior to buffer	97.1 (91.9, 99.0)	99.1 (92.7, 99.9)	98.7 (94.0, 99.7)	0.073
Blood/buffer applied to appropriate sections of RDT test	98.7 (96.2, 99.6)	99.7 (97.8, 99.9)	99.8 (98.8, 99.9)	0.040
RDT result read 15/20 minutes after buffer applied[a]	63.9 (51.2, 74.9)	63.7 (47.7, 77.2)	35.8 (25.7, 47.4)	<0.001

a. 15 minutes for ICTcombo, 20 for CAREstart as per test instruction

3.4. Exit Interviews

3.4.1. Sample size

A total of 3023 exit interviews were completed across the five HFS, ranging from 432 in 2014 to 863 in 2016 (Table 23). The vast majority of exit interviews took place at health centres.

Table 23. Number of exit interviews completed by year, health facility type and region

Year	Type	Region				Total
		Southern	Highlands	Momase	Islands	
2010	Health Centres	153	151	147	119	**570**
	Aid Posts	10	6	10	4	**30**
	Overall (%)	163 (27.2)	157 (26.2)	157 926.2)	123 (20.5)	**600**
2011	Health Centres	151	142	194	184	**671**
	Aid Posts	3	2	14	4	**23**
	Overall (%)	154 (22.2)	144 (20.8)	208 (30.0)	188 (27.1)	**694**
2012	Health Centres	146	98	138	105	**487**
	Aid Posts	8	6	0	0	**14**
	Overall (%)	154 (30.7)	104 (20.8)	138 927.5)	105 (21.0)	**501**
2014	Health Centres	71	73	180	121	**432**
	Aid Posts	**0**	0	6	7	**13**
	Overall (%)	71 (16.0)	73 (16.4)	180 (40.5)	121 (27.2)	**445**
2016	Health Centres	291	168	239	165	**863**
	Aid Posts	1	0	4	0	**5**
	Overall (%)	292 (33.6)	168 (19.4)	243 (28.0)	165 (19.0)	**868**
Total	**Health Centres**	**812**	**632**	**892**	**687**	**3023**
	Aid Posts	**22**	**14**	**34**	**15**	**85**
	Overall (%)	**834 (26.8)**	**646 (20.8)**	**926 (29.8)**	**702 (22.6)**	**3108**

As shown in Table 24, the highest proportion of exit interviews pertained to children less than five years of age (47.2% of the total). These interviews were completed with the child's respective caregiver. A relatively even proportion of interviews were completed with male and female patients (48.1% female).

Table 24. Selected characteristics of the exit interview sample by year[a]

Characteristic	Survey Year					Overall
	2010	2011	2012	2014	2016	
<5 yrs	300 (50.0)	371 (53.5)	256 (51.1)	194 (43.6)	345 (39.8)	1466 (47.2)
5-14 yrs	122 (20.3)	115 (16.6)	97 (19.4)	82 (18.4)	176 (20.2)	592 (19.1)
15+ yrs	178 (29.7)	208 (29.9)	148 (29.5)	169 (38.0)	347 (40.0)	1050 (33.7)
Female	291 (48.5)	341 (49.1)	233 (46.5)	213 (47.9)	417 (48.0)	1495 (48.1)

a. Interviews related to minors were completed with their respective caregivers

3.4.2. Treatment seeking times

Table 25 presents the median time and interquartile range, in hours, patients (or their caregivers) reported elapsing between: the onset of the first symptom and presenting to the health facility; departing for, and arriving at, the health facility; and arriving at the health facility and starting the clinical consultation (2016 only). As shown, the median wait time between the onset of symptoms and presenting to the health facility varied between 20 to 24 hours during the period 2010 to 2014, but rose to 48 hours by 2016. Whilst not shown in Table 24, the highest percentage of exit interviewees reporting to have sought treatment within 24 hours of symptom onset was 60.9% in 2011 and the lowest was 41.5% in 2016. Participants in the 2016 HFS who waited more than 24 hrs to seek treatment were asked to specify why. Responses included (based on a structured checklist): Symptoms too mild: 50.2% (255/508); Other commitments: 35.0% (178/508); Distance/lack of transport: 29.9% (152/508); Too unwell to travel: 13.0% (66/508); Sought treatment at home/elsewhere: 11.0% (56/508); Cost (transport or service fees): 10.8% (55/508); Bad weather: 6.7% (34/508); and Health facility closed: 3.4% (17/508). The median travel time was 0.5 to 0.6 of an hour across all five survey periods and the median waiting time in 2016 was 0.6 of an hour.

3.4.3. Treatment seeking costs

Between 26.3% and 32.7% of exit interviewees (2012-2016 only) reported incurring a transport-related cost when travelling to the health facility (Table 26). The median cost varied between 1.5 to 2.0 PGK across the three survey periods (cost of one-way trip only). Between 36.6% and 59.9% of exit interviewees across the five survey periods reported incurring a health service charge of some description during their consultation. This included 36.6% of exit interviewees in 2014 and 43.1% in 2016, both of which followed the introduction of a 'free healthcare policy' across PNG. The median reported cost was 1.00 PGK in 2010 and 2011, rising to 2.00 PGK in 2012, 2014 and 2016.

Table 25. Median (Inter Quartile Range) treatment seeking-related waiting and travel times in hours

Practice Indicator	Survey Year					*p*
	2010 (n=600)	2011 (n=694)	2012 (n=501)	2014 (n=445)	2016 (n=868)	
Onset of symptoms	23 (15, 16)	20 (14, 48)	24 (16, 55)	23 (17, 48)	48 (19, 72)	<0.001
Travel time to health facility (door to door)	0.5 (0.3, 1.5)	0.5 (0.3, 1.3)	0.6 (0.3, 1.0)	0.5 (0.3, 1.0)	0.5 (0.3, 1.0)	<0.001
Waiting time to see a health worker	-	-	-	-	0.6 (0.3, 1.3)	-

Table 26. Treatment seeking-related costs in PGK

Practice Indicator	Survey Year					*p*
	2010 (n=600)	2011 (n=694)	2012 (n=501)	2014 (n=445)	2016 (n=868)	
% (95% CI) incurring a transport related cost	-	-	32.7%	26.3%	27.7%	0.058
Median (IQR) cost PGK[a]	-	-	2.0 (1.0, 4.5)	1.5 (0.7, 3.0)	2.0 (1.0, 5.0)	<0.001
% (95% CI) incurring a health facility related cost	40.2%	59.9%	53.5%	36.6%	43.1%	<0.001
Median (IQR) cost PGK	1.0 (1.0, 2.0)	1.0 (1.0, 2.0)	2.0 (1.0, 2.0)	2.0 (1.0, 3.0)	2.0 (1.0, 3.0)	<0.001

a. One-way transport cost only

3.4.4. Medication use prior to seeking treatment

In the 2016 HFS (the only year in which it was directly measured), 2.4% (21/866) of participants reported taking an antimalarial prior to seeking treatment at the health facility. AL was the most frequently reported antimalarial consumed (n=17), followed by SP (n=4), PQ (n=2) and quinine (n=1). The reported source of the antimalarial was an existing home supply (n=11), pharmacy or store (n=6), friend (n=2) or village health volunteer (n=1). In addition, 28.6% (248/866) of participants reported that they had consumed some 'other' form of medication (i.e. other than an antimalarial) before seeking treatment. The most commonly reported 'other' drug was some form of analgesic, antipyretic or 'pain killer' (n=134), some form of antibiotic (n=125) or fefol (n=1). The reported source of these 'other' drugs was home supply (n=115), friends (n=47), pharmacy or store (n=42), village health volunteer (n=6), and a 'teacher' (n=1) or 'villagers' (n=1).

4. DISCUSSION

Time trend data pertaining to the four primary outcome indicators are discussed first, followed by a general discussion of key findings from the secondary data analyses.

4.1. Availability of RDTs and Operational Microscopy

Availability of RDTs peaked in the 2014 HFS were they were present in 87.2% of surveyed health facilities, a substantial increase from the baseline figure of 8.9% recorded in 2010. 2014 was also the first HFS in which RDT availability was relatively even across both health centres and aid posts, having rarely been available in the latter in the three preceding surveys. These findings suggest the RDT procurement and supply mechanisms in place at that point in time were capable of achieving high levels of coverage across the primary health care network. Nevertheless, a statistically significant reduction in overall RDT availability was observed between 2014 and 2016 (from 87.2% to 67.5%) suggesting some fragility in the RDT procurement and supply mechanisms. The reduction in RDT availability was reasonably evenly dispersed across both health centres and aid posts suggesting either form of primary health care facility was affected equally by the overall disruption in RDT supply.

Operational microscopy was rarely available in either health centres or aid posts at any point across the five HFS. This was not an unexpected finding as there was relatively minimal investment in improving microscopy coverage at the primary health care in PNG between 2010 and 2016. However, the general lack of operational microscopy at this level will prevent the malaria program from establishing species-specific trends in malaria cases at the primary health care level. More immediately, it does not allow health workers to confirm cases of *P. vivax* diagnosed as '*P. falciparum* or mixed infection' by RDT (with subsequent implications for the prescription of primaquine) nor diagnose malaria within two weeks after anti-malaria treatment (during which time an RDT may remain positive due to circulating antigen).

4.2. Availability of Artemether Lumefantrine

The availability of AL mirrored that of RDTs, peaking in 2014 at 87.2% (any does) from a 2010 baseline of 0%. As with RDT availability, 2014 was also the first HFS in which AL availability was relatively even between health centres and aid posts. A statistically significant reduction in AL availability between 2014 and 2016 was also observed ('any dose' decreasing from 87.2% to 66.2%) suggesting the

interruption in the RDT procurement and supply chain during this period also extended to AL. Substantial variation in the availability of weight/age related AL blister packs (i.e. Infant, child, youth and adult) across health facilities was evident in both 2014 and 2016, suggesting the AL procurement and supply chain may not be sufficiently sensitive to age/weight related demand for AL. This finding also highlights the importance of ensuring health workers are sufficiently trained and supported to improvise their use of weight/age specific AL blister packs when particular weight/age packs become unavailable. For example, if the 'adult' AL blister pack becomes unavailable then the health worker could improvise by providing two 'child' packs (with appropriate explanation) instead. Promoting flexible prescription practice of this type will substantially reduce the potential for malaria confirmed cases to go without AL in times of AL shortage. Equally, AL consumption data reported through the National Health Information System could be used for more appropriate weight/age package allocation if the data reported through the system can be considered sufficiently accurate.

4.3. Health Worker Training in the New National Malaria Treatment Protocol

Eighty-four percent of clinical staff employed in surveyed health facilities had been trained in the new NMTP during the 2011 HFS. This was the highest percentage across all five HFS and was not unexpected given the primary (and in many cases, only) NMTP training programme was implemented in late 2010/early 2011. By the time of the 2016 HFS, only 41.0% of clinical staff employed in the surveyed health facilities had reportedly received training in the new NMTP at any point since January 2010. This finding suggests that formal training in the new NMTP (outside of health worker degree/award programmes) has not been sustained and that the 'pool' of formally trained staff is rapidly diminishing with time. Nevertheless, the health worker compliance data (described below) suggests health workers largely adhere to the core NMTP protocols and at an ever increasing rate. Thus, the reduction in the pool of health workers formally trained in the new NMTP does not appear to be negatively impacting on performance. These data likely suggest that 'on the job' training has become a primary means of NMTP knowledge/skills uptake. Key gaps in health worker compliance remain (e.g. in treatment counselling, PQ prescription, RDT administration), so these findings should not be taken to mean no further training is necessary. Rather, core NMTP skills are now seemingly embedded in health worker practice, but additional training on the finer details of treating malaria and febrile case management patients could still reap significant improvements in patient care.

4.4. Health Worker Compliance with the New National Malaria Treatment Protocol

Dramatic changes in health worker practice were immediately evident in the first HFS post-implementation of the new NMTP (HFS 2012). The percentage of febrile patients tested for malaria infection by RDT or microscopy increased from 17.5% in 2010 to 68.8% in 2012 and the percentage of febrile patients prescribed an antimalarial decreased from 96.9% to 38.7% across the same period. Consistent improvement in health worker practice, in terms of compliance with some aspects of the new NMTP, was also observed between 2012 and 2016. For example, the percentage of antimalarial prescriptions compliant with national guidelines increased from 24.2% in 2012 to 57.4% in 2016 and the percentage of test confirmed malaria negative cases prescribed an antimalarial decreased from 19.9% to 5.7% over the same period. Nevertheless, approximately one-quarter of all febrile patients were still not being tested for malaria infection by RDT or microscopy in 2016, over 40% of antimalarial prescriptions were not compliant with national guidelines and presumptive or clinical diagnoses of malaria were still frequently occurring (although at ever decreasing rates).

By 2016, four years' post-implementation of the new NMTP, compliance with national antimalarial prescription guidelines was still substantially lower than the recorded rate of compliance with the previous (now obsolete) prescription protocol as measured in the six-month period immediately prior to protocol change (i.e. 2011; 77.5% in 2011 vs. 57.4% in 2016). Interestingly, a review of the noncompliant antimalarial prescriptions observed post 2011 suggest changes in the types of noncompliant prescription over time: in 2012 a majority of noncompliant prescriptions were due to continued use of the previous (now obsolete) prescription protocol whereas by 2016 a greater proportion of noncompliant prescriptions were due to a failure to prescribe PQ in cases of mixed- or non-*P.f* malaria infection (in combination with AL) or the inappropriate prescription of PQ to confirmed *P.f* cases (although continued use of the obsolete protocol was still observed, especially for presumptively/clinically diagnosed malaria cases).

These findings suggest health worker practice is continuing to evolve in a manner ever more consistent with the new NMTP, although there seemingly remains some reluctance to prescribe recommended antimalarials to presumptively/clinically diagnosed malaria cases and apparent uncertainty about the use of PQ. RDT use has seemingly plateaued at approximately 75% of febrile patients, although this likely reflects, in part, issues pertaining to RDT availability. Further gains in RDT use may be achievable with greater coverage (although it remains notable that observed rates of RDT use were similar between 2014 and 2016, even though coverage was greater in 2014).

4.5. Key Findings from Secondary Data Analyses

The consistent reduction in availability of now obsolete antimalarials (e.g. chloroquine, amodiaquine) since 2011 suggests the various antimalarial procurement and supply systems at national and provincial levels have appropriately adjusted to the new NMTP. The reduction in supply of obsolete antimalarials is also likely to have contributed to the improvement in health worker's antimalarial prescription compliance.

The data pertaining to aid post supervision suggest, on average, approximately 35-40% of aid posts are out of operation at any one point in time (the majority of these are long term closures). The loss of treatment coverage associated with aid post closure is offset in part by the operation of community-based volunteer schemes of which close to one-third of health centres reportedly supervised. Between 25-60% of these community schemes involved antimalarial prescription, suggesting there is room to improve antimalarial access by greater use of existing schemes.

Training opportunities for health workers in malaria case management (and likely febrile case management more broadly) have been limited since 2010. Regular supervision (at least once per six months) remains an exception for the majority of primary health care workers. Nevertheless, attitudes towards the new NMTP have consistently improved (i.e. increasingly aligned with the new NMTP) and practice continues to improve (as discussed above). Knowledge and practice gaps remain. Health worker knowledge of LLIN care appears to have deteriorated over time and, in addition to compliance issues identified above, health worker's treatment counselling practice is often poor (especially with regard to side effects of PQ) and the persistent failure of many health workers to wear gloves when administering an RDT poses a significant risk to their personal safety (although the availability of gloves was not assessed during the surveys and may have been a factor).

The exit interview data indicate that the median waiting time, from time of first symptom to seeking assistance at the health facility, was between 20-24 hours between 2010 and 2014. However, this time increased to 48 hours by 2016. Further investigation may be needed to determine the accuracy of this finding, although it is possible that a consequence of a declining malaria prevalence is greater ambivalence in terms of seeking help for a febrile illness. This contention is partially supported by the finding that, when asked why they had not sought treatment earlier, a majority of participants reported that their symptoms were too mild or that they had other commitments. Finally, it is of interest that the median cost of seeking treatment has not changed since 2012, and is double that of 2010, despite the free health care policy.

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