PAPUA NEW GUINEA & THE GLOBAL FUND
ROUND 8 MALARIA CONTROL PROGRAMME EVALUATION 2009 - 2014

REPORT ON

THE PAPUA NEW GUINEA NATIONAL MALARIA CONTROL PROGRAM: PRIMARY OUTCOME & IMPACT INDICATORS, 2009-2014

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1. INTRODUCTION

The Papua New Guinea Institute of Medical Research (PNGIMR), as a sub-recipient in the Global Fund (GF) Round 8 Malaria Grant to Papua New Guinea (PNG), was contracted to provide a range of monitoring and evaluation (M&E) activities in support of the PNG National Malaria Control Program, 2009-2014. These M&E activities, among other things, were designed to answer the following seven primary outcome and impact indicators:

Primary Outcome Indicators

1. Proportion of households with at least two long lasting insecticidal mosquito nets (LLIN)
2. Proportion of pregnant women who slept under an LLIN the previous night
3. Proportion of children under five years of age who slept under an LLIN the previous night
4. Percentage of children under five years of age with fever in the last two weeks who received antimalarial treatment according to national policy

Primary Impact Indicators

1. Parasite prevalence: The percentage of children aged 6-59 months with malaria infection
2. Annual parasite incidence: Number of malaria cases detected per 1000 population/year
3. All-cause mortality rate among children under five years of age

The data required to report on these indicators were collected from cross-sectional countrywide household surveys (HHS) conducted every second year (Outcome indicators 1-4 & Impact indicators 1 & 3) and from longitudinal surveillance in health facilities in selected sites across PNG (Impact indicator 2). The PNGIMR was required to report results for each of these indicators at scheduled times across the program timeframe, i.e. 2009 to 2014. Final and/or progressive findings (pertaining to the seven outcome/impact indicators) from previous HHS and from the longitudinal health facility surveys have been presented in the following reports:

- Pulford et al. Report on Incidence of Confirmed Malaria in Sentinel Surveillance Sites: Year 4 (2012/2013). Goroka: PNGIMR, 2014
- Hetzel et al. Report on Incidence of Confirmed Malaria in Sentinel Surveillance Sites: Year 3 (2011/2012). Goroka: PNGIMR, 2013.

- Hetzel et al. Papua New Guinea/The Global Fund Round 8 Malaria Control Program Evaluation, 2009-2014: Report on Countrywide Household Survey 2010/11, Malaria Control Intervention Coverage and Prevalence of Parasitaemia. Goroka; PNGIMR, 2012.

- Hetzel & Cuervo-Rojas. Preliminary Report on Year 2 Outcome and Impact Indicators. Goroka: PNGIMR, 2011.

- Hetzel et al. Papua New Guinea/The Global Fund Round 3 Malaria Control Programme Evaluation 2008-2009: Results from Cross-Sectional Surveys and Sentinel Sites. Goroka; PNGIMR, 2010.

This report presents the latest and final results for these seven indicators, inclusive of comparisons with previously reported findings, in the context of the Round 8 GF PNG Malaria Grant. It has been prepared as a short report detailing key findings obtained during the 2014 HHS and longitudinal surveillance during 2013/14. The study samples and additional supporting information are presented in the appendices. Additional reports describing the survey methodologies and presenting further secondary findings will be prepared and disseminated at a later date. Readers interested in a more detailed description of the HHS and longitudinal surveillance methodologies in the meantime may refer to the reports cited above or the 'in press' publication below:

- Hetzel MW, Pulford J, Maraga S, Barnadas C, Reimer L, Tavul L, Jamea-Maiasa S, Tandrapah T, Maalsen A, Makita L, Siba PM, Mueller I. Evaluation of the Global Fund-supported National Malaria Control Program of Papua New Guinea, 2009-2014. *Papua New Guinea Medical Journal (in press).*

Readers are further advised that all seven indicators described above were designed to be measured at the national level. However, in this report both national and regional level results are presented.

2. OUTCOME INDICATORS

2.1. Mosquito Net Ownership and Use

Figure 1 presents the year five (2014) targets and results, as measured by the 2014 HHS, for the three primary outcome indicators pertaining to LLIN ownership and use. A comparison with results obtained from the 2009 and 2011 HHS is also presented as well as an estimate of pre-LLIN-distribution coverage.

Key outcome indicators	**Target**	**Result** (95% CI)
Proportion of households with at least two LLIN:	90%	68.1% (63.7, 72.3)
Proportion of children <5 years sleeping under LLIN:	80%	59.5% (54.0, 64.8)
Proportion of pregnant women sleeping under LLIN:	70%	49.6% (39.3, 60.0)

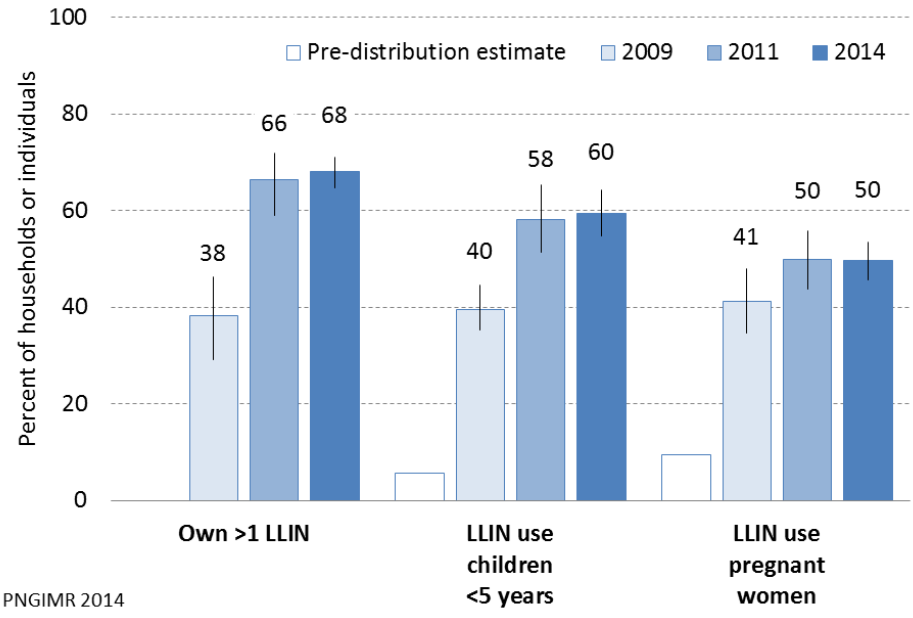

Figure 1: Time trend in key outcome indicators. Error bars are 95% CI.

As shown in Table 1, the 2014 HHS found that 82.2% (95% CO 78.7, 85.2) of all households countrywide owned a LLIN and 84.1% (95% CI 80.3, 97.3) a mosquito net of any type. Two

or more LLIN were found in 68.1% (95% CI 63.7, 72.3) and one net per two people in 55.4% (95% CI 50.6, 60.1) of the households. Net/LLIN ownership was lowest in the Highlands provinces.

Table 1: Key indicators of mosquito net ownership, 2014 HHS

Region	% of HH with at least one net	% of HH with at least one LLIN	% of HH with at least two LLIN	Mean number of LLIN per HH	% of HH with at least one LLIN per two people	Number of HH.
Southern	93.8	93.0	82.3	3.4	66.7	628
Highlands	70.8	68.6	49.7	1.8	41.9	596
Momase	92.9	90.8	80.4	3.0	61.4	462
Islands	84.1	91.5	80.2	3.1	70.8	481
P-value	*<0.001**	*<0.001**	*<0.001**	*<0.001*$^{\$}$	*<0.001**	
Overall	**84.1**	**82.2**	**68.1**	**2.6**	**55.4**	**2,167**

*Weighted analysis. *Chi-square test.* $^{\$}$*Linear regression.*

The year five target of 90% household ownership of at least two LLIN was reached in 22.8% (21/92) of the survey villages, including 37.0% of villages in Southern, 35% of villages in Momase and 20% of villages in the Islands. No village in the Highlands had reached the target. A total of 68.3% (95% CI 64.3, 72.3) of the survey population had access to a LLIN in their household at a ratio of one net per two people.

Overall, 53.9% (95% CI 49.4, 58.4) of all individuals reported using a LLIN the previous night and 55.2% (95% CI 50.5, 59.7) using a net of any type (Table 2). In the target group of children under five years of age, 59.5% (95% CI 54.0, 64.8) had used a LLIN and among pregnant women, 49.6% (95% CI 39.3, 60.0). LLIN use in children under five years was significantly higher than in older age groups (χ^2, 1df, P = 0.003). A correlation was found between access to a LLIN and LLIN use; however, in all regions, use remained substantially lower than access, with the smallest difference observed in Momase region.

LLIN use was lowest in the Highlands (37.3%) and highest in Momase region (68.2%). The age group 15-19 years was least likely to use a LLIN (44.9%). Across all age groups, no difference in net or LLIN use was found between male and female household members.

However, in the age groups 15-19 and 20+ years, male household members were significantly less likely to use a LLIN than female household members (39.6% vs. 47.2%, *P* = 0.006, and 46.9% vs. 53.8%, *P* < 0.001, for the two age groups respectively).

Table 2: Key indicators of mosquito net use, 2014 HHS

	% HH members with access to LLIN in their HH	% HH members who slept under net last night	% HH members who slept under LLIN last night	Number of HH members
Region				
Southern	76.5	60.8	59.9	3,871
Highlands	52.8	37.5	37.3	2,732
Momase	75.5	70.7	68.2	2,688
Islands	83.7	55.2	53.9	2,374
P-value	*<0.001*[$]	*<0.001**	*<0.001**	
Age group				
<1		68.6	67.1	318
1-4		58.7	57.8	1,354
5-9		58.0	56.5	1,667
10-14		54.0	52.3	1,489
15-19		46.9	44.9	1,167
20+		54.8	53.8	5,663
P-value		*<0.001**	*<0.001**	
Sex				
M		54.6	53.3	5,789
F		55.8	54.6	5,837
P-value		*0.229**	*0.208**	
Overall	**68.3**	**55.2**	**53.9**	**11,665**

*Weighted analysis. *Chi-square test. [$]Linear regression.*

The year five target of 80% LLIN use in children under five years of age was reached in 28.3% (26/92) of the surveyed villages, including 33.3% of villages in Southern, 4% (1) of villages in the Highlands, 50% of the villages in Momase, and 30% of the Islands villages. The target of 70% LLIN use by pregnant women was reached in 35.9% (33/92) of the villages, including 33.3% in Southern, 16% in the Highlands, 65% in Momase, and 35% in the Islands.

Tables presenting key indicators of mosquito net use in children under five years of age and by pregnant women are presented in Appendix C.

An interesting finding was that larger households were less likely to own one LLIN per two people and members of larger households were less likely to use a LLIN than members of smaller households (Figure 3).

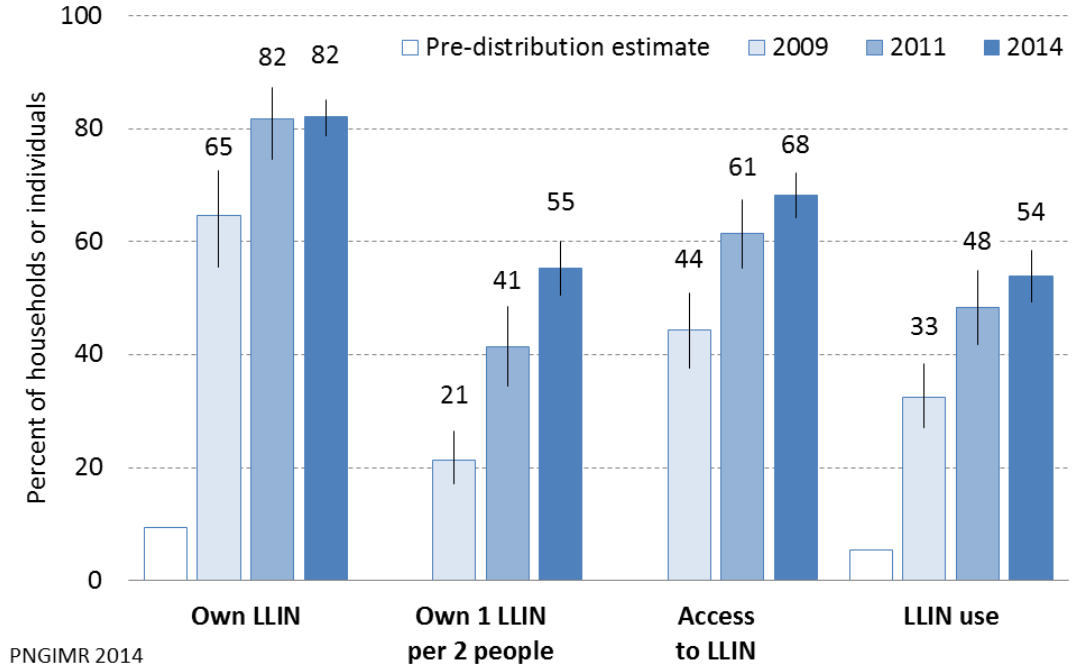

Figure 2: Time trend in LLIN ownership, access and use. Error bars represent 95% CI.

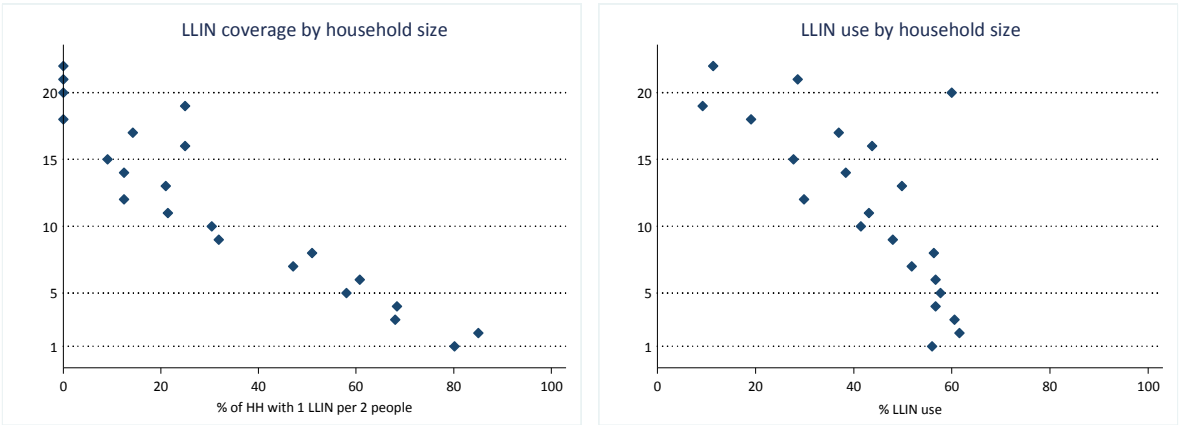

Figure 3: Relationship of household size and LLIN ownership (left) and use (right)

2.2 Treatment Seeking for Fever

Figure 4 presents the year five (2014) target and result, as measured by the 2014 HHS, for the primary outcome indicator: Percentage of children under five years of age who received antimalarial treatment according to national policy. A comparison with results obtained from the 2009 and 2011 HHS is also presented.

Key outcome indicator	**Target**	**Result** (95% CI)
Percentage of children younger than 5 years of age with fever in the last 2 weeks who received antimalarial treatment according to national policy:	60%	3.8% (1.0, 12.6)
Of those testing positive for malaria:		80.0% (28.4, 99.5)

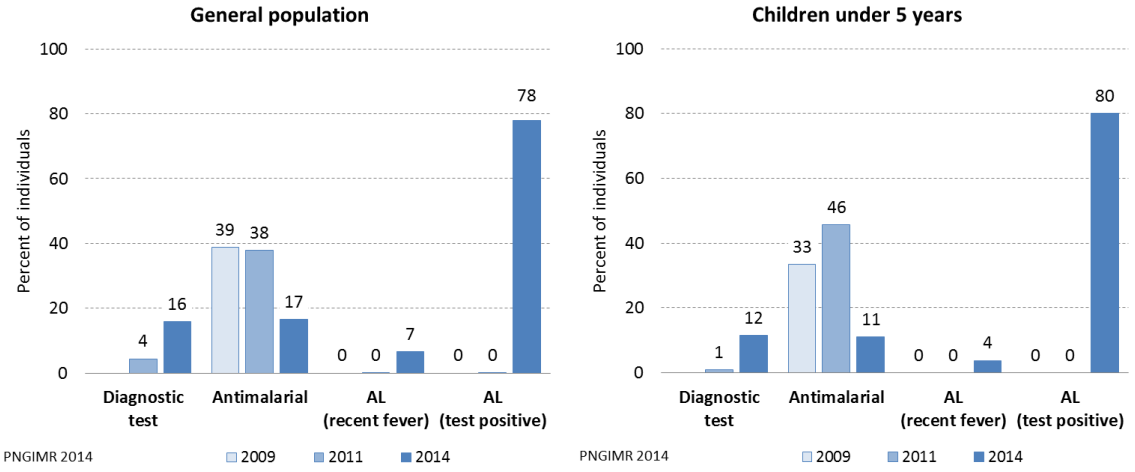

Figure 4: Time trend in treatment seeking indicators: general population (left) and children <5 years of age (right)

Less than half (43.3%, 95% CI 35.9, 51.1) of all recent fever episodes were brought for treatment to a health facility (usually a health centre [24.1%] or aid post[15.8%]) and 15.9% (95% CI 12.0, 20.9) of all cases had a diagnostic blood test performed, with no statistically significant difference between age groups, sex or region (Table 3). Of those people attending a health facility, 35.4% (95% CI 26.4, 45.5) had a diagnostic blood test done, which was positive in 25.5% of the cases.

An antimalarial medicine was taken by 16.5% (95% CI 11.5, 23.2) and the recommended first-line treatment artemether-lumefantrine (AL) by 6.7% (95% CI 3.7, 12.1) of householders with a recent fever. In the target group of children under five years of age, 11.0% (95% CI 6.3, 18.5) were treated with an antimalarial and 3.8% (95% CI 1.0, 12.6) with AL. The difference between age groups, sex, or geographical region was not statistically significant (Table 3).

Table 3: Key indicators of treatment seeking for recent fever episodes, 2014 HHS

Background characteristics	Fever cases	% attending health facility	% tested (RDT, microscopy, other)	% receiving antimalarial	% receiving AL
Region					
Southern	78	44.8	25.4	17.3	6.6
Highlands	107	41.2	13.7	14.0	5.7
Momase	130	44.3	12.3	19.3	8.2
Islands	75	47.6	28.8	16.7	6.3
*P-value**		*0.900*	*0.139*	*0.782*	*0.860*
Age group					
<5	103	43.5	17.4	18.4	3.8
5+	287	42.6	11.6	11.0	7.8
*P-value**		*0.872*	*0.179*	*0.140*	*0.348*
Sex					
M	191	40.2	16.3	16.8	7.2
F	198	45.7	15.7	16.4	6.4
*P-value**		*0.382*	*0.903*	*0.901*	*0.790*
Overall	**390**	**43.3**	**15.9**	**16.5**	**6.7**

**Chi-square test.*

While only a small proportion of fever cases were brought to a health facility and tested, 77.8% (95% CI 52.4, 93.6; no analysis weights applied) of those tested positive and only 2.1% (95% CI 0, 11.3, $P < 0.001$) of those tested negative were administered AL. In the age group of children under five years, the respective proportions were 80% (4/5) and 0% (0/10), but based on a very small number of cases. At the same time, non-AL antimalarials were taken by several of the test-negative cases (12.8% across all age groups).

2.3 Intermittent Preventive Treatment of pregnant women (IPTp)

IPTp coverage is not a primary outcome or impact indicator in the PNGIMRs evaluation of the PNG National Malaria Control Program, 2009-2014. However, no data on IPTp coverage have previously been reported for PNG and they are included here for the benefit of future program planning. IPTp with 2-3 doses of sulphadoxine-pyrimethamine (SP) at least one month apart in the second and third trimesters is recommended for malaria prevention in all pregnant women as part of the new malaria treatment protocol. The reported data were obtained from female participants in the 2014 countrywide HHS who reported a live birth between the period January 2008 and the day of survey (n=911).

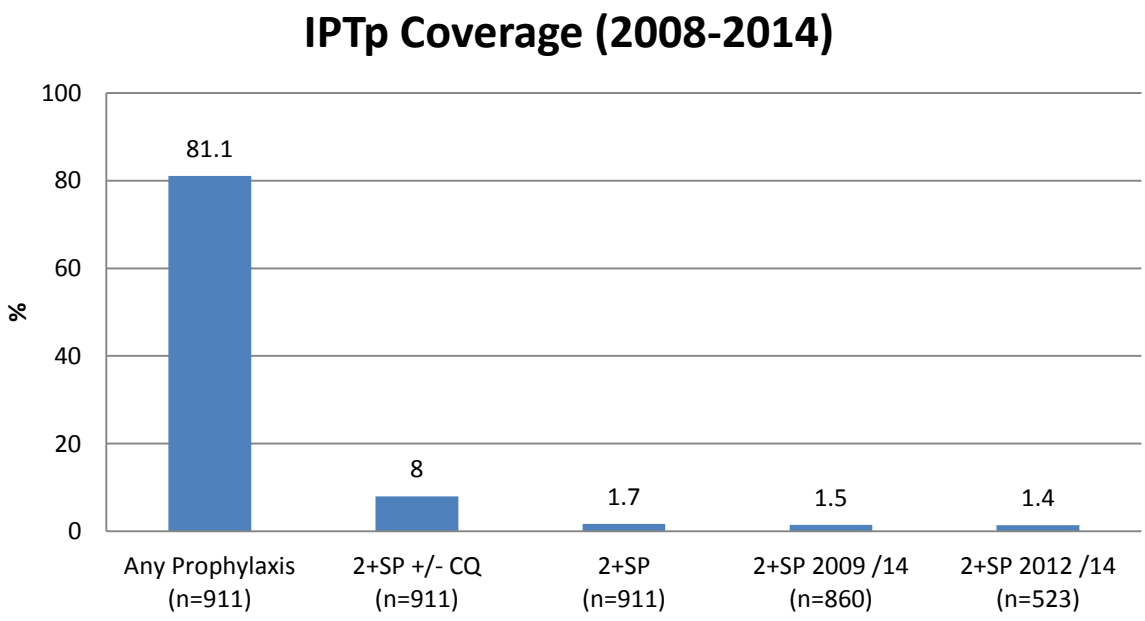

Figure 5: IPTp coverage (2008-2014)

As shown in Figure 5 and Table 4, 81.1% (95% CI 78.4, 83.6) of participants reported receiving some form of malaria prophylaxis during their most recent pregnancy. In all cases, the reported drug was either chloroquine (CQ), SP or a combination of the two. However, only 8.0% (95% CI 6.3, 10.0) of participants reported receiving at least two doses of SP during their most recent pregnancy, although in the majority of these cases (57/73) the participant also reported receiving chloroquine.

Overall, only 1.7% (95% CI 0.9, 2.8) of participants reported receiving at least two doses of SP during their most recent pregnancy without also receiving any other type of antimalarial prophylaxis (e.g. chloroquine). This is consistent with the IPTp policy in the current national treatment guidelines (2009), although this analysis cannot confirm the timing of each dose. To examine whether adherence to the IPTp policy improved after 2009 (when it was formally introduced) and 2012 (when it was included in the revised standard treatment guidelines for adults), separate analyses were conducted for the periods 2009-2014 and 2012-2014. As shown in Figure 5, adherence to the IPTp policy remained virtually unchanged across these time periods (1.5% and 1.4%, respectively).

Table 4 presents IPTp coverage at the regional level for all women in the 2014 HHS reporting a pregnancy during 2008-2014. Table 5 presents the same information, but the analysis is restricted to women who reported antenatal attendance during their pregnancy.

Table 4: IPTp coverage by region and overall, HHS 2014 (all pregnancies, n=911)

Region	**N**	**Malaria Prophylaxis**		
		Any Antimalarial	2+SP +/- CQ	2+ SP only
		% (95% CI)	% (95% CI)	% (95% CI)
Southern	265	81.5 (76.3, 86.0)	10.1 (6.8, 14.4)	1.2 (0.2, 3.4)
Highlands	219	74.0 (67.6, 79.7)	4.5 (2.2, 8.1)	2.8 (1.0, 5.9)
Momase	249	81.9 (76.6, 86.5)	9.5 (6.2, 13.8)	1.6 (0.4, 4.1)
Islands	178	88.2 (82.5, 92.5)	7.1 (3.7, 12.0)	1.2 (0.1, 4.2)
Total	**911**	**81.1 (78.4, 83.6)**	**8.0 (6.3, 10.0)**	**1.7 (0.9, 2.8)**

Table 5: IPTp coverage by region and overall, HHS 2014 (antenatal attendees, n=827)

Region	**N**	**Malaria Prophylaxis**		
		Any Antimalarial	2+SP +/- CQ	2+ SP only
		% (95% CI)	% (95% CI)	% (95% CI)
Southern	251	85.7 (80.7, 89.7)	11.1 (7.4, 15.7)	2.0 (0.6, 4.6)
Highlands	198	80.8 (74.6, 86.0)	5.1 (2.5, 9.1)	3.0 (1.1, 6.5)
Momase	209	95.7 (92.0, 98.0)	10.8 (7.0, 15.8)	2.3 (0.8, 5.4)
Islands	169	91.1 (85.8, 94.9)	7.5 (3.9, 12.7)	1.8 (0.4, 5.1)
Total	**827**	**88.1 (85.7, 90.3)**	**8.8 (7.0, 11.0)**	**2.3 (1.4, 3.5)**

3. IMPACT INDICATORS

3.1.Malaria Prevalence

Figure 6 presents the year five (2014) target and result, as measured by the 2014 HHS, for the primary outcome indicator: Percentage of children age 6-59 months with malaria infection. General population prevalence data and a comparison with results obtained from the 2009 and 2011 HHS are also presented.

Key impact indicator	**Target**	**Result** (95% CI)
Percentage of children aged 6 - 59 months with malaria infection (<1600 m):	17%	3.0% (1.7, 5.2)
P. falciparum:		2.0% (0.9, 4.2)
P. vivax:		1.7% (0.8, 3.5)

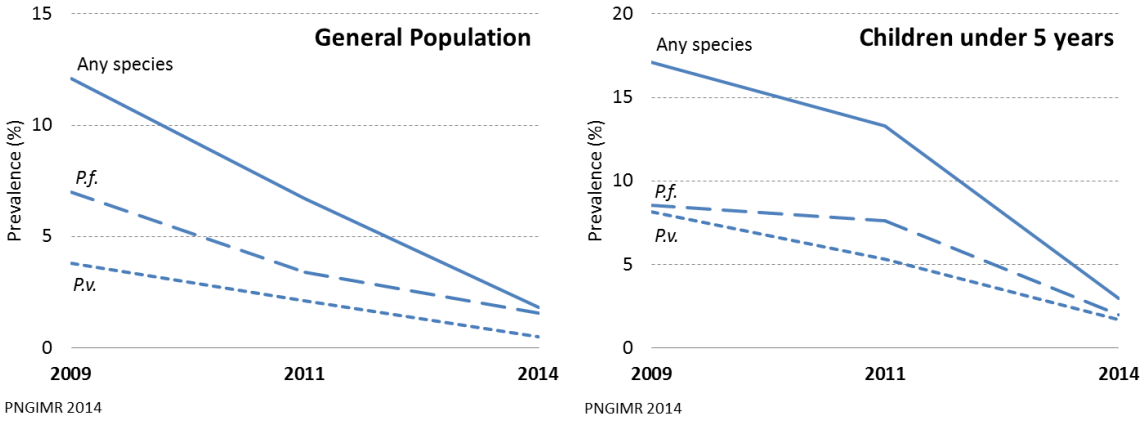

Figure 6: Time trend in malaria prevalence <1600 m altitude: general population (left) and children <5 years of age (right)

In survey villages below 1600 m altitude, 1.8% (95% CI 1.2, 2.8) of the general population was infected with malaria parasites. Prevalence of *P. falciparum* amounted to 1.6% (95% CI 1.0, 2.5) and *P. vivax* to 0.5% (95% CI 0.3, 0.8). No infections with *P. malariae* or *P. ovale* were found. Mixed infections of *P. falciparum* and *P. vivax* were rare (17 cases; 0.2%, 95% CI 0.1, 0.5).

In the target group of children 0.5-5 years of age in these villages, prevalence was 3.0% (95% CI 1.7, 5.2) with any species, 2.0% (95% CI 0.9, 4.2) with *P. falciparum* and 1.7% (95% CI 0.8, 3.5) with *P. vivax*. Mixed infections with *P. falciparum* and *P. vivax* were found in 9 children (0.8%, 95% CI 0.3, 2.1) (Table 6).

Table 6: Country-wide malaria parasite prevalence by age group (< 1600 m altitude), 2014 HHS

Age group (years)	N	Parasite prevalence (%)			
		All	***P. falciparum***	***P. vivax***	***Pf+Pv* mixed**
Age group (years)					
0.5-4	848	3.0	2.0	1.7	0.8
5-9	1,047	3.9	3.7	0.6	0.3
10-14	802	2.2	1.4	0.9	0.1
15-19	612	0.5	0.5	0.00	0.0
20+	3546	1.2	1.1	0.2	0.1
*P-value**		*0.002*	*0.005*	*0.002*	*0.091*
Region					
Southern	2,738	0.1	0.02	0.1	0.0
Highlands	420	0.3	0.3	0.3	0.3
Momase	1,835	3.3	2.8	0.7	0.2
Islands	1,879	3.4	2.8	1.1	0.6
*P-value**		*<0.001*	*<0.001*	*0.063*	*0.177*
Total	6872	1.8	1.6	0.5	0.2

*Weighted analysis. *Chi-square test*

In the Highlands and Momase villages located at or above 1600 m, only two of 1,536 blood samples were found to be infected (one *P. falciparum* infection, one mixed *P. falciparum* & *P. vivax* infection).

Parasite prevalence was low throughout the country, but highest in the Islands and Momase regions. Parasite-positive slides were found in 11 province, in 26 (28%) of the 92 survey villages. In villages with positive slides, prevalence rates ranged from 0.6% to 15.3%. Provincial level malaria parasite prevalence is presented in Appendix C.

3.2. Clinical Incidence

Figure 7 presents the year five (2014) target and result, as measured by longitudinal surveillance in four sentinel sites, for the primary impact indicator: Number of malaria cases detected per 1000 population/per year. A comparison with results obtained from years two, three and four are also presented.

Key impact indicator	**Target**	**Result**
Annual parasite incidence: Number of cases detected per 1000 population/per year:	150/1000	48/1000

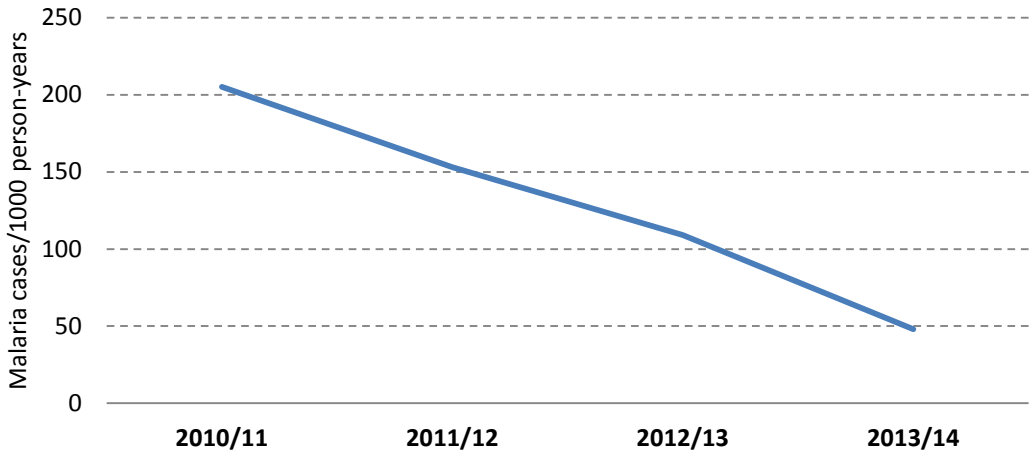

Figure 7: Time trend in clinical incidence, pooled data from 4 sentinel surveillance sites

The pooled crude malaria incidence rate for the period August 2013 – July 2014 was 48 cases per 1000 person years/per year in the four PNGIMR sentinel surveillance sites. This represents a continued reduction in crude malaria incidence of approximately 50 cases per 1000 person years/per year in these sites since August 2010.

As shown in Table 7, the crude malaria incidence rate is lowest in the Highlands site at Karimui (2/1000) and highest in the Momase site at Sausi (137/1000). While the reduction across the pooled sites has declined at a consistent rate, the rate of reduction is not consistent between sites and fluctuations across time are evident (Table 7).

Table 7: Incidence of RDT-confirmed malaria in the four regions of Papua New Guinea for the period August 2013-July 2014.

Region Province (Health Facility)	**Population 2013/14 (number)[1]**	**Total screening days (number)**	**Total screening years (number)**	**Screening person-time (person-years)**	**Total RDT positive cases (number)**	**Crude Malaria Incidence Rate (RDT positive cases / 1000 person-years) August 13 – July 14**	*Crude Malaria Incidence Rate* *Aug 12 – Jul 13[2]*	*Crude Malaria Incidence Rate* *Aug 11 – Jul 12[3]*	*Crude Malaria Incidence Rate* *Aug 10 – Jul 11[4]*
Southern									
Milne Bay (East Cape HC)	6376	238	0.65	4144.4	331	**80**	184	204	251
Highlands									
Chimbu (Sigimaru HC)	10044	187	0.51	5122.4	8	**2**	13	9	186
Momase									
Madang (Sausi HC)	5677	171	0.47	2668.2	365	**137**	93	109	154
Islands									
New Ireland (Lemakot HC)	12668	225	0.62	7854.2	255	**32**	153	238	199
Sentinel Sites (Pooled)	34765	-	-	19789.2	959	**48**	109	153	205

[1] Total population calculations based on 2012/2013 PNGIMR population census in the catchment area and adjusted using the following annual growth rates (as provided by NDoH): Milne Bay 0.0250; Chimbu 0.0180; Madang 0.0270; and New Ireland 0.0290.
[2] Comparison period as reported in: Pulford et al. Report on Incidence of Confirmed Malaria in Sentinel Surveillance Sites: Year 4 (2012/2013). Goroka: PNG IMR, 2014.
[3] Comparison period, as reported in: Hetzel et al. Report on Incidence of Confirmed Malaria in Sentinel Surveillance Sites: Year 3 (2011/2012). Goroka: PNG IMR, 2013.
[4] Comparison period, as reported in: Hetzel & Cuervo-Rojas. Preliminary Report on Year 2 Outcome and Impact Indicators. Goroka: PNG IMR, 2011.

3.3.All-Cause Mortality.

Figure 8 presents the result, across multiple five year intervals, for the primary impact indicator: all-cause mortality rate among children <5 years of age. A target was not determined for this indicator and the time trend data are based on a retrospective analysis of birth histories obtained from women of reproductive age (15-49 years) during the 2014 HHS.

Key impact indicator	**Period**	**Result** (95% CI)
All-cause mortality rate among children younger than 5 years of age:	2005-09	53.4/1000 (39.2, 72.6)
	2010-14	46.2/1000 (33.9, 64.4)

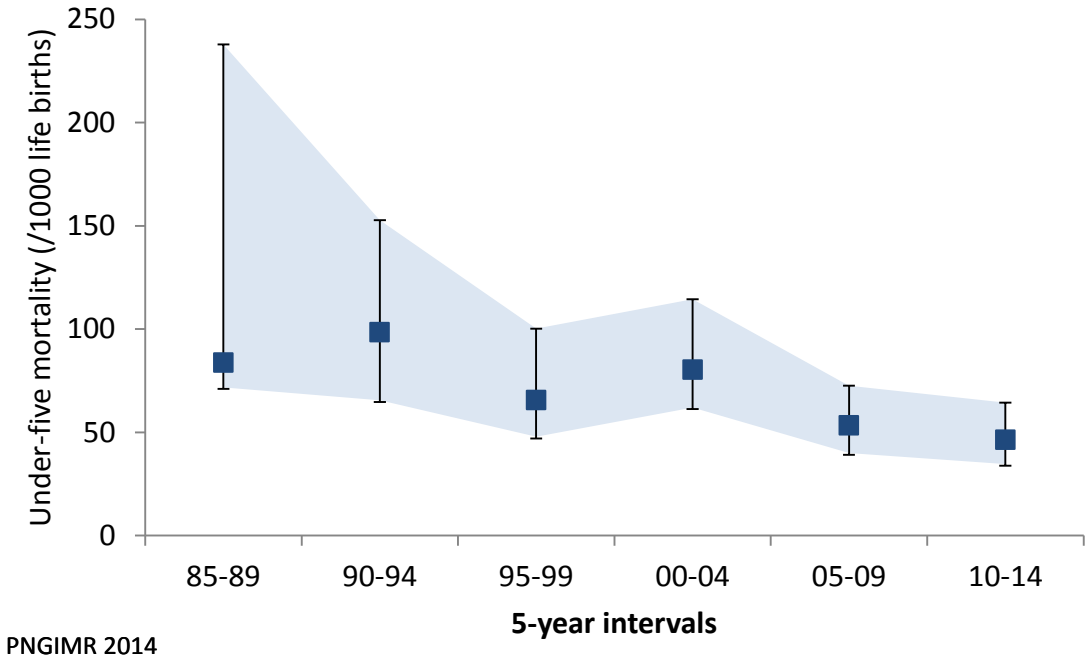

Figure 8: Time trend in <5 yrs all-cause mortality (national level data)

As shown in Figure 8 and Table 8, the national all-cause mortality rate among children under five years of age for the five year period of the current GF Round 8 grant(2010-2014) was 46.2/1000 live births. This represents a decrease in all-cause mortality when compared to the five year period immediately preceding the current grant (2005-2009, 53.4/1000) and is the lowest rate in all of the five year periods (dating back to 1985-1989) that could be calculated from the 2014 HHS birth history data.

At the regional level, the all-cause mortality rate for children under five years of age in the 2010-2014 period was lowest in the Islands region (40.3/1000) and highest in the Southern region (55.3/1000). However, while in Southern, Highlands and Momase regions, a general declining trend could be observed, this was not the case for the Islands region in which the rate of 40.3/1000 (2010-2014) represented a substantial increase on the reported mortality rate for the two subsequent time periods (2000-2004, 16.1/1000; 2005-2009, 18.7/1000). Having said this, the 95% confidence intervals for the regional level data are particularly large due to the smaller number of observations and the findings should be interpreted cautiously at this level as should all reported mortality rates for the periods prior to 2005 at both regional and national levels (small sample sizes and irregularities in the birth- and sex-ratios for these earlier periods limit confidence in the reported data).

Table 8: All-cause mortality rates for children under five years of age across five year intervals by region and nationwide[1]

Interval	Southern	Highlands	Momase	Islands	PNG
	/1000 (95% CI)	/1000 (95% CI)	/1000 (95% CI)	/1000 (95% CI)	/1000 (95% CI)
1985-1989	-	-	-	-	83.7 (71.0, 237.8)
1990-1994	121.7 (95.9, 278.3)	-	119.0 (76.6, 220.2)	-	98.4 (64.7, 152.8)
1995-1999	43.5 (26.6, 94.6)	61.8 (42.4, 158.2)	77.5 (44.8, 145.2)	80.8 (48.6, 242.4)	65.5 (47.1, 100.2)
2000-2004	79.3 (53.8, 116.8)	91.3 (64.8, 169.8)	83.0 (58.4, 159.1)	16.1 (7.7, 87.6)	80.2 (61.2, 114.5)
2005-2009	56.3 (36.2, 97.0)	54.1 (36.0, 107.7)	58.8 (36.6, 103.6)	18.7 (7.8, 59.3)	53.4 (39.2, 72.6)
2010-2014	55.3 (36.5, 94.3)	44.6 (24.4, 83.6)	44.5 (26.9, 87.2)	40.3 (20.5, 93.0)	46.2 (33.9, 64.4)

1. Estimated rates reported for the mid-point of each specified interval

4. DISCUSSION

Program Outcome

Time trend analyses of the primary outcome indicators suggest that LLIN coverage, when measured as the percentage of households owning two or more LLIN, and use among children under five and pregnant women plateaued after the first phase (years 2009-2011) of the Round 8 grant support. Despite all three of these LLIN-related indicators showing substantial improvement in this first phase, only minor increases in the second phase (2012-2014) were observed and all three remained well below the year five targets at the time of program conclusion (2014). However, more detailed analyses revealed continued improvement in LLIN access, when measured as ownership of at least two LLIN per household (80% in three out of the four regions of PNG), as proportion of households with one LLIN per two people (increase from 21% to 55%) and as population access to a LLIN within each one's household (increase from 44% to 68%).With the latter being the most relevant indicator of access, there is an evident potential for improvement, which may be addressed by providing more LLINs, particularly to larger households. However, the proportion of people using a LLIN remains substantially below the proportion of people with access to a LLIN. This gap between access and use is most likely linked to human behavioural factors.

On balance, these findings suggest that the current LLIN distribution strategy may be close to achieving its maximum coverage potential. Limitations in LLIN access may be most relevant in larger households and in locations without recent LLIN distribution. Current rates of LLIN usage may reflect to a large degree people's willingness to use a LLIN. Thus, to achieve greater household coverage (ie. to reach the 90% target) and to improve LLIN usage, new strategies may need to be introduced in the next program phase (2014-2018). Ideally, strategies that build on and strengthen the existing LLIN program and ensure continuous supply of LLINs to all households should be favoured as, despite falling short of program targets, this program has achieved substantial increases in LLIN access and has undoubtedly contributed significantly to the very impressive program impact (discussed below).

Further investigations into the longevity and retention rates of LLINs as well as human behavioural factors related to net use in different transmission settings are needed to better understand reasons for gaps in LLIN ownership and use.

Progress on the outcome indicator pertaining to treatment seeking for febrile illness fell well short of the program target for year five; however, progress was evident in terms of the percentage of febrile cases receiving a malaria rapid diagnostic test (RDT) and 80% of malaria RDT positive cases received the appropriate antimalarial in 2014. The utility of this indicator is somewhat in doubt given the rapidly changing malaria epidemiology in PNG. With a decreasing proportion of febrile illnesses attributable to malaria, the assessment of treatment rates should focus on confirmed malaria rather than unspecific febrile illnesses. However, there are unsolved technical issues related to retrospectively assessing malaria infection. Nevertheless, there clearly remains considerable scope to improve access to appropriate malaria testing in cases of febrile illness as well as access to artemether lumefantrine (AL). As health facility access was consistently low across the 2009-2014 NMCP, then further consideration should be given to programs that promote RDT/AL access at the community level (such as those facilitated by Population Services International in West and East Sepik and East New Britain). Further investigations into reasons for not attending formal health facilities might usefully inform ongoing and future initiatives aimed at improving primary health care service delivery. The IPTp coverage data suggest considerable scope for improving malaria prophylaxis in the next NMCP. The fact that over 80% of women who gave birth between 2008-2014 reported receiving some form of malaria prophylaxis indicates that the opportunity to provide an effective prophylaxis exists; health workers need better support to provide the policy recommended antimalarials.

Program Impact

The three primary impact indicators align well with each other in that each shows a consistent decline in malaria morbidity or mortality over the course of the 2009-2014 period. The reductions in malaria prevalence between 2009 and 2014, in both children aged between 6-59 months and the general population, are substantial (12.4% to 1.8%) as is the reduction in incidence of outpatient malaria cases reported at the four sentinel surveillance sites (205/1000 to 48/1000). Furthermore, the reported reductions in malaria prevalence and clinical incidence have considerably surpassed the program targets and, when viewed in conjunction

with the decreasing all-cause mortality rate among children under five, strongly suggest the GF supported NMCP has exceeded expectations in terms of health impact. But the sentinel site data in particular also reveal that the reductions in incidence and transmission are not homogeneous throughout the country and evidence from entomological surveys (not presented as part of this report) clearly shows that the transmission potential is still intact.

Conclusion

The 2009-2014 GF support to the NMCP has resulted in major (but stagnating) improvements in LLIN coverage and use, some improvement in malaria treatment seeking and a marked decline in malaria prevalence and incidence. Whilst a dearth of reliable data from previous decades limits comparisons, it is perhaps not unreasonable to conclude on the basis of the reported findings that over the period 2009 to 2014, the NMCP has achieved the greatest reduction in malaria prevalence and incidence, and to the lowest levels, in the history of malaria control in PNG. This should rightly be recognised as a major accomplishment. What offers even greater encouragement, is that the outcome data suggest there is still considerable scope to obtain further impact from the existing suite of program interventions if complementary strategies are introduced (e.g. intensified LLIN use campaigns, scale up of HMM, etc.). At the same time, it should be noted that the decline in malaria occurred over a period of gradually intensifying malaria control and that a failure to maintain the level of interventions at the current level may lead to a rapid resurgence of malaria as observed in the 1980s.

APPENDIX A: PNGIMR HOUSEHOLD SURVEY (HHS) SAMPLE, 2013/14

Household interviews (outcome indicators 1, 2 & 3)

The PNGIMR HHS 2013/14 was conducted in 92 villages across 19 provinces, whereas Jiwaka and Hela were still considered part of their respective former provinces and West New Britain Province was excluded.

Sixty-six (71.7%) villages were located below 1200 m altitude, 4 (4.3%) villages between 1200 and 1599 m and 22 (23.9%) villages at 1600 m or above. The low number of villages at an intermediate altitude reflects the population distribution in PNG.

A total of 2,167 household interviews were completed with a median number of 116 households per province (interquartile range [IQR] 108, 124) and 25 (IQR 20, 27) households per village.

The sample included observations of 11,665 individuals who slept in the surveyed households the night before the survey with a median number of 591 (IQR 560.5, 668) individuals per province and 127 (IQR 98, 151) per village. Of the 11,665 individuals who slept in one of the survey households the previous night, 50.2% were female, 14.3% were below five years of age and 155 were pregnant women age 15-49 years. The median age of household members present last night was 19 years (IQR 8, 36).

Table 9 presents the number of surveyed households and household members by province and region. Table 10 presents the age breakdown of household members present the night prior to the survey.

Table 9: Survey sample by province and region

Region	Province	Villages		Households*		Individuals[$]	
		N	(%)	N	(%)	N	(%)
Southern	01 Western	5	5.4	106	4.9	588	5.0
	02 Gulf	4	4.3	109	5.0	639	5.5
	03 Central	5	5.4	125	5.8	773	6.6
	04 NCD	4	4.3	81	3.7	680	5.8
	05 Milne Bay	4	4.3	90	4.2	400	3.4
	06 Oro	5	5.4	117	5.4	791	6.8
	Total Southern	**27**		**628**		**3,871**	
Highlands	07 Southern Highlands	4	4.3	98	4.5	387	3.3
	08 Enga	6	6.5	135	6.2	652	5.6
	09 Western Highlands	5	5.4	129	6.0	656	5.6
	10 Chimbu	5	5.4	110	5.1	477	4.1
	11 Eastern Highlands	5	5.4	124	5.7	560	4.8
	Total Highlands	**25**		**596**		**2,732**	
Momase	12 Morobe	5	5.4	107	4.9	515	4.4
	13 Madang	5	5.4	121	5.6	845	7.2
	14 East Sepik	6	6.5	124	5.7	561	4.8
	15 Sandaun	4	4.3	110	5.1	767	6.6
	Total Momase	**20**		**462**		**2,688**	
Islands	16 Manus	5	5.4	130	6.0	620	5.3
	17 New Ireland	5	5.4	120	5.5	591	5.1
	18 East New Britain	5	5.4	115	5.3	580	5.0
	19 West New Britain	Not covered					
	20 Bougainville	5	5.4	116	5.4	583	5.0
	Total Islands	**20**		**481**		**2,374**	
	Total	**92**		**2,167**		**11,665**	

Percentages are column proportions. NCD = National Capital District; *Completed household interviews. [$]Present in household last night.

Table 10: Age break-down of household members present the night prior to the survey

Age group (years)	N	%
<5	1,672	14.3
5-9	1,667	14.3
10-14	1,489	12.8
15-19	1,167	10.0
20+	5,663	48.6
Missing	7	0.1
Total	**11,665**	**100.0**

Blood samples (impact indicator 1)

Capillary blood samples were collected from 8,408 individuals with a median number of 429 (IQR 358, 499) per province and 88 (IQR 71, 110) per village. Overall, 11.7% were below the age of five years and 52.2% were female. An age break-down by region is presented in Table 11.

Table 11: Number of blood samples by age group and region

Age group	Southern		Highlands		Momase		Islands		Total	
	N	%	N	%	N	%	N	%	N	%
0.5-4	329	12.0	171	9.4	276	14.0	209	11.1	985	11.7
5-9	389	14.2	210	11.6	299	15.1	320	17.0	1,218	14.5
10-14	313	11.4	165	9.1	216	10.9	250	13.3	944	11.2
15-19	239	8.7	165	9.1	159	8.0	165	8.8	728	8.7
20+	1,458	53.3	1,065	58.7	1,022	51.7	932	49.6	4,477	53.2
Missing	10	0.4	38	2.1	5	0.3	3	0.2	56	0.7
Total	2,738		1,814		1,977		1,879		8,408	

Most blood samples (77.8%) were collected from individuals living in villages below 1200 m altitude and 4.0% from villages located between 1200 and 1599 m. A total of 1,394 participants from the Highlands region, and 142 from Momase, originated from villages located at 1600 m altitude or higher (in total 18.3%). National-level prevalence calculations presented in this report are based on result from the 6,872 participants living in villages below 1600 m altitude, where the climate is favourable for endemic transmission, in order to allow for results to be compared with previous surveys (2008/09 and 2010/11). Data from villages located at 1600 m or higher is presented separately.

Treatment-seeking interviews (outcome indicator 4)

A total of 390 household members were reported to have had a febrile illness episode in the past two weeks, 103 (26.4%) of them were children below five years of age (Table 12) and 198 (50.8%) were female. The median number of cases per province was 20 (IQR 12, 30).

Table 12: Age break-down of household members reporting a febrile illness in the two weeks prior to survey.

Age group (years)	N	%
<5	103	26.4
5-9	75	19.2
10-14	25	6.4
15-19	13	3.3
20+	169	43.3
Missing	5	1.3
Total	**390**	**100**

Female household Members of Reproductive Age (15-49 years) interviews (impact indicator 3 and IPTp coverage)

Across participating households, a total of 2,826 females of reproductive age (15-49yrs) were reported to have resided in the house the night prior to survey. Birth history (to calculate all-cause mortality in children under 5) and IPTp coverage (for most recent birth since 2008) data were obtained from 65.6% (1854/2826) of these women. The median number of interviews per province was 91 (IQR 63, 134).

APPENDIX B: SENTINEL SURVEILLANCE SAMPLE, Jul 2010- Jul 2014

Table 13: Surveillance data recorded across four sentinel health facilities for the period July 2010 to July 2014 (impact indicator 2)

		MONTHS											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
EAST CAPE													
2010	**No. Screened**							104	160	186	181	312	161
	No. RDT +							44	71	135	127	170	104
	Days screened							18	28	29	28	29	18
	RDT positivity							42%	44%	73%	70%	54%	65%
2011	**No. Screened**	245	243	195	143	173	106	75	90	68	105	78	59
	No. RDT +	143	141	120	68	59	19	26	25	11	19	23	31
	Days screened	24	24	26	24	27	18	21	26	25	26	20	20
	RDT positivity	58%	58%	62%	48%	34%	18%	35%	28%	16%	18%	29%	53%
2012	**No. Screened**	170	245	177	199	287	191	88	120	151	164	107	83
	No. RDT +	91	150	119	94	210	115	43	54	66	43	27	25
	Days screened	25	25	27	22	27	26	17	26	24	27	26	16
	RDT positivity	54%	61%	67%	47%	73%	60%	49%	45%	44%	26%	25%	30%
2013	**No. Screened**	212	197	205	326	304	129	127	74	57	49	93	17
	No. RDT +	106	106	127	106	126	78	51	17	17	8	28	4
	Days screened	24	24	24	25	27	24	25	23	25	15	25	7
	RDT positivity	50%	54%	62%	63%	41%	60%	40%	23%	30%	16%	30%	24%
2014	**No. Screened**	164	126	118	63	81	74	40					
	No. RDT +	78	33	62	24	29	22	9					
	Days screened	20	20	21	20	22	19	21					
	RDT positivity	48%	26%	53%	38%	36%	30%	23%					
KARIMUI													
2010	**No. Screened**											221	
	No. RDT +											163	
	Days screened											7	
	RDT positivity											74%	
2011	**No. Screened**		104	79	166	112	95	68	48	46	45	38	25
	No. RDT +		55	39	67	38	37	28	9	9	6	6	1
	Days screened		10	8	19	19	20	16	22	20	20	22	22
	RDT positivity		53%	49%	40%	34%	39%	41%	19%	20%	13%	16%	4%
2012	**No. Screened**	23			61	103	22		34	113	142	129	
	No. RDT +	2			3	5	0		0	16	10	10	
	Days screened	22			19	31	10		10	28	31	29	
	RDT positivity	9%			5%	5%	0%		0%	14%	7%	8%	
2013	**No. Screened**	89	60	122	170	46	61	63	42				50
	No. RDT +	14	2	13	14	3	1	3	2				3
	Days screened	19	18	25	26	14	24	28	25				15
	RDT positivity	16%	3%	11%	8%	7%	2%	5%	5%				6%
2014	**No. Screened**	99	82	126	48	52	67	46					
	No. RDT +	1	0	0	1	0	0	1					
	Days screened	27	21	20	17	21	21	20					
	RDT positivity	1%	0%	0%	2%	0%	0%	2%					

		MONTHS											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SAUSI													
2010	**No. Screened**								4	135	112	85	167
	No. RDT +								1	30	23	16	34
	Days screened								1	21	18	13	20
	RDT positivity								25%	22%	21%	19%	20%
2011	**No. Screened**	231	164	246	152	137	79	96	87	53	113	78	76
	No. RDT +	81	67	82	43	37	20	21	17	7	19	18	5
	Days screened	23	18	23	17	20	14	20	18	21	21	20	14
	RDT positivity	35%	41%	33%	28%	27%	25%	22%	20%	13%	17%	23%	7%
2012	**No. Screened**	174	188	164	264	137	118	135	198	130	183	155	132
	No. RDT +	41	45	43	86	26	26	27	63	29	33	27	20
	Days screened	21	21	21	19	15	20	15	20	18	20	21	13
	RDT positivity	24%	24%	26%	33%	19%	22%	20%	32%	22%	18%	17%	15%
2013	**No. Screened**		150	116	88	113	114	40	134	72	144	90	40
	No. RDT +		25	14	12	9	17	12	34	20	22	45	16
	Days screened		17	17	20	19	14	6	18	10	23	14	6
	RDT positivity		17%	12%	14%	8%	15%	30%	25%	28%	15%	50%	40%
2014	**No. Screened**	50	139	111	59	56	182	110					
	No. RDT +	12	52	26	14	15	72	37					
	Days screened	10	20	16	12	13	19	10					
	RDT positivity	24%	37%	23%	24%	27%	40%	34%					
LEMAKOT													
2010	**No. Screened**												
	No. RDT +												
	Days screened												
	RDT positivity												
2011	**No. Screened**	194	354	326	368	577	331	223	266	202	104	200	185
	No. RDT +	56	113	103	160	193	149	87	66	37	23	63	55
	Days screened	20	24	25	22	21	19	21	22	21	11	22	20
	RDT positivity	29%	32%	32%	43%	33%	45%	39%	25%	18%	22%	32%	30%
2012	**No. Screened**	180	256	300	145	520	300	221	269	245	199	280	121
	No. RDT +	67	143	195	98	402	250	182	256	146	145	48	49
	Days screened	20	21	22	15	22	17	14	22	19	12	22	15
	RDT positivity	37%	56%	65%	68%	77%	83%	82%	95%	60%	73%	17%	40%
2013	**No. Screened**	181	232	246	278	274	204	143	139	111	68	109	52
	No. RDT +	75	146	56	74	75	44	37	36	21	8	19	13
	Days screened	19	18	20	20	16	19	19	19	19	13	19	15
	RDT positivity	41%	63%	23%	27%	27%	22%	26%	26%	19%	12%	17%	25%
2014	**No. Screened**	135	102	96	91	89	178	148					
	No. RDT +	22	40	23	18	16	19	20					
	Days screened	18	19	20	21	22	20	20					
	RDT positivity	16%	39%	24%	20%	18%	11%	14%					

APPENDIX C: ADDITIONAL DATA TABLES

Table 14: Key indicators of mosquito net use in children under five years of age, HHS 2014

	% HH members who slept under net last night	% HH members who slept under LLIN last night	Number of HH members
Region			
Southern	60.6	59.7	532
Highlands	48.2	48.2	365
Momase	71.2	69.0	446
Islands	61.8	61.7	329
P-value	*0.014*	*0.021*	
Sex			
M	61.6	60.7	865
F	59.4	58.3	800
P-value	*0.567*	*0.519*	
Overall	**60.5**	**59.5**	**1,672**

Weighted analysis.

Table 15: Key indicators of mosquito net use by pregnant women, HHS 2014

	% HH members who slept under net last night	% HH members who slept under LLIN last night	Number of HH members
Region			
Southern	70.3	68.6	38
Highlands	36.9	36.9	41
Momase	57.3	56.7	43
Islands	30.5	30.5	24
P-value	*0.071*	*0.085*	
Overall	50.1	49.6	146

Weighted analysis.

Table 16: Province-level malaria parasite prevalence (< 1600 m altitude), HHS 2014

Province		Parasite prevalence (%)			
	N	Overall	*P. falciparum*	*P. vivax*	*Pf* + *Pv* mixed
01 Western	504	0	0	0	0
02 Gulf	504	0.20	0.20	0	0
03 Central	474	0	0	0	0
04 NCD	301	0	0	0	0
05 Milne Bay	324	0.93	0	0.93	0
06 Oro	631	0	0	0	0
07 Southern Highlands	335	0.30	0.30	0	0
08 Enga	335	0	0	0	0
09 Western Highlands	377	0.53	0.53	0.53	0.53
10 Chimbu	338	0	0	0	0
11 Eastern Highlands	429	0	0	0	0
12 Morobe	424	0.24	0.24	0	0
13 Madang	447	6.26	6.26	0.22	0.22
14 East Sepik	461	1.08	0.87	0.43	0.22
15 Sandaun	645	6.05	4.50	2.17	0.62
16 Manus	547	0.73	0.18	0.55	0
17 New Ireland	494	3.24	2.83	1.21	0.81
18 East New Britain	409	7.09	5.87	2.69	1.47
19 West New Britain					
20 Bougainville	429	0	0	0	0