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ROUND 8 MALARIA CONTROL PROGRAM EVALUATION 2009 - 2014

REPORT ON

COUNTRY-WIDE HOUSEHOLD SURVEY 2010/11: MALARIA CONTROL INTERVENTION COVERAGE AND PREVALENCE OF PARASITAEMIA

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DEDICATION

This report is dedicated to the memory of **Gibson Gideon**, **Tania Oakiva**, **Lydia Petrus**, **Leonard Vavana** and **George Dogoya**. Our five PNG IMR staff members and three boat operators disappeared on 1st of August 2011 without a trace from West New Britain province. The team was conducting field work for the malaria household survey presented in this report.

Despite weeks of intensive search funded by our Institute and supported by friends and collaborators from PNG and around the world, we remain, until today, in uncertainty about what has really happened to them. Many rumours have arisen, have been recited in local media, and have unsettled families and friends. Yet, despite strong evidence of a crime and repeated promises from an official side, the Royal Papua New Guinea Constabulary is yet to release a police report.

We remain with hope that one day our friends might return to us. But we are ready to accept the truth, whatever it may be, should it ever be revealed to us. In our hearts, our thoughts, and our prayers, our five friends will always be with us.

EXECUTIVE SUMMARY

Background

The PNG National Malaria Control Program (NMCP) has been implementing two successive grants form the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) since 2004. The interventions supported by these grants include the free distribution of long-lasting insecticide treated mosquito nets (LLIN), improved malaria diagnosis and artemisinin-based combination therapy (ACT) in health facilities and supportive behaviour change and advocacy campaigns.

Methods

A comprehensive independent evaluation program, implemented by the PNG Institute of Medical Research (PNG IMR), is an integral part of the Round 8 grant (2009-2014). As part of the evaluation, PNG IMR carried out a country-wide household survey in 2010/11 assessing the coverage with household-level malaria interventions and the community prevalence of malaria infection. The survey covered a random sample of 1,997 households in 77 villages across 17 provinces. Blood samples were collected from 9,982 individuals.

Results

Across PNG, 81.7% of all households owned at least one, 60.9% at least two LLIN. Ownership was highest in the Islands region (98.3% and 83.6%, respectively). Usage of LLIN the previous night amounted to 48.9% in the general population, 59% in children under five and 50.6% in pregnant women. LLIN usage was lowest in the Islands Region (overall 40.0%, children under five 48.2%).

Most LLIN had been obtained through village-based distributions (78.6%) and health facilities/ante-natal clinics (10.8%) and the majority of nets were less than 2 years old. LLIN found in households were generally newer and in better condition than non-LLIN.

In villages below 1600 m altitude, 6.7% of the general population were infected with malaria parasites. Species-specific prevalence rates were 3.4% for *P. falciparum*, 2.1% *P. vivax*, 0.05% *P. malariae* and 0.1% mixed infections of *P. falciparum* and another species. Parasite prevalence in children under five years of age reached 13.3% for any species, 7.6% for *P. falciparum*, 5.3% *P. vivax* and 0.4% mixed infections. *P. falciparum* peaked in children aged 1-5 years, *P. vivax* in children below 1 year. Parasite prevalence rates showed significant regional differences with the highest prevalence observed in the Islands regions. Endemicity decreased with altitude.

Of all individuals reporting a febrile illness in the past two weeks, 23.1% were treated according to the applicable guidelines for the treatment of uncomplicated malaria (chloroquine or amodiaquine plus sulphadoxine-pyrimethamine). In children under five years, 32.4% were treated accordingly. Chloroquine monotherapy was reported as the most frequently administered treatment. Artemisinin monotherapies were taken by 7.5% of all fever patients. Only one case of ACT treatment was found.

Conclusions

Ownership and usage of mosquito nets increased markedly since the last survey conducted in 2008/09. For both indicators, the Global Fund performance target for year 2 was contained within the 95% confidence interval of the measured value. Treatment according to national guidelines, however, remained below the target, particularly if ACT were considered the appropriate medication. The impact of the program was reflected in an impressive 50% drop in country-wide malaria prevalence when compared to 2008/09. The measured value already fell below the year 5 target for this indicator. It is highly plausible that reduction in prevalence is a direct impact of the NMCP interventions.

CONTENTS

ABBREVIATIONS

ACT	Artemisinin-based Combination Therapy
AQ	Amodiaquine
CCM	Country Coordinating Mechanism
CI	Confidence Interval
CQ	Chloroquine
GFATM	The Global Fund to Fight AIDS, Tuberculosis and Malaria
GPS	Global Positioning System
Hb	Haemoglobin
IQR	Interquartile Range
LLIN	Long-Lasting Insecticide Treated Net
NCD	National Capital District
NDoH	National Department of Health
NMCP	National Malaria Control Program
NGO	Non-Governmental Organization
OR	Odds Ratio
Pf	*Plasmodium falciparum*
PNG	Papua New Guinea
PNG IMR	Papua New Guinea Institute of Medical Research
PR	Principal Recipient
PSI	Population Services International
Pv	*Plasmodium vivax*
RAM	Rotarians Against Malaria
RDT	Rapid Diagnostic Test
SOP	Standard Operating Procedure
SP	Sulphadoxine-Pyrimethamine
SR	Sub-Recipient
WBC	White Blood Cell
WHO	World Health Organization

1 INTRODUCTION

1.1 The PNG National Malaria Control Program

The PNG National Malaria Control Program (NMCP) has been financially supported by The Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) since 2004. The first GFATM malaria grant (Round 3 grant, 2004-2009) provided PNG with the necessary resources to roll out a free distribution campaign of long-lasting insecticide treated mosquito nets (LLIN) and invest in the improvement of malaria diagnosis in health facilities by introducing rapid diagnostic tests (RDT) and improving microscopy services on a limited scale.

In 2008, the PNG Country Coordinating Mechanism (CCM) submitted a successful proposal for a second five year malaria grant to GFATM (Round 8 grant, 2009-2014). The key objectives of the Round 8 grant build on the interventions initiated in Round 3 and cover the continued free distribution of LLIN, the introduction of artemisinin-based combination therapy (ACT) for malaria, the strengthening of malaria diagnosis at all levels, and communication and advocacy to increase malaria awareness and understanding in the community and at the political level.

The Round 8 grant was awarded to three Principal Recipients (PR): the National Department of Health (NDoH; succeeded by Oil Search Health Foundation in 2012), Rotarians Against Malaria (RAM) and Population Services International (PSI). During Phase I of the grant (2009-2011), Divine Word University/Diwai Pacific Ltd. implemented training programs for health care workers and laboratory technicians as Sub-Recipient (SR) of the grant.

A comprehensive monitoring and evaluation component is an integral part of the Round 8 proposal submitted to the GFATM.

The Papua New Guinea Institute of Medical Research (PNG IMR) is responsible for the overall independent evaluation of the outcomes and impact of the GFATM supported NMCP. The PNGIMR evaluation plan aims to assess key outcome and impact indicators against targets defined in the Round 8 grant performance framework. It also aims to validate routine data reporting mechanisms and provide accurate, up-to-date information on different aspects of the changing malaria epidemiology in PNG [1]. The five-year evaluation plan developed by PNG IMR combines several complementary data collection mechanisms aiming to simultaneously assess changes in intervention coverage as well as trends in malaria morbidity, mortality, and transmission [1].

This report presents key data collected by PNG IMR during the 2010/11 country-wide household survey. Results are presented in a format to satisfy requirements of the GFATM Round 8 grant performance framework. Changes over time are assessed primarily against the methodologically identical household survey conducted by PNG IMR under Round 3 in 2008/09 [2,3].

1.2 The Country-wide Household Survey 2010/11

Households are the primary target for community-based malaria control interventions such as LLINs. Since the inception of the Round 3 grant, the NDoH and RAM have distributed several million such nets for free across PNG. The PNG IMR Round 3 evaluation in 2008/09 found that the first distribution round contributed to a substantial increase in LLIN coverage reaching 64.6% household-ownership of LLIN. However, the number of nets was found to be insufficient and the distribution too heterogeneous to achieve the stipulated targets of 80% household LLIN ownership and 80% usage by children under five years and pregnant women [3]. On the side of treatment of clinical episodes, malaria drugs were found to be widely available in health facilities but only 10% of children were found to be treated according to national guidelines (at the time chloroquine or amodiaquine plus sulphadoxine-pyrimethamine for uncomplicated malaria) [2,4].

The country-wide household survey is one of the principal data sources for the grant evaluation. The aim of the survey is to simultaneously assess malaria control intervention coverage and population prevalence of parasitaemia. The household survey thus provides data for the evaluation of the following performance framework indicators:

- Impact indicator 1: Parasite prevalence: percentage of children aged 6 - 59 months with malaria infection
- Outcome indicator 1: Proportion of households with at least 2 LLINs.
- Outcome indicator 2: Proportion of pregnant women who slept under LLIN the previous night.
- Outcome indicator 3: Proportion of children under 5 years old who slept under LLIN the previous night.
- Outcome indicator 4: Percentage of children younger than 5 years of age with fever in the last 2 weeks who received antimalarial treatment according to national policy

The household survey will take place twice over the five year grant period (2010/11 and 2013/14), while the Round 3 survey conducted in 2008/09 serves as baseline.

2 METHODOLOGY

2.1 Study sites and population

This survey was planned to be conducted country-wide in all 20 provinces. Due to a major mishap during which five PNG IMR staff members went missing in West New Britain Province in August 2011 (see dedication at beginning of this report), data collection was discontinued after completing 17 out of 20 provinces.

Sampling of survey locations was based on a province-stratified multi-stage sampling approach. A random sample of five villages per province was drawn from a geo-referenced village database derived from the 2000 PNG National Census [5]. Two extra villages were sampled as back-up in case one of the initially sampled could not be surveyed. Random selection of villages was performed using Stata 8.1 software[1]. Within each village, 30 households were randomly selected from a household list established by the survey team leader and village representatives, following standard operating procedures[2]. In villages with less than 30 households, all households were included. A household was excluded if after three separate attempts there was no eligible household member (adult resident) available to provide consent and information. Within each sampled household, all present and consenting household members were eligible for blood collection. An age cut-off of 6 months was applied and no blood sample was collected from younger children. The rational for this cut-off was to increase acceptability of the survey within the community and in consideration of the generally low parasitaemia prevalence in this very young age group [6].

[1] SOP for Randomly Sampling Household Survey Villages. HHS01/2010/V2; V. Samof, PNG IMR, 17.09.2010.
[2] Procedure for Randomly Sampling Households within Survey Villages; M. Hetzel, PNG IMR, 25.11.2010.

2.2 Survey procedures

The survey was conducted between November 2010 and August 2011 by three trained field teams, each consisting of one scientific officer as team leader, at least one nursing officer and a research assistant. Teams were working simultaneously at different sites. All team members were trained in administering the survey questionnaires and the nursing officers underwent training in collecting capillary blood samples for microscopy slides according to established standard operating procedures.

Prior to surveying a particular province, the provincial health advisor was informed of the scope and timing of the survey and requested to commission a local health officer to accompany the PNG IMR survey team. Upon arrival in a study village, the survey team established contact with the local village leader/councilor in order to explain the purpose and procedures of the survey, obtain approval to conduct the field work, and establish a list of all households in the village in preparation for random sampling. Village locations and elevation above sea level were recorded with hand-held GPS devices (Garmin).

Three different survey instruments were used, including: 1) a household questionnaire applied to the head of randomly selected households, 2) a treatment seeking questionnaire for episodes of recent illness, 3) a prevalence form to accompany each collected blood sample, and 4) a village leader questionnaire to obtain background information on each survey location and village leader’s perceptions and attitudes towards malaria control. Data presented in this report focuses on data obtained in forms 1-3.

Capillary blood collection was performed by finger-stick by a registered nursing officer or community health worker. One thick and one thin smear were then prepared on the same glass slide for each survey participant. For symptomatic household members, a malaria RDT (ICT Combo, ICT Diagnostics, South Africa) was performed and positive cases were treated according to standard treatment guidelines[3]. At the same time, haemoglobin (Hb) levels were measured with a portable HemoCue Hb 201+ Analyser (HemoCue AB, Ängelholm, Sweden) and axillary temperature measured with an electronic thermometer.

2.3 Survey instruments

2.3.1 Household questionnaire

Following the design of the Malaria Indicator Survey Household Questionnaire [3,7], this instrument assessed coverage and usage of mosquito nets and exposure to BCC. The form recorded details of each household member and visitor in the household, socio-economic variables and details about each mosquito net (if any) present in the household at the time of the survey. For each net, details about its use the previous night were recorded, including a reference to the household member or visitor who slept under the net. Household members with a febrile illness episode in the last two weeks were identified with this instrument. The household questionnaire was applied to one adult member in each sampled household, preferably the household head

2.3.2 Treatment seeking questionnaire

This instrument was designed to elicit details on the treatment of recent febrile illness episodes, in particular the source of treatment and the type of medication taken (if any). The instrument was administered to each person reported to have had a febrile illness in the last two weeks or the parent/caretaker of such a person of he/she was under the age of 15 years.

[3] Febrile community members who were not part of sampled households were equally tested and provided with appropriate treatment or referred to the nearest health facility by a qualified team member.

2.3.3 Prevalence form

This instrument accompanied each blood sample collected from eligible and consenting household members. It recorded any previous or current antimalarial intake, recent travel, body temperature and Hb measurement data. The form was administered directly to the household member or his/her caretaker.

2.3.4 Village leader questionnaire

This form recorded background information on each survey village, such as GPS coordinates and basic weather information for the survey dates. The form also aimed at eliciting village leader's perceptions and attitudes towards health problems in their village and towards malaria control interventions. These aspects of the household survey will not be presented in this report.

2.4 Laboratory procedures

Thin blood smears were fixed with methanol in the field and thick and thin smears were stained with Giemsa upon return from the field following PNG IMR standard operating procedures. Thick and thin smears were read by light microscopy at the microscopy laboratories of PNG IMR in Madang and Goroka.

A minimum of 200 thick film fields were read before a slide was declared negative. In 2008/09, the number of parasites was counted until reaching 200 white blood cells (WBC). For positive slides, parasites were counted until completing the field that contained the 200th WBC. If the parasite count was <100, the count of parasites and WBCs continued until completing the field that contained the 500th WBC[4].

[4] SOP for Malaria Microscopy – Examining a blood slide. M08/11; L. Robinson, PNG IMR, 10.01.2011.

All slides were read twice by two different WHO accredited malaria microscopists. Confirmatory reads were performed by a senior microscopist in case of discordant results. A slide was considered positive for *Plasmodium* spp when at least two microscopists had found malaria parasites. In some instances, the identification of the *Plasmodium* species was compromised by the slide quality, e.g. as a result of long storage during field travels prior to staining, or due to auto-fixation. Positive slides which had three discordant species identifications after the third read were included in the analysis of overall parasite prevalence but not in the species-specific analysis.

2.5 Data analysis

All data were double-entered into a Visual Foxpro 9.0 (Microsoft) or DMSys (SigmaSoft international) database at PNG IMR Madang or Goroka and analysed with Stata (StataCorp LP, College Station, USA) software.

For household and individual level intervention coverage measurements, unweighted and weighted proportions were estimated using the survey design command set in Stata. The report presents aggregated national and regional level data as weighted proportions. Overall weights were calculated as the inverse of an observation's probability of selection. To account for the staged sampling strategy, the overall probability of selection was calculated as a product of the selection probabilities at each sampling stage, i.e. the probability of a village being selected within a district and the probability of a household being selected within a village. Since all individuals of the sampled household were eligible, individual level weights equalled the weights of the households to which an individual belonged.

Malaria parasitaemia data is presented as point prevalence of infection with any *Plasmodium* species or specifically with *P. falciparum*, *P. vivax*, *P. malariae*, *P. ovale*, i.e. as proportions of positives among all collected blood samples. National-level figures are weighted proportions including locations below 1600 meters altitude in order to ensure comparability with previous reports. Stata survey commands were applied to adjust confidence intervals (CI) for stratification by province and clustering at village-level.

Unweighted provincial and village level data are provided in the Appendix for reference purposes only. A table with the indicators specific to the grant performance framework can be found in Appendix 4. The aim of this evaluation was to provide national level estimates for the overall evaluation of the GFATM grant. The survey sample does therefore not necessarily allow for inferences to be made from provincial or village level estimates to the situation in the entire province.

Bivariate analyses included chi-square tests to assess dichotomous variables, Mann-Whitney U and Kruskal–Wallis tests to compare non-normally distributed continuous data, and t-tests to compare normally distributed continuous data.

2.6 Ethical considerations

Participation in this survey was voluntary. Verbal informed consent was obtained from the head of the sampled household from each interviewee and from individuals or caretakers prior to the collection of a blood sample. Household members who refused to give blood were only administered the accompanying questionnaire.

The study protocol was approved by the Institutional Review Board of PNG IMR (IMR IRB No. 0933) and the Medical Research Advisory Committee (MRAC No. 10.12).

3 RESULTS

3.1 Sample characteristics

3.1.1 Household and individual interviews

The household survey was conducted in 77 villages across 17 provinces, including 27 villages in Southern, 18 in the Highlands, 17 in Momase and 15 in the Islands region. Due to the reasons mentioned in the methods section, the provinces of West New Britain, Eastern Highlands and Autonomous Region of Bougainville were not covered. Fifty-eight (75.3%) villages were located below 1200 m altitude, 5 (6.5%) villages between 1200 and 1599 m and 14 (18.2%) villages in the Highlands region at 1600 m or above. The low number of villages at an intermediate altitude reflects the population distribution in PNG [8].

A total of 1,997 household interviews were completed with a median number of 118 households per province (interquartile range [IQR] 101, 135) and 27 (IQR 23, 30) households per village. The sample included observations of 12,534 individuals who slept in the surveyed households the night before the survey with a median number of 707 (IQR 643, 799) individuals per province and 162 (IQR 130, 191) per village. Table 1 presents the number of household and individual level observations by province and region; village-level data are presented in Appendix 1 for reference purposes only.

Of all individuals who slept in one of the survey households the previous night, 6, 239 (49.9%) were female, 1,777 (14.2%) were below five years of age, 1,878 (15%) between 5 and 9 years, 1,498 (12%) between 10 and 14 years, 1,333 (10.6%) between 15 and 19 years and 6,015 (48%) were 20 years or older. Age could not be established for 33 (0.3%) of all individuals. The median age of individuals was 19 (IQR 8, 34) years in Southern, 22 (IQR 10, 40) in the Highlands, 17 (IQR 7, 32) in Momase and 17 (IQR 7, 34) in the Islands region. The regional differences were statistically significant (Kruskal-Wallis rank test $P < 0.001$).

Table 1: Survey sample by province and region

Reg	Province	Villages n	Villages (%)	Households* n	Households* (%)	Individuals[$] n	Individuals[$] (%)
Southern	01 Western	3	(3.9)	73	(3.7)	452	(3.6)
	02 Gulf	4	(5.2)	116	(5.8)	738	(5.9)
	03 Central	5	(6.5)	155	(7.8)	1,029	(8.2)
	04 NCD	5	(6.5)	149	(7.5)	1,309	(10.4)
	05 Milne Bay	5	(6.5)	151	(7.6)	822	(6.6)
	06 Oro	5	(6.5)	141	(7.1)	909	(7.3)
	Total Southern	27		785		5,259	
Highlands	07 Southern Highlands	4	(5.2)	94	(4.7)	492	(3.9)
	08 Enga	5	(6.5)	117	(5.9)	621	(5.0)
	09 Western Highlands	5	(6.5)	128	(6.4)	664	(5.3)
	10 Chimbu	4	(5.2)	95	(4.8)	643	(5.1)
	11 Eastern Highlands	Not covered					
	Total Highlands	18		434		2,420	
Momase	12 Morobe	5	(6.5)	111	(5.6)	799	(6.4)
	13 Madang	4	(5.2)	101	(5.1)	653	(5.2)
	14 East Sepik	5	(6.5)	122	(6.1)	709	(5.7)
	15 Sandaun	3	(3.9)	62	(3.1)	516	(4.1)
	Total Momase	17		396		2,677	
Islands	16 Manus	5	(6.5)	118	(5.9)	688	(5.5)
	17 New Ireland	5	(6.5)	129	(6.5)	783	(6.3)
	18 East New Britain	5	(6.5)	135	(6.8)	707	(5.6)
	19 West New Britain	Not covered					
	20 Bougainville	Not covered					
	Total Islands	15		382		2,178	
	Total	77	(100)	1,997	(100)	12,534	(100)

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

Table 2 presents the age breakdown of household members by province and region. A total of 3,454 women between age 15 and 49 years were included in the sample, 128 (3.8%) of whom were reportedly pregnant at the time of the interview. Self-reported pregnancy did not differ between regions (P = 0.665).

The relative over-representation of Southern region in the survey sample was compensated in the analysis of results by applying weights as described in the methods section of this report.

Table 2: Individual-level survey sample by age group, province and region

Reg	Province	<1 year n (%)	1-4 years n (%)	5-9 years n (%)	10-14 years n (%)	15-19 years n (%)	20+ years n (%)	Total*
Southern	01 Western	6 (1.3)	52 (11.5)	71 (15.7)	72 (15.9)	60 (13.3)	191 (42.3)	452
	02 Gulf	23 (3.1)	82 (11.1)	107 (14.5)	92 (12.5)	77 (10.4)	357 (48.4)	738
	03 Central	33 (3.2)	149 (14.5)	171 (16.6)	142 (13.8)	114 (11.1)	415 (40.3)	1029
	04 NCD	33 (2.5)	115 (8.8)	145 (11.1)	116 (8.9)	146 (11.2)	745 (56.9)	1309
	05 Milne Bay	22 (2.7)	82 (10.0)	133 (16.2)	106 (12.9)	91 (11.1)	387 (47.1)	822
	06 Oro	21 (2.3)	105 (11.6)	130 (14.3)	115 (12.7)	111 (12.2)	423 (46.5)	909
	Total Southern	138 (2.6)	585 (11.1)	757 (14.4)	643 (12.2)	599 (11.4)	2,518 (47.9)	5,259
Highlands	07 Southern Highlands	11 (2.2)	45 (9.1)	85 (17.3)	63 (12.8)	45 (9.1)	240 (48.8)	492
	08 Enga	10 (1.6)	56 (9.0)	60 (9.7)	57 (9.2)	68 (11.0)	370 (59.6)	621
	09 Western Highlands	10 (1.5)	87 (13.1)	105 (15.8)	66 (9.9)	60 (9.0)	336 (50.6)	664
	10 Chimbu	4 (0.6)	55 (8.6)	69 (10.7)	80 (12.4)	70 (10.9)	360 (56.0)	643
	Total Highlands	35 (1.5)	243 (10.0)	319 (13.2)	266 (11.0)	243 (10.0)	1,306 (54.0)	2,420
Momase	12 Morobe	15 (1.9)	105 (13.1)	126 (15.8)	93 (11.6)	104 (13.0)	354 (44.3)	799
	13 Madang	12 (1.8)	97 (14.9)	99 (15.2)	76 (11.6)	78 (11.9)	290 (44.4)	653
	14 East Sepik	8 (1.1)	95 (13.4)	127 (17.9)	110 (15.5)	72 (10.2)	294 (41.5)	709
	15 Sandaun	7 (1.4)	74 (14.3)	78 (15.1)	59 (11.4)	49 (9.5)	249 (48.3)	516
	Total Momase	42 (1.6)	371 (13.9)	430 (16.1)	338 (12.6)	303 (11.3)	1,187 (44.3)	2,677
Islands	16 Manus	18 (2.6)	98 (14.2)	112 (16.3)	67 (9.7)	43 (6.3)	350 (50.9)	688
	17 New Ireland	22 (2.8)	120 (15.3)	146 (18.6)	85 (10.9)	64 (8.2)	346 (44.2)	783
	18 East New Britain	19 (2.7)	86 (12.2)	114 (16.1)	99 (14.0)	81 (11.5)	308 (43.6)	707
	Total Islands	59 (2.7)	304 (14.0)	372 (17.1)	251 (11.5)	188 (8.63)	1,004 (46.1)	2,178
	Overall	274 (2.2)	1,503 (12.0)	1,878 (15.0)	1,498 (12.0)	1,333 (10.6)	6,015 (48.0)	12,534

*Percentages are row proportions. Reg = Region. ; NCD = National Capital District; *Missing age values are not displayed in this table but are included in the totals.*

3.1.2 Blood samples

Capillary blood samples and corresponding individual background data were available from a total of 9,982 household members, ranging from 369 to 804 (median 629; IQR 485, 672) per province. The number of survey participants per village ranged from 21 to 217 (median 130; IQR 107, 155). Fifty-eight (75.3%) villages with 7,922 (79.4%) participants were located below 1200 m altitude, 5 (6.5%) villages with 543 (5.4%) participants between 1200 and 1599 m and 14 (18.2%) villages in the Highlands region with 1,517 (15.2%) participants at 1600 m or above.

Of all blood samples, 5,238 (52.5%) originated from female survey participants. A total of 1,395 (14.0%) were children 0.5 to 5 years, 1,600 (16.0%) 5 to 9 years, 1,132 (11.3%) 10 to 14 years, 883 (8.9%) 15 to 19 years and 4,957 (49.7%) 20 years of age or older. Fifteen (0.15%) participants could not be assigned to one of these age groups. Age distribution differed significantly between regions when including participants from villages above 1600 meters altitude (P < 0.001) but did not when this population was excluded (P = 0.073). The number and age distribution of survey participants providing a blood sample is presented in Table 3. Sample details by village can be found in Appendix 1.

Table 3: Number of blood samples by age group and region

Age group (years)	Region					Total
	Southern	Highlands <1600m	Highlands 1600+m	Momase	Islands	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
0.5-5	563 (14.5)	52 (12.1)	126 (8.3)	339 (15.4)	315 (16.1)	1,395 (14.0)
5-9	644 (16.6)	66 (15.3)	163 (10.7)	373 (16.9)	354 (18.1)	1,600 (16.0)
10-14	465 (12.0)	48 (11.1)	143 (9.4)	261 (11.8)	215 (11.0)	1,132 (11.3)
15-19	373 (9.6)	40 (9.3)	136 (9.0)	182 (8.3)	152 (7.8)	883 (8.8)
20+	1,817 (46.9)	225 (52.2)	945 (62.3)	1,046 (47.5)	924 (47.1)	4,957 (49.7)
Total	3,871 (100)	431 (100)	1,517 (100)	2,203 (100)	1,960 (100)	9,982 (100)

Percentages are column proportions.

In order to ensure comparability of results with the 2008/09 country-wide household survey [2] and between regions, only villages located below 1600 m altitude, where the climate is favourable for endemic perennial to low seasonal transmission, were included in the overall calculation of country-level prevalence rates.

3.1.3 Treatment-seeking interviews

In 77 villages, 462 household members reported to have had a febrile illness episode in the past two weeks, 136 of them were children below five years of age (Table 4). The calculation of community-level febrile illness rates can not be based directly on this data and is not part of this report.

Table 4: Sample of treatment seeking interviews by province and region

Reg	Province	Household members with fever in past two weeks		Children under five years with fever in past two weeks	
		n	**(%)**	**n**	**(%)**
Southern	01 Western	16	(3.5)	3	(2.2)
	02 Gulf	18	(3.9)	3	(2.2)
	03 Central	53	(11.5)	23	(16.9)
	04 NCD	37	(8.0)	13	(9.6)
	05 Milne Bay	37	(8.0)	10	(7.4)
	06 Oro	23	(5.0)	5	(3.7)
	Total Southern	184		57	
Highlands	07 Southern Highlands	9	(2.0)	0	0.0
	08 Enga	17	(3.7)	2	(1.5)
	09 Western Highlands	18	(3.9)	5	(3.7)
	10 Chimbu	20	(4.3)	2	(1.5)
	11 Eastern Highlands	Not covered			
	Total Highlands	64		9	
Momase	12 Morobe	24	(5.2)	7	(5.2)
	13 Madang	13	(2.8)	7	(5.2)
	14 East Sepik	11	(2.4)	3	(2.2)
	15 Sandaun	12	(2.6)	1	(0.7)
	Total Momase	60		18	
Islands	16 Manus	38	(8.2)	11	(8.1)
	17 New Ireland	75	(16.2)	26	(19.1)
	18 East New Britain	41	(8.9)	15	(11.0)
	19 West New Britain	Not covered			
	20 Bougainville	Not covered			
	Total Islands	154		52	
	Total	462	(100)	136	(100)

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

3.2 Mosquito net ownership

Country-wide, 81.7% (95% CI 74.4, 87.2) of all households owned a LLIN and 86.9% (79.3, 92.0) a mosquito net of any type. Two or more LLIN were found in 60.9% (52.2, 68.9) of the households. Net and LLIN ownership was highest in the Islands, where all net owning households had at least one LLIN. Key net ownership results are presented in Table 5.

Table 5: Key indicators of mosquito net ownership

Region	Households with at least one net	Number of nets per household	Households with one or more LLIN	Households with two or more LLIN	Number of LLIN per household	Number of households
	% (95% CI)	Mean (95% CI)	% (95% CI)	% (95% CI)	Mean (95% CI)	
Southern	96.9 (95.1, 98.1)	3.8 (3.5, 4.0)	94.3 (91.6, 96.2)	66.9 (55.3, 76.8)	2.5 (2.1, 2.9)	784
Highlands	78.2 (64.2, 87.8)	2.9 (2.0, 3.8)	75.7 (62.2, 85.5)	54.6 (38.6, 69.7)	1.7 (1.3, 2.2)	434
Momase	90.2 (81.5, 95.0)	3.1 (2.7, 3.5)	75.4 (62.9, 84.8)	58.9 (48.6, 68.4)	1.9 (1.4, 2.4)	396
Islands	98.3 (95.0, 99.4)	3.5 (3.2, 3.7)	98.3 (95.0, 99.4)	83.6 (78.5, 87.6)	3.1 (3.0, 3.3)	382
P-value	*<0.001**	*0.017$*	*0.002**	*0.065**	*<0.001$*	
Overall	86.9 (79.3, 92.0)	3.2 (2.8, 3.6)	81.7 (74.4, 87.2)	60.9 (52.2, 68.9)	2.1 (1.8, 2.3)	1,997

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

3.3 Mosquito net usage

Overall, 48.9% (95% CI 42.4, 55.5) of all surveyed individuals had used a LLIN the previous night and 55.5% (48.6, 62.3) a net of any type (Table 6). In the target group of children under five years of age, 59.0% (51.6, 66.0) had used a LLIN and 66.3% (58.4, 73.3) any type of net (Table 7). Among pregnant women, 50.6% (39.8, 61.3) had used a LLIN and 56.8% (46.6, 66.4) had slept under any type of net (Table 8).

Usage of nets in general and LLIN in particular was highest in infants below one year of age and decreased significantly with increasing age ($P < 0.001$). Female household members were more likely to sleep under a LLIN ($P = 0.003$) or any type of net ($P = 0.002$) than male household members. However, this apparent difference in the general population resulted from differences in the age groups above 15 years, while in younger age groups there was no difference in usage between male and female household members.

Regional differences in usage were observed, with Southern region showing the highest and the Islands the lowest overall usage rates. The same regional differences were apparent in the general population (LLIN $P = 0.005$; any net $P < 0.001$) and in the target group of children under five years (LLIN $P = 0.037$; any net $P = 0.01$). In infants, reported usage was 70% or higher in all regions and no statistically significant regional difference was observed in this young age group. In pregnant women usage was lowest in the Highlands; however, this was only statistically significant for nets in general ($P = 0.005$; LLIN $P = 0.12$) and this finding should be interpreted with caution considering the relatively small number of pregnant women identified during the survey.

Net usage results are presented in more detail in Table 6 for the general population, Table 7 for children under five years and Table 8 for pregnant women aged 15 to 49 years.

Table 6: Key indicators of mosquito net usage

Background characteristics	Household members who slept under net last night		Household members who slept under LLIN last night		Number of household members
	%	(95% CI)	%	(95% CI)	
Age group (years)					
<1	78.4	(68.4, 86.0)	74.4	(64.5, 82.3)	274
1-4	64.4	(56.4, 71.7)	56.7	(49.1, 63.9)	1,503
5-9	59.7	(51.1, 67.8)	52.0	(43.5, 60.5)	1,878
10-14	57.3	(50.3, 64.1)	50.1	(43.0, 57.2)	1,498
15-19	47.7	(40.3, 55.2)	42.4	(35.5, 49.5)	1,333
20+	52.5	(45.5, 59.4)	46.2	(39.9, 52.7)	6,015
*P-value**	*<0.001*		*<0.001*		
Sex					
M	53.5	(46.3, 60.6)	47.2	(40.4, 54.0)	6,259
F	57.7	(50.8, 64.2)	50.7	(44.3, 57.2)	6,239
*P-value**	*0.002*		*0.003*		
Region					
Southern	72.0	(61.8, 80.4)	67.7	(57.6, 76.4)	5,259
Highlands	42.7	(32.2, 54.0)	40.6	(30.1, 52.0)	2,420
Momase	65.9	(51.2, 78.1)	48.4	(35.9, 62.0)	2,677
Islands	41.5	(34.0, 49.4)	40.0	(32.8, 47.6)	2,178
*P-value**	*<0.001*		*0.005*		
Overall	55.5	(48.6, 62.3)	48.9	(42.4, 55.5)	12,534

*Weighted analysis. *Chi-square test.*

Table 7: Mosquito net usage by children under five years of age

Background characteristics	Children <5 years who slept under net last night		Children <5 years who slept under LLIN last night		Number of Children <5 years
	%	(95% CI)	%	(95% CI)	
Sex					
Male	67.6	(59.5, 74.7)	60.0	(52.6, 67.1)	927
Female	64.7	(56.3, 72.3)	58.0	(49.6, 65.9)	842
*P-value**	*0.236*		*0.413*		
Region					
Southern	80.2	(71.5, 86.8)	75.7	(66.9, 82.8)	723
Highlands	53.9	(40.1, 67.1)	52.6	(39.5, 65.5)	278
Momase	74.9	(56.6, 87.2)	57.2	(41.3, 71.7)	413
Islands	51.0	(42.0, 60.0)	48.2	(40.2, 56.2)	363
*P-value**	*0.010*		*0.037*		
Overall	66.3	(58.4, 73.3)	59.0	(51.6, 66.0)	1,777

*Weighted analysis. *Chi-square test.*

Table 8: Mosquito net usage by pregnant women aged 15 to 49 years

Background characteristics	Pregnant women who slept under net last night		Pregnant women who slept under LLIN last night		Number of pregnant women age 15-49 years
	%	(95% CI)	%	(95% CI)	
Region					
Southern	76.4	(64.1, 85.4)	69.3	(50.1, 83.6)	49
Highlands	37.3	(19.3, 59.7)	37.3	(19.3, 59.7)	21
Momase	66.0	(52.8, 77.2)	51.0	(32.1, 69.6)	27
Islands	46.7	(26.4, 68.2)	46.7	(26.4, 68.2)	23
*P-value**	*0.005*		*0.120*		
Overall	56.8	(46.6, 66.4)	50.6	(39.8, 61.3)	120

*Weighted analysis. *Chi-square test*

Of all surveyed non-users, 25.8% (18.0, 35.5) slept in a household without any net. People who lived in one of the surveyed households were more than twice as likely to sleep under a mosquito net as visitors to the surveyed households (odds ratio [OR] = 2.7; 95% CI 1.6, 3.64; $P < 0.001$).

Generally, users of LLIN were more likely to sleep under a net that was in good condition than users of non-LLIN ($P < 0.001$). 48.4% (41.5, 55.4) of LLIN users slept under a net that had no holes, while 49.1% of non-LLIN users were using a net with holes larger than approximately 3 cm in diameter (Table 9).

Table 9: Mosquito net condition by LLIN and non-LLIN users

Condition of net used by household member*	LLIN users (N=6066)		Non-LLIN net users (N=813)	
	%	(95% CI)	%	(95% CI)
No holes	48.4	(41.5, 55.4)	22.4	(16.1, 30.2)
Holes ø ≤ 3 cm	26.9	(23.1, 31.2)	27.5	(22.4, 33.3)
Holes ø < 10 cm	20.2	(15.4, 26.0)	41.1	(32.7, 50.0)
Holes ø > 10 cm	4.2	(2.5, 6.9)	8.0	(4.9, 12.9)
P-value (chi-square)		*<0.001*		

*Weighted analysis. *Hole size was approximated: ø ≤ 3 cm "coin-size", ø < 10 cm "smaller than fist", ø > 10 cm "larger than fist"*

3.4 Mosquito net characteristics: age, source, price, condition

A total of 6,066 mosquito nets were recorded during the survey. Based on the weighted analysis, 87.8% (95% CI 84.5, 91.0) of all nets were LLIN. Only the Permanet brand (Vestergaard-Frandsen) of LLIN was found. Permanet single-size nets accounted for 15.7%, double-size for 61.2% and extra-large for 11.3% of all nets. The survey team also found four home-made mosquito nets. More net characteristics are presented in Table 10.

Table 10: Mosquito net characteristics

	LLIN		Other net		Overall	
	%	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**
Net obtained	*N=5036*		*N=542*		*N=5578*	
3 months ago	4.8	(2.2, 7.4)	4.2	(0.8, 7.6)	4.7	(2.4, 7.1)
4-6 months ago	13.0	(7.9, 18.1)	4.8	(0.6, 8.9)	12.1	(7.4, 16.9)
6 months - 1 year ago	30.6	(22.3, 38.9)	9.3	(3.9, 14.8)	28.4	(21.0, 35.8)
1-2 years ago	13.9	(7.5, 20.3)	14.0	(9.1, 18.9)	13.9	(8.0, 19.8)
2-3 years ago	4.5	(1.6, 7.3)	4.1	(1.4, 6.7)	4.4	(1.8, 7.0)
> 3 years ago	33.2	(27.5, 39.0)	63.7	(55.7, 71.7)	36.4	(31.1, 41.7)
*P-value**	*<0.001*					
Source	*N=5361*		*N=705*		*N=6066*	
Distribution in village	78.6	(69.6, 87.5)	6.0	(3.3, 8.6)	69.7	(60.9, 78.4)
Health facility/ANC[1]	10.8	(4.8, 16.8)	1.6	(0, 3.7)	9.7	(4.3, 15)
Relative/friend	0.9	(0.4, 1.3)	1.6	(0.3, 2.8)	1.0	(0.4, 1.4)
Gift[2]	1.4	(0.6, 2)	3.5	(0.9, 5.9)	1.6	(0.9, 2.3)
Purchased store	3.4	(1.7, 4.9)	79.9	(73.4, 86.3)	12.8	(9, 16.4)
Purchased informal[3]	4.7	(0, 10.4)	3.1	(1.1, 5.1)	4.5	(0, 9.5)
Other/unknown	0.2	(0, 0.4)	4.3	(1.6, 6.9)	0.7	(0.3, 1.1)
*P-value**	*<0.001*					

*Weighted analysis. *Chi-square test. [1]Includes health workers, provincial health offices, NDoH, ANC=ante-natal clinic. [2]Promotions, employers, schools, churches. [3]Market, steer vendors, other informal sources.*

LLIN were generally newer than non-LLIN. Only 33.2% (27.5, 39.0) of all LLIN had been in the possession of the surveyed household for more than three years, compared to 63.7% (55.7, 71.7) of non-LLIN. The main source of LLIN were distributions (78.6%; 69.6, 87.5) and health facilities (or health workers) including ante-natal clinics (10.8%; 4.8, 16.8). Most non-LLIN were purchased from stores (79.9%; 73.4, 86.3). Some nets had been provided for free by major national employers (eg. bank, mining/petroleum company), churches or as promotional gifts (Table 10).

In total, 82.6% (75.5, 89.8) of all mosquito nets were obtained free of charge: 90.7% (84.3, 97.2) of all LLIN and 14.5% (7.6, 21.5) of all non-LLIN. For 746 nets which were not obtained for free, a purchasing price was reported alongside the source of the net (Table 11). A total of 38 nets were purchased during a distribution campaign, accounting for 0.9% of all distributed nets found in the survey (median price K5, IQR 5, 15). Of all nets provided through health facilities or health workers, 35 (5.3%) were purchased for a median price of K7 (IQR 5, 10). In stores, nets were sold at a higher price than on the informal market. Interestingly, LLIN were cheaper than non-LLIN when purchased from informal providers (*P* = 004). Only in stores did the price for Permanet LLIN differ with net size; however, single and double size nets were sold at similar prices, while extra-large nets were generally more expensive (median test, *P* = 0.012).

Table 11: Price paid for mosquito nets by net source (non-weighted analysis)

Source	LLIN		Other net		Overall	
	N (%)$	Median price (K)	N (%)$	Median price (K)	N (%)$	Median price (K)
Distribution in village	32 (0.8)	5 (5, 10)	6 (10.7)	17.5 (15, 19)	38 (0.9)	5 (5, 15)
*P-value**			*0.075*			
Health facility/ANC	32 (5.0)	7 (5, 7)	3 (21.4)	10 (10, 20)	35 (5.3)	7 (5, 10)
*P-value**			*0.028*			
Relative/friend	3 (6.4)	3 (2, 5)	-	-	3 (4.4)	2 (2, 5)
*P-value**			*N/A*			
Purchased store	129 (88.4)	15 (12, 22)	440 (82.4)	18 (15, 25)	569 (83.7)	18 (12, 25)
*P-value**			*0.573*			
Purchased informal	86 (95.6)	8 (3, 12)	15 (79.0)	18 (10, 20)	101 (92.7)	10 (5, 15)
*P-value**			*0.004*			
Total	282		464		746	

**Chi-square test. $Percentage denotes the proportion of nets purchased out of all nets from a particular source.*

The condition of mosquito nets was assessed by establishing whether holes were present. The hole size was approximated and the largest hole in a net was categorised: up to the size of a one Kina coin (ø ≤ 3 cm), up to the size of the palm of a hand or fist (ø < 10 cm) or larger than the size of a fist (ø > 10 cm). This categorization allowed for an easy and practical assessment of the size of holes in the field. However, the number of holes was not counted and the location of holes was not recorded.

Overall, 58.6% (53.2, 63.9) of LLIN and 29.9% (21.9, 37.8) of non-LLIN that were in possession of the surveyed households had no holes. Generally, LLIN were in better condition than non-LLIN (Figure 1).

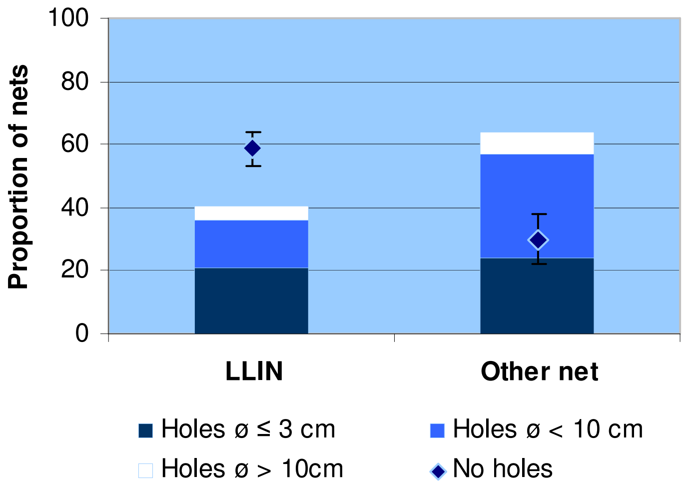

Figure 1: Proportion of mosquito nets with holes by net type

Age of the net (defined here as the time since the net had been obtained by a surveyed household), was a key determinant of net condition. Firstly, it should be noted that of the nets aged ½-1 year, only 59.0% (50.8, 67.2) of LLIN and 50.4% (0, 105.3) of non-LLIN were left without any holes. About 20.5% (10.3, 30.6) of all LLIN of this age had holes sized 3-10 cm. It appeared that non-LLIN started developing holes in general, and larger holes in particular, earlier than LLIN. The majority of all nets aged 2-3 years and still in the possession of the household had holes, in the case of non-LLIN mostly large holes (ø 3-10 cm) (Figure 2).

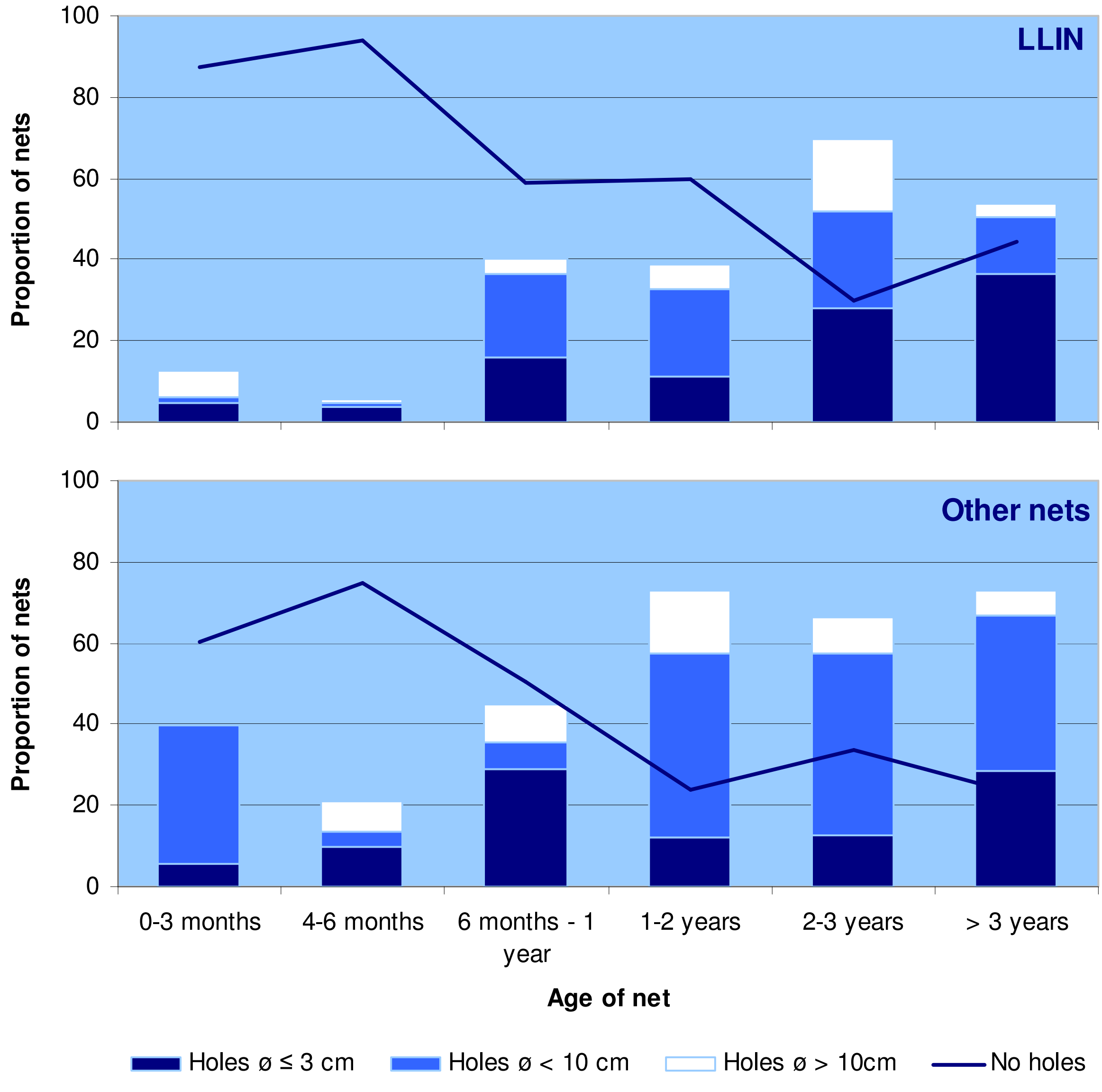

Figure 2: Proportion of nets with holes by net type and age

It should be emphasized that the above estimates do not account for nets that were discarded due to their condition. The larger proportion of non-LLIN in bad condition might therefore potentially reflect a practice of retaining these nets longer than LLIN, even when they are in bad condition.

Of all nets found in surveyed households, 67.2% (62.9, 71.3) had been used the previous night, with no difference between LLIN and non-LLIN. Nets that had no holes and nets with large holes (ø >10 cm) were used less frequently than nets with small to medium sized holes (Table 12).

Table 12: Usage of mosquito nets by net condition

Condition of net*	Proportion of nets used	
	%	**(95% CI)**
No holes	57.1	(51.7, 62.3)
Holes ø ≤ 3 cm	82.8	(77.8, 86.9
Holes ø < 10 cm	83.9	(77.8, 88.7)
Holes ø > 10 cm	58.8	(50.0, 67.0)
No information	51.8	(37.2, 66.1)
P-value (chi-square)	*<0.001*	
Overall	67.2	(62.9,71.3)

*Weighted analysis. *Hole size was approximated: ø ≤ 3 cm "coin-size", < 10 cm "smaller than fist", > 10 cm "larger than fist"*

This survey also assessed reasons why particular nets that were found in surveyed households were not being used the previous night (rather than reasons for a particular person not using a net). The most frequently cited reasons for a net being unused the previous night was that the net was reserved, e.g. for a particular person who was absent, or being spared for later use (37.5% of unused nets; 95% CI 31, 44.1). Heat and perceived absence of mosquitoes were other commonly cited reasons for non-use, followed by an indifference towards or general opposition against using mosquito nets. Nets in good condition were most frequently reserved or spared for later use, while nets with large holes (ø >10 cm) were generally considered too damaged to be useful. Interestingly, perceived heat was mainly cited as reason for not using nets that were new or in good condition. Several nets had not been used the previous night because they were considered in need of washing or had just been washed and not put back in place (Table 13).

Table 13: Frequently reported reasons for mosquito nets not being used

Reported reasons for net not being used	Mosquito net condition: No holes %	(95% CI)	Holes ø ≤ 3 cm %	(95% CI)	Holes ø < 10 cm %	(95% CI)	Holes ø > 10cm %	(95% CI)	Total %	(95% CI)	P-value*
Net spared/reserved	43.9	(36.3, 51.6)	24.8	(13, 36.6)	23.0	(10.3, 35.8)	5.1	(0, 10.5)	37.5	(31, 44.1)	**<0.001**
User did not sleep in household last night	6.5	(4.2, 8.8)	19.4	(12.1, 26.8)	21.0	(3.5, 38.6)	14.2	(5.8, 22.6)	9.8	(6.4, 13.3)	**<0.001**
Too hot	11.2	(7, 15.5)	4.9	(1, 8.8)	3.7	(0, 8.6)	0.3	(0, 0.9)	9.0	(5.6, 12.5)	**0.001**
No mosquitoes	9.8	(5.6, 13.9)	5.3	(1.7, 8.9)	10.7	(0, 24.3)	8.5	(1.6, 15.3)	9.0	(5.3, 12.7)	0.500
Indifferent / opposed to net use	5.0	(3.2, 6.7)	10.2	(2, 18.4)	10.9	(2.3, 19.5)	7.5	(0, 15.4)	6.1	(4.2, 8.1)	0.137
House factors / space	1.7	(0.5, 2.8)	3.0	(0, 6.7)	0.0	(0, 0)	3.7	(0, 7.9)	1.8	(0.8, 2.7)	0.419
Net dirty / being washed	1.1	(0, 2.6)	5.2	(0.4, 10)	1.3	(0, 3.4)	1.2	(0, 3.7)	1.6	(0.1, 3.1)	0.156
Other vector control method preferred	1.1	(0.2, 2.1)	1.6	(0, 3.8)	1.2	(0, 3.8)	0.0	(0, 0)	1.1	(0.1, 2.1)	0.806
There is no malaria	0.9	(0, 1.9)	3.9	(0, 11.1)	0.0	(0, 0)	0.0	(0, 0)	1.1	(0.1, 2.1)	0.350
Afraid of smoke/fire damaging the net	1.0	(0, 2.3)	0.8	(0, 2.4)	0.0	(0, 0)	2.5	(0, 7.5)	1.0	(0.1, 1.9)	0.777
Does not know how to use net	0.7	(0, 1.5)	0.0	(0, 0)	0.0	(0, 0)	0.0	(0, 0)	0.5	(0, 1.1)	0.837
Net expired/damaged	0.5	(0, 1)	10.3	(0, 23.8)	9.7	(1.4, 17.9)	24.5	(9, 39.9)	3.8	(1.8, 5.8)	**<0.001**

**Chi-square test. The red to yellow shading indicates the five most frequently reported reasons (most frequent – less frequent). Weighted analysis.*

3.5 Prevalence of parasitaemia

In survey villages below 1600 m altitude, 6.7% (95% CI 4.7, 9.4) of the general population were infected with malaria parasites (any species). Parasite prevalence of *P. falciparum* amounted to 3.4% (2.1, 5.3), *P. vivax* 2.1% (1.4, 3.0), *P. malariae* 0.05% (0.0, 0.2) and mixed infections of *P. falciparum* with another species to 0.1% (0, 0.2) (Table 14). Above 1600 m altitude, 1.1% (0.4, 3.0) of the population was found to be parasite positive, with 0.5% (0.3, 0.9) *P. falciparum*, 0.4% (0.1, 2.8) *P. vivax* and no mixed infections.

In the target group of children below five years of age and below 1600 m altitude, prevalence of malaria infection was 13.3% (9.1, 19.2), with 7.6% (4.5, 12.4) *P. falciparum* and, 5.3% (3.1, 8.7) *P. vivax* and 0.4% (0.2, 1.1) *P. falciparum* mixed infections (Table 14). Above 1600 m altitude, no positive child was found in this age group.

Table 14: Country-wide malaria parasite prevalence by age group (< 1600 m altitude)

Age group (years)	N	Parasite prevalence (%)$			
		All	*P. falciparum*	*P. vivax*	*Pf* mixed
		% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Age group (years)					
0.5-5	1,269	13.3 (9.1, 19.2)	7.6 (4.5, 12.4)	5.3 (3.1, 8.7)	0.4 (0.2, 1.1)
5-9	1,437	10.2 (6.5, 15.9)	5.3 (2.9, 9.5)	2.6 (1.6, 4.4)	0.1 (0, 0.6)
10-14	989	7.7 (5.3, 11.1)	3.6 (2.2, 5.7)	2.4 (1.4, 4.2)	0
15-19	747	5.2 (2.8, 9.4)	2.8 (1.4, 5.6)	1.5 (0.8, 3.1)	0.03 (0, 0.3)
20+	4,012	3.3 (2.4, 4.6)	1.4 (0.9, 2.1)	0.9 (0.5, 1.5)	0
*P-value**		*<0.001*	*<0.001*	*<0.001*	*0.019*
Region					
Southern	3,871	4.4 (2.8, 6.9)	1.8 (1.1, 2.8)	1.8 (0.8, 3.9)	0.03 (0, 0.2)
Highlands	431	0.3 (0, 2.6)	0.3 (0, 2.6)	0	0
Momase	2,203	8.0 (4.3, 14.3)	4.2 (1.8, 9.6)	2.0 (1.2, 3.5)	0.05 (0, 0.5)
Islands	1,960	14.3 (9.3, 21.3)	7.4 (5.0, 10.8)	4.9 (2.7, 8.8)	0.4 (0.1, 1.4)
*P-value**		*<0.001*	*0.006*	*0.017*	*0.026*
Total	8,465	6.7 (4.7, 9.4)	3.4 (2.1, 5.3)	2.1 (1.4, 3.0)	0.1 (0, 0.2)

*Weighted analysis. *Chi-square test. $Differences between overall prevalence and the sum of species-specific rates are due to uncertain species identification and, to a lesser extent, cases of P. malariae infection (see Methods section of this report).*

3.5.1 Individual-level risk factors for *Plasmodium* infection

Malaria prevalence was strongly age-dependent with a general trend of decreasing infection with increasing age. Overall prevalence was highest in children aged 1 to 5 years while infection with *P. vivax* appeared to peak in children below one year of age (Figure 3). Differences between age groups were significant for all species (all $P < 0.001$, Table 14). There was no statistically significant difference between male and female survey participants.

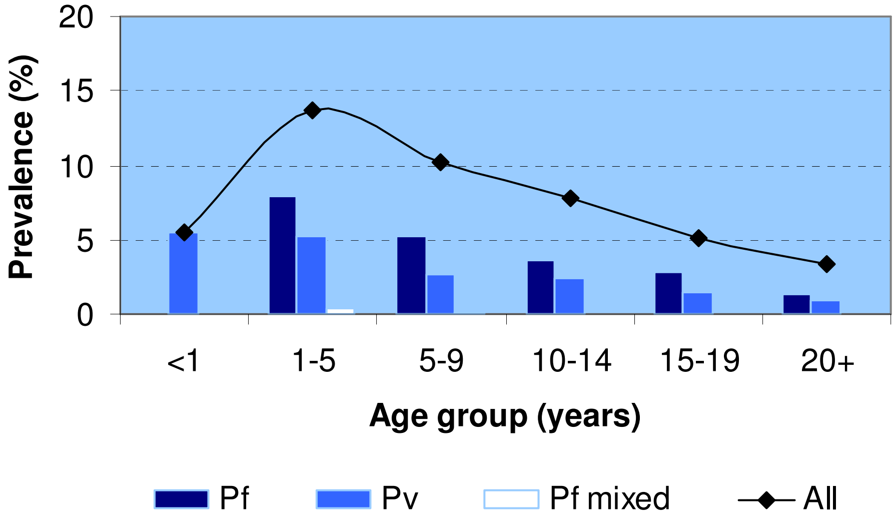

Figure 3: Country-level parasite prevalence by age group and species

Includes only locations < 1600 m altitude.

Prevalence was highest in Islands region, followed by Momase, Southern and the Highlands (Table 14). Differences between regions were significant for *P. falciparum*, *P. vivax* and *P. falciparum* mixed infections (all $P < 0.05$). The highest parasite rates were found in villages in Sandaun (Amsuku, 47.3%), New Ireland (Bom, 29.6%; Komalu, 26.2%) and East New Britain (Iwai, 20%; Manginuna, 18.8%). This was contrasted by villages in the same provinces with much lower parasite rates, such as Wutung in Sandaun (1.8%), Konangusngus in New Ireland (7.7%), or Karavia No. 2 in East New Britain (0.9%) (Appendix 2).

On a regional level, differences between age groups were highly significant in Momase and Islands (all *P* < 0.01 for *P. falciparum, P. vivax* and overall) with clear prevalence peaks in children below five years of age. In Southern region, infections were significantly lower in individuals aged 20 years or older (all *P* < 0.01 for *P. falciparum, P. vivax* and overall) but no difference was observed between the younger age groups. In the Highlands across all altitudes, the opposite situation was observed with higher parasite rates in individuals above 20 years of age (all *P* < 0.01 for *P. falciparum, P. vivax* and overall) (Figure 4).

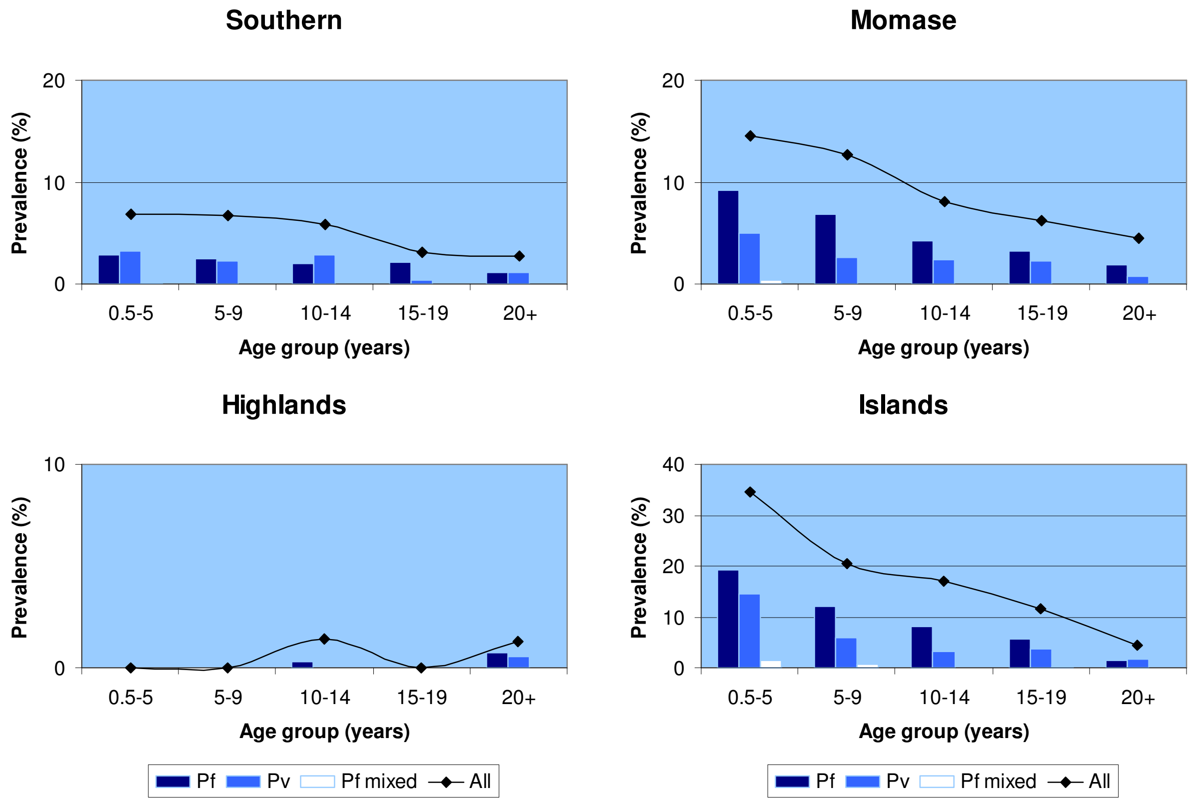

Figure 4: Regional parasite prevalence by age group and species

Highlands region includes all altitudes. Note the different Y-axis scales.

On a regional level, *P. falciparum* was the dominant parasite in Momase and Islands regions, while in Southern and the Highlands, no clear species dominance was found (Figure 4). At a provincial level, *P. falciparum* was the dominant parasite in three out of the four provinces with the highest parasite rates, i.e. in Sandaun, New Ireland and East New Britain, while in

Milne Bay, *P. vivax* infections were more common (Appendix 3). Across all provinces, *P. falciparum* was the predominant parasite in 34 (45.5%) and *P. vivax* in 14 (18.2%) of the 77 survey villages (Appendix 2).

3.5.2 Endemicity and altitude

Parasite prevalence was negatively correlated with altitude both in the general population (*Pf* ρ = -0.31, *P* = 0.006; *Pv* ρ = -0.32, *P* = 0.005) and in children below five years of age (*Pf* ρ = -0.31, *P* = 0.006; *Pv* ρ = -0.33, *P* = 0.004). Interestingly, infections at higher altitude were limited to individuals above five years of age, suggesting that cases might be introduced by travelling adults (Figure 5).

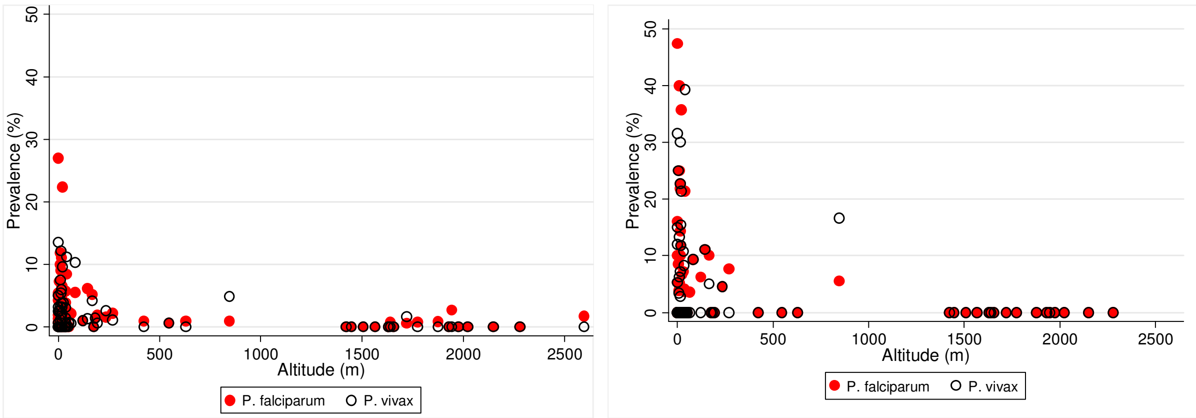

Figure 5: Association of altitude of survey village and parasite prevalence

All age groups (left) and children under five years (right).

3.6 Treatment seeking for fever

Overall, most fever episodes resulted in some action taken by the patient or the caretaker; 74.6% (95% CI 64.5, 82.6) of all cases of fever received some treatment, be it traditional or modern. In children under the age of five years, this proportion was higher with 82.2% (71.7, 89.3). In the Highlands and Momase regions, the highest number of reportedly untreated fever episodes was found (Table 15).

In the target group of children below five years of age, 45.2% (33.9, 56.9) were treated with an antimalarial and 32.4% (19.9, 48.1) with the previously recommended combination of chloroquine (CQ) or amodiaquine (AQ) plus sulphadoxine-pyrimethamine (SP). Across all age groups, 37.6% (30.0, 46.0) of all fever episodes were reportedly treated with an antimalarial and 23.1% (15.5, 33.0) with AQ/CQ + SP (Table 15). Treatment with AQ/CQ + SP was more frequent in children than in older patients ($P = 0.039$). In all surveyed households, only one adult treatment with artemether-lumefantrine could be established (0.1%; 0.0, 0.5).

Across the country, CQ monotherapy was the most frequently administered treatment (40.9%; 30.6, 52.1), followed by AQ and one of the previously recommended combinations of these drugs with SP (Table 16). Treatment patterns differed markedly by region with the Islands reporting the highest and the Highlands the lowest proportion of fevers treated with AQ/CQ + SP.

Particularly notable is the considerable proportion of cases treated with artemisinin monotherapies (mostly artemether tablets). In most countries, these arteminsinin monotherapies are banned for fear of contributing to the development of resistance against artemisinin derivatives in general. Only in few instances was an artemisinin combined with another antimalarial (eg. SP) (Table 16).

Table 15: Key indicators of treatment seeking for recent fever episodes

Background characteristics	Any treatment		Antimalarial		AQ/CQ + SP	
	%	(95% CI)	%	(95% CI)	%	(95% CI)
Age group (years)						
<5	82.2	(67.2, 91.2)	45.2	(33.9, 56.9)	32.4	(19.9, 48.1)
5-14	78.8	(57.3, 91.2)	45.3	(25.8, 66.3)	29.4	(14.2, 51.1)
15+	69.1	(54.7, 80.6)	30.8	(23.1, 39.7)	12.4	(6.4, 22.8)
*P-value**	*0.310*		*0.150*		*0.039*	
Sex						
M	75.9	(64.5,84.5)	37.7	(29.4, 46.5)	19.7	(9.8, 35.6)
F	73.3	(60.1,82.8)	37.7	(27.2, 49.5)	26.5	(16.3, 39.9)
*P-value**	*0.635*		*0.978*		*0.451*	
Region						
Southern	94.7	(90.1, 97.2)	37.5	(29.6, 46.0)	22.5	(13.8, 34.5)
Highlands	62.7	(45.7, 77.0)	29.2	(17.1, 45.3)	10.7	(1.6, 46.6)
Momase	62.6	(35.3, 83.7)	40.0	(23.1, 59.6)	13.8	(3.9, 38.7)
Islands	79.9	(58.6, 91.7)	50.8	(32.9, 68.6)	43.8	(31.0, 57.5)
*P-value**	*0.013*		*0.255*		*0.071*	
Overall	74.6	(64.5, 82.6)	37.6	(30.0, 46.0)	23.1	(15.5, 33.0)

**Chi-square test.*

Table 16: Antimalarial drugs taken by individuals with a recent fever episode

Antimalarial	Southern		Highlands		Momase		Islands		Overall	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
Monotherapies										
AQ	22.5	(11.7, 39.0)	0		10.7	(4.4, 24.0)	14.0	(5.5, 31.2)	11.8	(7.5, 18.0)
CQ	35.1	(26.4, 44.7)	46.9	(20.1, 75.7)	53.6	(21.2, 83.2)	30.6	(14.4, 53. 5)	40.9	(30.6, 52.1)
SP	1.6	(0.2, 12.9)	0		0		2.3	(0.7, 7.0)	1.0	(0.3, 3.0)
ART	5.0	(2.0, 12.0)	13.7	(1.4, 63.6)	7.2	(0.8, 42.6)	3.7	(0.9, 14.0)	7.5	(2.6, 19.5)
QU	4.8	(0.6, 29.9)	13.7	(1.4, 63.6)	4.0	(0.3, 35.8)	0		5.8	(1.5, 20.0)
Combination therapies										
AQ + SP	16.6	(7.7, 32.3)	1.8	(0.1, 22.4)	13.8	(3.3, 43.4)	16.4	(8. 8, 28.5)	11.9	(7.4, 18.8)
CQ + SP	5.9	(1.6, 20.2)	9.0	(0.7, 59.3)	0		27.4	(17.2, 40.8)	11.2	(6.3, 19.0)
ART + SP	5.6	(1.4, 20.2)	1.8	(0.1, 22.4)	0		0		2.0	(0.6, 6.3)
PQ*	0		3.4	(0.2, 42.0)	0		5.4	(0.9, 26.7)	2.3	(0.6, 8.6)
Other[$]	2.8	(0.3, 18.9)	9.9	(1.5, 44.6)	10.6	(3.8, 26.3)	0.3	(0, 3.3)	5.7	(2.4, 12.8)

*Percentages indicate proportions of all antimalarial treatments administered. AQ=Amodiaquine, CQ=Chloroquine, SP=Sulphadoxine-pyrimethamine, ART=Artesunate or artemether, QU=Quinine, PQ=Primaquine. *All PQ treatments were administered as combination with one or several other antimalarials. [$]Includes mainly other combinations of the above antimalarials.*

4 DISCUSSION AND RECOMMENDATIONS

4.1.1 Outcomes: Intervention coverage

Through repeated free distribution of mosquito nets, country-wide LLIN household ownership of 81.7% was achieved and 60.9% of the households in PNG now own more than one LLIN. This represents a 17.1 percentage point increase for one LLIN and 22.7 for more than one LLIN per household compared to the 2009 baseline survey findings [3]. In Southern and Islands regions, over 90% of households now own at least one LLIN and in all regions, except Momase, the proportion of households owning only non-LLIN is now marginal. Considering that pre-GFATM LLIN ownership levels were estimated at around 10%, this increase over time is both significant and remarkable [3]. It is important to note that in Momase and Highlands region, the increase in LLIN ownership was smallest, which may in part be attributed to the distribution campaign schedule in the surveyed areas.

Most of the nets found in this survey (69.7%) had been obtained through village-based distribution campaigns. While the data collection instruments did not allow for a distinction between the national campaign by RAM and other small scale distributions (eg through NGOs, churches or local leaders), the majority of the nets undoubtedly originated from the GFATM funded campaign. A total of 10.8% of all LLINs had been obtained through health facilities, which would include the provision of LLIN to pregnant mothers attending antenatal clinics. Most non-LLIN originated from retailers while some were provided by employers. It might be worthwhile exploring both of these avenues further considering the need to ensure a sustainable high possible coverage with treated nets. It should be noted in this context that private retailers as well as health facilities can be an important complementary source of continuous provision of LLIN in addition to distribution campaigns [9,10]. It might be useful to target awareness campaigns to those entities outside the national program that continue to supply mosquito nets to people either free of charge or at cost. The aim of this should be to minimise the number of non-LLIN on the market. The situation in Momase region warrants special attention considering the relatively high number of households owning only untreated nets.

Reports of fees being paid to obtain nets during village distributions were not frequent but should nevertheless be noted. While individual reports cannot be verified within the frame of a study like this, attention should be paid by program managers to minimize the risk of distribution agents charging the recipients of nets. It might also be useful to further explore the magnitude of this problem in the frame of the distribution through antenatal clinics. Considering the financial situation of many health facilities in PNG and a widespread lack of supervision and accountability [11], charging for free items may be tempting.

It was noted that LLIN were generally in better condition than non-LLIN; however, this may be due to LLIN also generally being newer. In addition, the analysis on net condition could not take into account those nets that had already been discarded. Approximately 70% of LLIN found were not older then 3 years and hence within their expected useful lifetime. Interestingly, both LLIN and other nets appeared to present with first damages after less than one year and after 2-3 years, the majority of nets are damaged. This needs to be considered in the further planning of distribution schedules. Nets that had large holes were generally not used any more. On the other hand, new nets were often not used either but rather spared for later use. This may reflect a high value attributed to the nets. To date, there is not evidence available about the physical condition at which nets cease to be protective.

The 2009 study found that usage was largely determined by ownership, i.e. most non-users of nets did not have access to an unused or spare net in their household [3]. The continued distribution of more nets, also in areas previously well covered, is therefore expected to lead to a further increase in net usage provided that nets are distributed to those households that really need them. Based on the mentioned survey as well as qualitative investigations

[12], is became evident that more nets as well as increased awareness are required to further increase net usage.

By 2011, 48.9% of the general population, 59.0% of children under five and 50.6% of pregnant women age 15-49 years were using a LLIN, representing an increase of 13.7, 19.5 and 9.3 percentage points for the three groups, respectively. Net usage was generally very high in infants but then decreased with increasing age. As in the 2009 survey, there was a notable discrepancy between ownership and usage particularly in the Islands region, where ownership was highest and usage lowest (except by pregnant women). Ownership was again an important predictor of usage with 25.8% of non-users not having any net in their household, compared to 31.0% in 2009 [3]. It was also found that visitors to households were often not using a mosquito net, an issue that may be considered in future awareness messages. Users of LLIN were generally better protected than non-LLIN users. Not only because of the insecticide, but also since their nets were generally in a better condition. Unpublished data from this survey suggests that the Island region was exposed to more intensive education, information and communication activities on malaria than other provinces. This may be a result of deliberate targeting and would present an adequate approach in this situation (Hetzel *et al.* manuscript in preparation).

4.1.2 Outcome: Malaria treatment coverage

Most episodes of fever resulted in treatment-seeking action. However, only the minority of all fevers (23.1%) was treated with an antimalarial combination recommended for the treatment of malaria in PNG. As at the time of this survey the country-wide artemether-lumefantrine (AL) roll-out had not yet started, this analysis is based on the old treatment guidelines with AQ/CQ + SP as recommended first-line treatment of uncomplicated malaria. The delayed implementation of the AL-based treatment is reflected in the < 1% of patients that were reportedly treated with AL.

There are several major concerns with regard to case management originating from the results of this survey. Firstly, ¼ of all fever episodes do not result in any treatment seeking action, contributing to the fact that only 37.6% of fevers are treated with an antimalarial. It is important to consider that this reflects the situation prior to the country-wide roll-out of point-of-care malaria diagnostic tests. The non-prescription of antimalarials can therefore in the majority of cases not be attributed to a negative parasitological test as these were not widely available nor were they commonly used in health facilities that stocked diagnostic tests [4,13]. Secondly, monotherapies with chloroquine or amodiaquine were reportedly the most frequently administered treatments for malaria. This slightly contradicts the results of a health facility survey which found that most prescribed treatments conformed to one or another of the first-line treatment recommendations [13]. The discrepancy can be attributed to several reasons. Firstly, patients might not adequately remember and report the drugs they received (however, this report only included patients indicating that they could remember the name of the drugs). Furthermore, not all prescribed drugs might have been swallowed by the patients and lastly, health workers might have tended to adhere better to treatment guidelines while the PNG IMR health facility survey team was present than under normal circumstances. However, if the tendency of administering CQ or AQ monotherapies does reflect the true situation, this is highly concerning since both drugs have, for years, been largely ineffective [14-16].

A further concern arising from this report is the apparently frequent administration of artemisinin monotherapies (overall 5.8%, 13.7% in the Highlands). Artemether tablets are sold widely in private pharmacies in PNG but are also frequently stocked by health facilities (54.4% of health facilities surveyed in 2010 stocked artemether tablets [4]). Artemisinins are a welcome alternative for health workers who prefer not to administer CQ, AQ or SP. However, WHO has for years been advocating a total ban on artemisinin monotherapies arguing that their use may threaten the still highly effective ACTs [17,18]. Most countries have therefore prohibited the use of artemisinin monotherapies. With the roll out of artemether-lumefantrine as first line treatment, PNG health authorities should follow these WHO recommendations and implement a ban on artemisinin monotherapies. This would have to include regulatory action as well as awareness creation among health workers and private sector providers.

4.1.3 Impact: Parasite prevalence

The results from this survey found that overall, 6.7% of people living below 1600 meters altitude are infected with malaria parasites. *Plasmodium falciparum* was the most commonly found parasite (3.4%), followed by *P. vivax* (2.1%). Only very few *P. malariae* and no *P. ovale* infection was found. Overall, prevalence rates were highest in children under five years of age (13.3%) and decreased with increasing age. The country-level parasitaemia prevalence measured during this survey presents a major reduction from the levels reported in 2009 [2]. While further analyses are required to allow a direct and detailed species-specific comparison with the 2009 results, the overall reduction in prevalence is estimated to be approximately 50%. The observed reduction appears larger for *P. falciparum* than for *P. vivax*.

Parasite prevalence was dependent on altitude with only few positive cases found above 1600 m altitude and there, only in individuals above five years of age. This might indicate an introduction of cases by travelling adults rather than local transmission. As reported previously [19,20], variations in endemicity occur at small and large scales in PNG and are influenced by many factors including the locally predominant *Anopheles* species, population density, migration, etc. This survey found the highest parasite rates in the Islands region and in Sandaun, Madang and Milne Bay provinces. Many areas of Southern region were confirmed low prevalence. It was also observed that *P. vivax* is becoming predominant in an increasing number of villages. This needs to be considered in the implementation of the new treatment guidelines (primaquine treatment of hypnozoites).

The GFATM-supported free distribution of LLIN and supportive behaviour change campaigns were the only malaria control intervention implemented at a large scale in PNG between 2004 and 2011 [3]. At the same time, there was no evidence of an obvious country-wide change in environmental or climatic factors and no notable large-scale economic development at a household level. The 2008/09 baseline and the 2010/11 survey were conducted during the same period of the year in order to minimise the effect of seasonal fluctuations in prevalence on the comparability of baseline and follow-up results. Considering all of the above, it is therefore highly plausible that the impressive reduction in malaria prevalence across PNG is a direct impact of the interventions implemented by the NMCP, namely the roll-out of LLIN.

4.1.4 Methodological issues

This was a cross-sectional survey following the model of the Malaria Indicator Survey [7]. It has the limitations inherent in every cross-sectional survey: data was assessed only at one point in time and most information was gathered retrospectively through interviews which may be prone to several types of biases that can never be entirely ruled out. However, care was taken to train the survey teams well in interview techniques in order to minimize potential biases.

Certain randomly sampled survey locations could not be accessed for logistical or security reasons which may have resulted in an undeliberate exclusion of very remote and difficult-to-access locations. These may well be the places which are also hardest to reach for program implementers and hence the results of this survey may, to a certain degree, overestimate intervention coverage.

Limitations of retrospective collection of data are well known and this is particularly true for treatment seeking behaviour, which was based on a two-week recall period. In addition, treatment seeking was not assessed based on a diagnostic test result which is important to consider in the interpretation of the data. If health workers follow relevant guidelines, no malaria test-negative fever should be treated with an antimalarial. With a reduction in malaria and an increasing proportion of non-malarial fevers, the assessment of this indicator may become even more complex. The adherence to guidelines in combination with a decrease in malaria-attributable fevers should lead to a reduction in the proportion of fevers treated with antimalarials. While the methodology applied in this evaluation followed the GFATM performance framework as well as the methods applied in the 2009 baseline survey, these aspects require consideration in future analyses following the roll-out of improved diagnostics.

Malaria parasite prevalence was assessed by two independent light microscopy reads with a confirmatory third read in case of discordant results. For a number of slides, the *Plasmodium* species could not be identified beyond doubt after three independent reads. Such slides were included in the analysis of overall prevalence rates if considered *Plasmodium* spp. positive by at least two microscopists, but excluded form any species-specific analysis. Problems with identifying species were related to the quality of the blood smears and the staining resulting mainly from sub-optimal storage, transport and staining conditions in the field. The issues were addressed whenever they were identified during the course of the survey but they could not be totally eliminated.

Malaria microscopy has a detection limit of approx. 20 parasites/µl of blood. Lower parasitaemia in collected blood samples would therefore not be detected. This needs to be considered in the interpretation of the data. For this survey, no molecular diagnosis was performed; however, this is planned for the follow-up survey in 2013/14 and results from PCR diagnosis assays can then be compared to 2009 baseline data.

Country-wide parasite prevalence was calculated including only villages below 1600 m altitude. This approach was deemed suitable for two reasons: firstly, this approach makes the data more easily comparable with the baseline survey in 2009 and secondly, did the age distribution differ significantly between areas below and above 1600 m. Particularly the proportion of children below five years of age was generally lower in high altitude villages, while this represented the age group with the highest infection rates. Excluding high altitude villages hence makes regional estimates comparable.

4.1.5 Progress towards grant performance targets and health impact

In terms of achieving the revised Phase 2 targets defined in the PF and assessed through a household survey, the program can be considered successful in all except one indicator (Appendix 4).

For the three LLIN-related outcome indicators (proportion of households with at least two LLIN, proportion of children under five using LLIN and proportion of pregnant women using LLIN), the Global Fund performance targets for year 2 were contained within the 95% confidence interval of the measured value. In the case of LLIN ownership and usage by children under five years, the measured value precisely matched the target value. It is important to note that both ownership and usage of LLIN increased markedly since the last survey conducted in 2008/09.

Treatment according to national guidelines remained well below the intended target, even when the old treatment guidelines (AQ/CQ + SP) were used as a basis for the assessment. If ACT were considered the appropriate medication, the discrepancy would even be more extreme. While an increase in treatment rates can be expected following the introduction of a new treatment, fundamental difficulties will persist in the assessment of this indicator, as outlined in a previous paragraph.

The impact of the program was reflected in an impressive 50% drop in country-wide malaria prevalence when compared to 2008/09. It is unlikely that any factor other than the large-scale free distribution of LLIN and accompanying behaviour change messages contributed significantly to this decline. The value measured in year 2 already fell below the year 5 target for this indicator. These results are supported by findings from other studies conducted by PNG IMR, including malaria case surveillance in Sentinel Sites (unpublished data). While the observed drop in malaria prevalence is a positive outcome of the program, sustained efforts are certainly required to maintain the current state and a further reduction may only be possible with a further intensification of control, including the roll-out of ACT and possibly complementary treatment and vector control interventions.

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APPENDIX 1: STUDY POPULATION DETAILS

Region	Province	Village	Code	Elev[1]	Household interviews N	(%)	Individuals N	(%)	Blood samples N	(%)
SOUTHERN	01 WESTERN	KIBULI	AKI	1	32	(1.6)	183	(1.5)	155	(1.6)
		KURUNTI	AKU	1	16	(0.8)	76	(0.6)	53	(0.5)
		SAMARI	ASA	1	25	(1.3)	193	(1.5)	161	(1.6)
	02 GULF	IOSIPI	BIO	1	29	(1.5)	173	(1.4)	155	(1.6)
		KEKE	BKE	1	29	(1.5)	210	(1.7)	134	(1.3)
		KUKIPI	BKP	1	31	(1.6)	191	(1.5)	159	(1.6)
		RABIA CAMP	BRA	1	27	(1.4)	164	(1.3)	125	(1.3)
	03 CENTRAL	BARAMATA SETTLM	CBA	1	31	(1.6)	201	(1.6)	161	(1.6)
		GALOMARUPU	CGA	1	37	(1.9)	231	(1.8)	190	(1.9)
		MEDENE	CME	1	35	(1.8)	184	(1.5)	145	(1.5)
		TUTUBU	CTU	1	29	(1.5)	193	(1.5)	154	(1.5)
		VARIARATA SCOUT CAMP	CVA	1	23	(1.2)	220	(1.8)	154	(1.5)
	04 NCD	GAHUNAGAUDI ST.	DGA	1	25	(1.3)	329	(2.6)	196	(2.0)
		GOLDIE ST.	DGO	1	30	(1.5)	267	(2.1)	121	(1.2)
		HENAO DR.	DHE	1	30	(1.5)	286	(2.3)	139	(1.4)
		KERMADEC	DKA	1	35	(1.8)	199	(1.6)	116	(1.2)
		LAHARA	DLA	1	29	(1.5)	228	(1.8)	97	(1.0)
	05 MILNE BAY	GARUAHI	EGA	1	26	(1.3)	145	(1.2)	131	(1.3)
		KAKAMWA	EKA	1	32	(1.6)	123	(1.0)	114	(1.1)
		MAIABARI	EMA	1	31	(1.6)	162	(1.3)	148	(1.5)
		SIILUGU	ESI	1	32	(1.6)	168	(1.3)	137	(1.4)
		WATULUMA	EWA	1	30	(1.5)	224	(1.8)	189	(1.9)
	06 ORO	ELCOM COMPOUND	FEC	1	29	(1.5)	199	(1.6)	136	(1.4)
		FODUMA	FFO	1	28	(1.4)	192	(1.5)	172	(1.7)
		HARURO	FHA	1	28	(1.4)	182	(1.5)	157	(1.6)
		HORAU	FHO	1	27	(1.4)	160	(1.3)	133	(1.3)
		PUIN	FPU	1	29	(1.5)	176	(1.4)	139	(1.4)
HIGHLANDS	07 SOUTHERN HIGHLANDS	IYANA	GIY	3	30	(1.5)	153	(1.2)	186	(1.9)
		KOALI	GKO	3	26	(1.3)	142	(1.1)	126	(1.3)
		PUNDIA	GPU	3	17	(0.9)	94	(0.8)	82	(0.8)
		WAGAI	GWA	3	21	(1.1)	103	(0.8)	91	(0.9)
	08 ENGA	BETA	HBE	3	24	(1.2)	126	(1.0)	100	(1.0)
		LONDO	HLO	3	25	(1.3)	116	(0.9)	114	(1.1)
		TAKUUP	HTA	3	30	(1.5)	184	(1.5)	143	(1.4)
		WABAG SECONDARY	HWA	3	16	(0.8)	97	(0.8)	74	(0.7)
		YOMONDI	HYO	3	22	(1.1)	98	(0.8)	59	(0.6)
	09 WESTERN HIGHLANDS	BOKBAKE	IBO	2	32	(1.6)	152	(1.2)	125	(1.3)
		FACTORY	IFA	2	21	(1.1)	98	(0.8)	73	(0.7)
		KUNAI GRASS	IKU	3	27	(1.4)	175	(1.4)	119	(1.2)
		MOPARUI	IMO	3	27	(1.4)	130	(1.0)	67	(0.7)
		NEW CAMP	INE	2	21	(1.1)	109	(0.9)	94	(0.9)

Region	Province	Village	Code	Elev[1]	Household interviews		Individuals		Blood samples	
					N	(%)	N	(%)	N	(%)
HIGHLANDS	10 CHIMBU	DAUN BASE	JDA	3	28	(1.4)	178	(1.4)	123	(1.2)
		DPI-FORESTRY	JDP	2	24	(1.2)	165	(1.3)	139	(1.4)
		KURUMBUKOTARU	JKU	3	20	(1.0)	143	(1.1)	113	(1.1)
		WOMAI	JWO	3	23	(1.2)	157	(1.3)	120	(1.2)
MOMASE	12 MOROBE	DRAYTON STREET	LDR	1	15	(0.8)	157	(1.3)	130	(1.3)
		MENYA	LME	2	24	(1.2)	163	(1.3)	112	(1.1)
		NAMBARIWA	LNA	1	28	(1.4)	234	(1.9)	217	(2.2)
		NUMBUGU	LNU	1	19	(1.0)	101	(0.8)	103	(1.0)
		SAMBIO	LSA	1	25	(1.3)	144	(1.2)	110	(1.1)
	13 MADANG	ABIKKAL	MAB	1	20	(1.0)	138	(1.1)	92	(0.9)
		ARINGEN	MAR	1	27	(1.4)	151	(1.2)	119	(1.2)
		MARUP 2	MMA	1	24	(1.2)	136	(1.1)	97	(1.0)
		MEBU	MME	1	30	(1.5)	228	(1.8)	166	(1.7)
	14 EAST SEPIK	BOIKIN	NBO	1	14	(0.7)	74	(0.6)	64	(0.6)
		JAMA	NJA	1	29	(1.5)	175	(1.4)	167	(1.7)
		KOIKIN	NKO	1	30	(1.5)	181	(1.4)	140	(1.4)
		KUSAUN	NKU	1	30	(1.5)	173	(1.4)	192	(1.9)
		MASALANGA	NMA	1	19	(1.0)	106	(0.9)	96	(1.0)
	15 SANDAUN	AMSUKU	OAM	1	17	(0.9)	117	(0.9)	74	(0.7)
		DCA/WARA KONGKONG	ODC	1	18	(0.9)	131	(1.1)	107	(1.1)
		WUTUNG	OWU	1	27	(1.4)	268	(2.1)	217	(2.2)
ISLANDS	16 MANUS	JOWAN 1	PJO	1	23	(1.2)	160	(1.3)	130	(1.3)
		KALI	PKA	1	29	(1.5)	168	(1.3)	163	(1.6)
		NIHON	PNI	1	31	(1.6)	144	(1.2)	133	(1.3)
		PUMBANIN	PPU	1	29	(1.5)	195	(1.6)	182	(1.8)
		TILIENU	PTI	1	6	(0.3)	21	(0.2)	21	(0.2)
	17 NEW IRELAND	BOM	QBO	1	19	(1.0)	121	(1.0)	125	(1.3)
		KONANGUSNGUS	QKG	1	30	(1.5)	166	(1.3)	130	(1.3)
		KOMAT	QKT	1	18	(0.9)	113	(0.9)	93	(0.9)
		KOMALU	QKU	1	35	(1.8)	235	(1.9)	214	(2.1)
		LEON	QLE	1	27	(1.4)	148	(1.2)	140	(1.4)
	18 EAST NEW BRITAIN	BUKA	RBU	1	30	(1.5)	128	(1.0)	128	(1.3)
		IWAI	RIW	1	17	(0.9)	93	(0.7)	80	(0.8)
		KARAVIA NO.2	RKA	1	30	(1.5)	159	(1.3)	110	(1.1)
		MANGINUNA	RMA	1	30	(1.5)	156	(1.2)	165	(1.7)
		VIVIRAN	RVI	1	28	(1.4)	171	(1.4)	146	(1.5)
	Total				**1,997**	**(100)**	**12,534**	**(100)**	**9,982**	**(100)**

APPENDIX 2: PARASITE PREVALENCE BY SURVEY VILLAGE

All age groups

Region	Province	Village	Code	Elev[1]	N	Parasite prevalence (%) All	Pf	Pv	Pm	Pf mixed
SOUTHERN	01 WESTERN	KIBULI	AKI	1	155	0.6	0.6	0.0	0.0	0.0
		KURUNTI	AKU	1	53	0.0	0.0	0.0	0.0	0.0
		SAMARI	ASA	1	161	4.3	1.9	0.6	0.0	0.0
	02 GULF	IOSIPI	BIO	1	155	0.6	0.0	0.0	0.0	0.0
		KEKE	BKE	1	134	0.7	0.7	0.0	0.0	0.0
		KUKIPI	BKP	1	159	1.3	0.6	0.0	0.0	0.0
		RABIA CAMP	BRA	1	125	1.6	1.6	0.0	0.0	0.0
	03 CENTRAL	BARAMATA SETTLM	CBA	1	161	1.2	0.6	0.0	0.0	0.0
		GALOMARUPU	CGA	1	190	2.6	2.1	0.5	0.0	0.0
		MEDENE	CME	1	145	16.6	5.5	10.3	0.0	0.0
		TUTUBU	CTU	1	154	5.2	1.9	2.6	0.0	0.0
		VARIARATA SCOUT CAMP	CVA	1	154	3.2	0.6	0.6	0.0	0.0
	04 NCD	GAHUNAGAUDI ST.	DGA	1	196	1.5	1.0	0.5	0.0	0.0
		GOLDIE ST.	DGO	1	121	0.0	0.0	0.0	0.0	0.0
		HENAO DR.	DHE	1	139	1.4	0.0	0.7	0.0	0.0
		KERMADEC	DKA	1	116	0.0	0.0	0.0	0.0	0.0
		LAHARA	DLA	1	97	0.0	0.0	0.0	0.0	0.0
	05 MILNE BAY	GARUAHI	EGA	1	131	7.6	3.1	3.8	0.0	0.0
		KAKAMWA	EKA	1	114	4.4	0.0	2.6	0.0	0.0
		MAIABARI	EMA	1	148	18.2	4.7	12.2	0.0	0.0
		SIILUGU	ESI	1	137	10.9	6.6	2.2	0.0	0.7
		WATULUMA	EWA	1	189	3.2	1.1	1.1	1.1	0.0
	06 ORO	ELCOM COMPOUND	FEC	1	136	0.7	0.0	0.0	0.0	0.0
		FODUMA	FFO	1	172	2.9	0.0	0.0	0.0	0.0
		HARURO	FHA	1	157	3.2	1.9	0.6	0.0	0.0
		HORAU	FHO	1	133	0.0	0.0	0.0	0.0	0.0
		PUIN	FPU	1	139	7.2	5.8	1.4	0.0	0.0
HIGHLANDS	07 SOUTHERN HIGHLANDS	IYANA	GIY	3	186	2.7	0.5	1.6	0.0	0.0
		KOALI	GKO	3	126	0.8	0.8	0.0	0.0	0.0
		PUNDIA	GPU	3	82	0.0	0.0	0.0	0.0	0.0
		WAGAI	GWA	3	91	0.0	0.0	0.0	0.0	0.0
	08 ENGA	BETA	HBE	3	100	0.0	0.0	0.0	0.0	0.0
		LONDO	HLO	3	114	0.0	0.0	0.0	0.0	0.0
		TAKUUP	HTA	3	143	0.0	0.0	0.0	0.0	0.0
		WABAG SECONDARY	HWA	3	74	2.7	2.7	0.0	0.0	0.0
		YOMONDI	HYO	3	59	1.7	1.7	0.0	0.0	0.0
	09 WESTERN HIGHLANDS	BOKBAKE	IBO	2	125	0.0	0.0	0.0	0.0	0.0
		FACTORY	IFA	2	73	1.4	1.4	0.0	0.0	0.0
		KUNAI GRASS	IKU	3	119	0.0	0.0	0.0	0.0	0.0
		MOPARUI	IMO	3	67	0.0	0.0	0.0	0.0	0.0
		NEW CAMP	INE	2	94	0.0	0.0	0.0	0.0	0.0

Region	Province	Village	Code	Elev[1]	N	Parasite prevalence (%)				
						All	Pf	Pv	Pm	Pf mixed
HIGHLANDS	10 CHIMBU	DAUN BASE	JDA	3	123	0.8	0.8	0.0	0.0	0.0
		DPI-FORESTRY	JDP	2	139	0.0	0.0	0.0	0.0	0.0
		KURUMBUKOTARU	JKU	3	113	0.0	0.0	0.0	0.0	0.0
		WOMAI	JWO	3	120	0.8	0.8	0.0	0.0	0.0
MOMASE	12 MOROBE	DRAYTON STREET	LDR	1	130	0.0	0.0	0.0	0.0	0.0
		MENYA	LME	2	112	0.0	0.0	0.0	0.0	0.0
		NAMBARIWA	LNA	1	217	13.4	11.1	1.4	0.0	0.0
		NUMBUGU	LNU	1	103	8.7	1.0	4.9	0.0	0.0
		SAMBIO	LSA	1	110	0.9	0.9	0.0	0.0	0.0
	13 MADANG	ABIKKAL	MAB	1	92	4.3	2.2	1.1	0.0	0.0
		ARINGEN	MAR	1	119	14.3	5.0	2.5	0.0	0.0
		MARUP 2	MMA	1	97	2.1	1.0	1.0	0.0	0.0
		MEBU	MME	1	166	12.7	7.2	0.0	0.0	0.0
	14 EAST SEPIK	BOIKIN	NBO	1	64	3.1	0.0	3.1	0.0	0.0
		JAMA	NJA	1	167	4.8	2.4	0.6	0.0	0.0
		KOIKIN	NKO	1	140	2.9	1.4	1.4	0.0	0.0
		KUSAUN	NKU	1	192	5.2	1.6	2.6	0.0	0.0
		MASALANGA	NMA	1	96	11.5	5.2	4.2	0.0	0.0
	15 SANDAUN	AMSUKU	OAM	1	74	47.3	27.0	13.5	1.4	1.4
		DCA/WARA KONGKONG	ODC	1	107	16.8	4.7	3.7	0.0	0.0
		WUTUNG	OWU	1	217	1.8	0.0	1.8	0.0	0.0
ISLANDS	16 MANUS	JOWAN 1	PJO	1	130	1.5	1.5	0.0	0.0	0.0
		KALI	PKA	1	163	0.0	0.0	0.0	0.0	0.0
		NIHON	PNI	1	133	6.8	0.8	6.0	0.0	0.8
		PUMBANIN	PPU	1	182	1.1	0.5	0.0	0.0	0.0
		TILIENU	PTI	1	21	0.0	0.0	0.0	0.0	0.0
	17 NEW IRELAND	BOM	QBO	1	125	29.6	22.4	9.6	0.0	3.2
		KONANGUSNGUS	QKG	1	130	7.7	3.8	3.1	0.0	0.0
		KOMAT	QKT	1	93	19.4	11.8	3.2	0.0	0.0
		KOMALU	QKU	1	214	26.2	8.4	11.2	0.0	0.5
		LEON	QLE	1	140	10.7	4.3	5.0	0.0	0.0
	18 EAST NEW BRITAIN	BUKA	RBU	1	128	12.5	5.5	3.1	0.8	0.8
		IWAI	RIW	1	80	20.0	10.0	7.5	0.0	0.0
		KARAVIA NO.2	RKA	1	110	0.9	0.9	0.0	0.0	0.0
		MANGINUNA	RMA	1	165	18.8	9.1	5.5	0.0	1.2
		VIVIRAN	RVI	1	146	8.2	6.2	1.4	0.0	0.0
	Total				9982					

[1]Elevation: 1 = 0-1199 m, 2 = 1200-1599 m, 3 = 1600+ m

Parasite prevalence in children <5 years (CU5)

Region	Province	Village	Code	Elev[1]	N CU5	Parasite prevalence (%) All	Pf	Pv	Pm	Pf mixed
SOUTHERN	01 WESTERN	KIBULI	AKI	1	15	0.0	0.0	0.0	0.0	0.0
		KURUNTI	AKU	1	9	0.0	0.0	0.0	0.0	0.0
		SAMARI	ASA	1	25	8.0	0.0	0.0	0.0	0.0
	02 GULF	IOSIPI	BIO	1	20	0.0	0.0	0.0	0.0	0.0
		KEKE	BKE	1	22	0.0	0.0	0.0	0.0	0.0
		KUKIPI	BKP	1	16	0.0	0.0	0.0	0.0	0.0
		RABIA CAMP	BRA	1	15	0.0	0.0	0.0	0.0	0.0
	03 CENTRAL	BARAMATA SETTLM	CBA	1	27	3.7	3.7	0.0	0.0	0.0
		GALOMARUPU	CGA	1	28	3.6	3.6	0.0	0.0	0.0
		MEDENE	CME	1	32	18.8	9.4	9.4	0.0	0.0
		TUTUBU	CTU	1	29	3.4	0.0	3.4	0.0	0.0
		VARIARATA SCOUT CAMP	CVA	1	29	3.4	0.0	0.0	0.0	0.0
	04 NCD	GAHUNAGAUDI ST.	DGA	1	24	4.2	4.2	0.0	0.0	0.0
		GOLDIE ST.	DGO	1	20	0.0	0.0	0.0	0.0	0.0
		HENAO DR.	DHE	1	10	0.0	0.0	0.0	0.0	0.0
		KERMADEC	DKA	1	20	0.0	0.0	0.0	0.0	0.0
		LAHARA	DLA	1	13	0.0	0.0	0.0	0.0	0.0
	05 MILNE BAY	GARUAHI	EGA	1	15	6.7	6.7	0.0	0.0	0.0
		KAKAMWA	EKA	1	8	25.0	0.0	25.0	0.0	0.0
		MAIABARI	EMA	1	20	40.0	10.0	30.0	0.0	0.0
		SIILUGU	ESI	1	17	17.6	11.8	11.8	0.0	5.9
		WATULUMA	EWA	1	39	5.1	5.1	0.0	0.0	0.0
	06 ORO	ELCOM COMPOUND	FEC	1	21	4.8	0.0	0.0	0.0	0.0
		FODUMA	FFO	1	26	3.8	0.0	0.0	0.0	0.0
		HARURO	FHA	1	14	0.0	0.0	0.0	0.0	0.0
		HORAU	FHO	1	25	0.0	0.0	0.0	0.0	0.0
		PUIN	FPU	1	24	8.3	0.0	8.3	0.0	0.0
HIGHLANDS	07 SOUTHERN HIGHLANDS	IYANA	GIY	3	10	0.0	0.0	0.0	0.0	0.0
		KOALI	GKO	3	10	0.0	0.0	0.0	0.0	0.0
		PUNDIA	GPU	3	6	0.0	0.0	0.0	0.0	0.0
		WAGAI	GWA	3	16	0.0	0.0	0.0	0.0	0.0
	08 ENGA	BETA	HBE	3	9	0.0	0.0	0.0	0.0	0.0
		LONDO	HLO	3	5	0.0	0.0	0.0	0.0	0.0
		TAKUUP	HTA	3	9	0.0	0.0	0.0	0.0	0.0
		WABAG SECONDARY	HWA	3	10	0.0	0.0	0.0	0.0	0.0
		YOMONDI	HYO	3	0					
	09 WESTERN HIGHLANDS	BOKBAKE	IBO	2	15	0.0	0.0	0.0	0.0	0.0
		FACTORY	IFA	2	11	0.0	0.0	0.0	0.0	0.0
		KUNAI GRASS	IKU	3	18	0.0	0.0	0.0	0.0	0.0
		MOPARUI	IMO	3	8	0.0	0.0	0.0	0.0	0.0
		NEW CAMP	INE	2	15	0.0	0.0	0.0	0.0	0.0

Region	Province	Village	Code	Elev[1]	N	Parasite prevalence (%)				
						All	Pf	Pv	Pm	Pf mixed
HIGHLANDS	10 CHIMBU	DAUN BASE	JDA	3	9	0.0	0.0	0.0	0.0	0.0
		DPI-FORESTRY	JDP	2	11	0.0	0.0	0.0	0.0	0.0
		KURUMBUKOTARU	JKU	3	2	0.0	0.0	0.0	0.0	0.0
		WOMAI	JWO	3	14	0.0	0.0	0.0	0.0	0.0
MOMASE	12 MOROBE	DRAYTON STREET	LDR	1	13	0.0	0.0	0.0	0.0	0.0
		MENYA	LME	2	19	0.0	0.0	0.0	0.0	0.0
		NAMBARIWA	LNA	1	32	21.9	21.9	0.0	0.0	0.0
		NUMBUGU	LNU	1	18	22.2	5.6	16.7	0.0	0.0
		SAMBIO	LSA	1	15	0.0	0.0	0.0	0.0	0.0
	13 MADANG	ABIKKAL	MAB	1	13	7.7	7.7	0.0	0.0	0.0
		ARINGEN	MAR	1	19	15.8	5.3	5.3	0.0	0.0
		MARUP 2	MMA	1	16	6.3	6.3	0.0	0.0	0.0
		MEBU	MME	1	35	11.4	8.6	0.0	0.0	0.0
	14 EAST SEPIK	BOIKIN	NBO	1	13	15.4	0.0	15.4	0.0	0.0
		JAMA	NJA	1	16	0.0	0.0	0.0	0.0	0.0
		KOIKIN	NKO	1	20	0.0	0.0	0.0	0.0	0.0
		KUSAUN	NKU	1	22	9.1	4.5	4.5	0.0	0.0
		MASALANGA	NMA	1	20	20.0	10.0	5.0	0.0	0.0
	15 SANDAUN	AMSUKU	OAM	1	19	68.4	47.4	31.6	0.0	5.3
		DCA/WARA KONGKONG	ODC	1	14	35.7	14.3	7.1	0.0	0.0
		WUTUNG	OWU	1	35	2.9	0.0	2.9	0.0	0.0
ISLANDS	16 MANUS	JOWAN 1	PJO	1	26	3.8	3.8	0.0	0.0	0.0
		KALI	PKA	1	25	0.0	0.0	0.0	0.0	0.0
		NIHON	PNI	1	20	0.0	0.0	0.0	0.0	0.0
		PUMBANIN	PPU	1	28	0.0	0.0	0.0	0.0	0.0
		TILIENU	PTI	1	2	0.0	0.0	0.0	0.0	0.0
	17 NEW IRELAND	BOM	QBO	1	28	46.4	35.7	21.4	0.0	7.1
		KONANGUSNGUS	QKG	1	28	21.4	7.1	10.7	0.0	0.0
		KOMAT	QKT	1	16	37.5	25.0	6.3	0.0	0.0
		KOMALU	QKU	1	28	60.7	21.4	39.3	0.0	3.6
		LEON	QLE	1	25	28.0	16.0	12.0	0.0	0.0
	18 EAST NEW BRITAIN	BUKA	RBU	1	20	30.0	10.0	15.0	5.0	5.0
		IWAI	RIW	1	15	53.3	40.0	13.3	0.0	0.0
		KARAVIA NO.2	RKA	1	14	0.0	0.0	0.0	0.0	0.0
		MANGINUNA	RMA	1	22	50.0	22.7	22.7	0.0	4.5
		VIVIRAN	RVI	1	18	27.8	11.1	11.1	0.0	0.0
	Total				1395					

[1]Elevation: 1 = 0-1199 m, 2 = 1200-1599 m, 3 = 1600+ m

APPENDIX 3: PARASITE PREVALENCE BY PROVINCE

All age groups, sorted by overall prevalence (highest to lowest)

Region*	Province	Total	Parasite prevalence (%)$			
			All	Pf	Pv	Pf mixed
I	17 NEW IRELAND	702	19.4	**9.7**	7.1	0.7
M	15 SANDAUN	398	14.3	**6.3**	4.5	0.3
I	18 EAST NEW BRITAIN	629	12.1	**6.4**	3.3	0.5
M	13 MADANG	474	9.3	**4.4**	1.1	0.0
S	05 MILNE BAY	719	8.8	3.1	**4.3**	0.1
M	12 MOROBE	672	5.8	**3.9**	1.2	0.0
S	03 CENTRAL	804	5.5	2.1	**2.6**	0.0
M	14 EAST SEPIK	659	5.3	2.1	2.1	0.0
S	06 ORO	737	2.8	**1.5**	0.4	0.0
S	01 WESTERN	369	2.2	**1.1**	0.3	0.0
I	16 MANUS	629	2.1	0.6	**1.3**	0.2
H	07 SHP	485	1.2	0.4	**0.6**	0.0
S	02 GULF	573	1.0	**0.7**	0.0	0.0
S	04 NCD	669	0.7	0.3	0.3	0.0
H	08 ENGA	490	0.6	**0.6**	0.0	0.0
H	10 CHIMBU	495	0.4	**0.4**	0.0	0.0
H	09 WHP	478	0.2	**0.2**	0.0	0.0
	Total	9982				

**H=Highlands (green), M=Momase (blue), I=Islands (yellow), S=Southern (green). $Dominant species in bold.*

APPENDIX 4: SUMMARY OF GFATM ROUND 8 PF INDICATORS

Indicator assessed through household survey	Baseline			Value [95% CI] (Target*)		Comments
	Value	Year	Source	Year 2	Year 5	
Impact Indicator						
Parasite prevalence: percentage of children aged 6 - 59 months with malaria infection (detection of parasitaemia by microscopy)	24.08%	2009	Household survey	**13.3% [9.1, 19.2]** (20%)	(17%)	
Outcome Indicators						
Proportion of households with at least 2 LLINs.	38.2%	2009	Household survey	**60.9% [52.2, 68.9]** (61%)	(90%)	
Proportion of pregnant women who slept under LLIN the previous night.	41.3%	2009	Household survey	**50.6% [39.8, 61.3]** (60%)	(70%)	
Proportion of children under 5 years old who slept under LLIN the previous night.	39.5%	2009	Household survey	**59.0% [51.6, 66.0]** (60%)	(80%)	
Percentage of children younger than 5 years of age with fever in the last 2 weeks who received antimalarial treatment according to national policy.	10.0%	2009	Household survey	**32.4%* [19.9, 48.1] 0%**** (50%)	(60%)	2009: CQ/AQ+SP Year 2: *CQ/AQ+SP **AL

**Targets based on grant PNG-812-G08-M Phase 2 Performance Framework, 16 February 2012.*