Factors determining the occurrence of submicroscopic malaria infections and their relevance for control

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Supplementary Table S1. 106 included PCR and slide-prevalence surveys: data and references

Author (publication year), reference	Country	Location	Year data collected	Number tested by PCR	Number positive by PCR	Number tested by microscopy	Number positive by microscopy	PCR method	Microscopy method*		Age group	Included in previous JID 2009 systematic review, DOI: 10.1086/644781?
									N fields	N leucocytes		
Vafa (2007) [61]	Mali	Mopti	2001	212	85	212	34	nested	-	300	children & adults	yes
Vafa (2007) [61]	Mali	Mopti	2001	214	66	214	32	nested	-	300	children & adults	yes
Roper (1996) [62]	Sudan	Daraweesh	1993	79	10	79	2	nested	200	-	children & adults	yes
Roper (1996) [62]	Sudan	Daraweesh	1994	79	15	79	4	nested	200	-	children & adults	yes
Roper (1996) [62]	Sudan	Daraweesh	1994	79	19	79	8	nested	200	-	children & adults	yes
Roper (1996) [62]	Sudan	Daraweesh	1994	73	14	73	0	nested	200	-	children & adults	yes
John (2005) [63]	Kenya	Kipsamoite	1999	123	13	123	10	nested	-	200	children & adults	yes
John (2005) [63]	Kenya	Kipsamoite	2000	267	25	267	17	nested	-	200	children & adults	yes
John (2005) [63]	Kenya	Kipsamoite	2000	273	16	273	8	nested	-	200	children & adults	yes
John (2005) [63]	Kenya	Kipsamoite	2001	152	9	152	2	nested	-	200	children & adults	yes
John (2005) [63]	Kenya	Kipsamoite	2002	228	33	228	18	nested	-	200	children & adults	yes
Ofulla (2005) [64]	Kenya	Kanyawegi		301	251	301	220	nested	-	200	children & adults	yes
Stich (2006) [65]	Burkina Faso	Bourasso	2000	201	185	201	162	nested	-	-	children & adults	yes
Alves (2002) [66]	Brazil	Portuchuelo	1998	164	16	175	4	nested	200	-	children & adults	yes
Alves (2002) [66]	Brazil	Portuchuelo	1999	142	25	142	2	nested	200	-	children & adults	yes

Author (publication year), Reference	Country	Location	Year data collected	Number tested by PCR	Number positive by PCR	Number tested by microscopy	Number positive by microscopy	PCR method	Microscopy method*		Age group	Included in previous JID 2009 systematic review, DOI: 10.1086/644781?
									N fields	N leucocytes		
Alves (2002) [66]	Brazil	Portuchuelo	1999	125	2	125	0	nested	200	-	children & adults	yes
Alves (2002) [66]	Brazil	Ji-Paraná	2000	128	58	172	10	nested	200	-	children & adults	yes
Muller (2001) [67]	Sao Tome & Principe	Riboque	1998	491	321	491	194	nested	-	200	children & adults	yes
Alves (2006) [68]	Republic of Cabo Verde	Santiago Island	1998-2000	338	3	338	0	nested	-	500	children & adults	yes
Alves (2006) [68]	Republic of Cabo Verde	Santiago Island	2003	261	10	261	0	nested	-	500	children & adults	yes
Cortes (2004) [69]	Papua New Guinea	Wosera	2000	628	330	628	175	nested	-	-	children & adults	yes
Roshanravan (2003)[70]	Peru	Iquitos	1999	819	28	819	12	nested	100	-	children & adults	yes
Zwetyenga (1998)[71]	Senegal	Ndiop	1994	143	110	143	52	nested	200	-	children & adults	yes
Toma (2001)[72]	Lao PDR	Phavang		143	77	143	46	nested	100	-	children & adults	yes
Toma (2001)[72]	Lao PDR	Sisomsouen		193	20	193	7	nested	100	-	children & adults	yes
Mehlotra (2002)[73]	Papua New Guinea	Wosera	1998-1999	340	179	1759	352	nested	-	200	children & adults	yes
Mehlotra (2002)[73]	Papua New Guinea	Liksul	2000	330	195	972	217	nested	-	200	children & adults	yes
Owusu-Agyei (2002)[74]	Ghana	Kassena-Nankana	2000	308	252	308	217	nested	200	-	children & adults	yes
Felger (1995)[75]	Papua New Guinea	East Sepik	1992	304	144	304	75	nested	100	-	children & adults	yes
Snounou (1993)[76]	Guinea Bissau	Bor	1992	110	90	110	28	nested	-	200	children & adults	yes
Snounou (1993)[76]	Guinea Bissau	Bor	1992	79	69	79	38	nested	-	200	children & adults	yes
Ntoumi (1995)[77]	Senegal	Dielmo	1992	65	50	65	50	nested	300	-	children & adults	yes

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									N fields	N leucocytes		
Marques (2005)[78]	Mozambique	Manchiana	2001	70	50	70	43	nested	-	500	children & adults	yes
Marques (2005)[78]	Mozambique	Manchiana	2002	70	55	70	43	nested	-	500	children & adults	yes
Marques (2005)[78]	Mozambique	Ilha Josina	2001	81	73	81	53	nested	-	500	children & adults	yes
Marques (2005)[78]	Mozambique	Ilha Josina	2002	87	79	87	66	nested	-	500	children & adults	yes
Khaminsou (2008)[79]	Lao PDR	Houy Jang	2006	130	18	130	12	semi-nested	100	-	children & adults	yes
Khaminsou (2008)[79]	Lao PDR	Keng Thong	2006	130	32	130	22	semi-nested	100	-	children & adults	yes
Nsobya (2004)[80]	Uganda	Kampala	2000	316	114	316	55	nested	100	-	children only	yes
Touré (2006)[81]	Gabon	Dienga		278	58	278	20	nested	-	-	adults only	yes
Guerra-Neira (2006)[82]	Equatorial Guinea	Sacriba	1998	36	24	36	18	semi-nested	-	-	children only	yes
Guerra-Neira (2006)[82]	Equatorial Guinea	Bareso	1998	35	22	35	14	semi-nested	-	-	children only	yes
Guerra-Neira (2006)[82]	Equatorial Guinea	Ureka	1998	81	50	81	40	semi-nested	-	-	children only	yes
Silue (2006)[83]	Cote d'Ivoire	Taabo	2001	424	356	424	232	nested	-	200	children only	yes
Kobbe (2006)[84]	Ghana	Afigya Sekyere	2003	962	175	1069	158	nested	200	-	children only	yes
Paganotti (2006)[85]	Burkina Faso	Bassy & Zanga	2002	92	89	92	76	nested	200	-	children only	yes
Paganotti (2006)[85]	Burkina Faso	Bassy & Zanga	2002	58	56	58	51	nested	200	-	children only	yes
Mayor (2003)[86]	Mozambique	Manhica	1999	178	76	249	34	nested	-	-	adults only	yes
Mayor (2003)[86]	Mozambique	Manhica	1997	310	135	625	154	nested	-	-	children only	yes

Author (publication year), reference	Country	Location	Year data collected	Number tested by PCR	Number positive by PCR	Number tested by microscopy	Number positive by microscopy	PCR method	Microscopy method*		Age group	Included in previous JID 2009 systematic review, DOI: 10.1086/644781?
									N fields	N leucocytes		
Vafa (2008)[87]	Senegal	Niakhar	2002	372	164	372	130	nested	200	-	children only	yes
Vafa (2008)[87]	Senegal	Niakhar	2003	372	190	372	130	nested	200	-	children only	yes
Wataya (1993)[88]	Solomon Islands	Guadalcanal	1991	98	8	98	8	nested	1000	-	children & adults	yes
Dal-Bianco (2007)[89]	Gabon	Lambarene	2005-2006	470	244	493	57	nested	100	-	adults only	yes
Peyerl-Hoffman (2001)[90]	Uganda	Kabarole	1997-1998	406	225	406	140	nested	100	-	children & adults	yes
Cerutti (2007)[91]	Brazil	Espírito Santo	2002-2003	1527	10	1777	0	nested	100	-	children & adults	yes
Dent (2007)[92]	Kenya	Kanyawegi	2003	201	141	201	117	PCR-LDR	-	-	children & adults	yes
Mueller (2009)[93]	Papua New Guinea	Jama	2005	203	71	203	45	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Sengo	2005	153	76	153	45	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Mewi	2005	133	65	133	41	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Wapins	2005	145	72	145	31	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Bangeleko	2005	172	101	172	58	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Wombisa	2005	174	91	174	57	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Malba 1	2005	163	82	163	38	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Malba 2	2005	174	102	174	49	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Yeniko	2005	184	88	184	61	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Urita	2005	166	101	166	48	PCR-LDR	100	-	children & adults	no

Author (publication year), reference	Country	Location	Year data collected	Number tested by PCR	Number positive by PCR	Number tested by microscopy	Number positive by microscopy	PCR method	Microscopy method*		Age group	Included in previous JID 2009 systematic review, DOI: 10.1086/644781?
									N fields	N leucocytes		
Mueller (2009)[93]	Papua New Guinea	Bonohoi	2005	174	95	174	57	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Wagarom	2005	175	117	175	75	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Sunuhu	2005	188	148	188	85	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Ilaita 3	2005	148	83	148	23	PCR-LDR	100	-	children & adults	no
Mueller (2009)[93]	Papua New Guinea	Ilaita 4	2005	175	95	175	43	PCR-LDR	100	-	children & adults	no
Ladeia-Andrade (2009)[94]	Brazil	Unini river	2002	233	8	275	4	nested	100	-	children & adults	no
Ladeia-Andrade (2009)[94]	Brazil	Unini river	2002	277	20	286	2	nested	100	-	children & adults	no
Ladeia-Andrade (2009)[94]	Brazil	Jau river	2002	47	5	47	1	nested	100	-	children & adults	No
Ladeia-Andrade (2009)[94]	Brazil	Unini river	2003	320	11	321	4	nested	100	-	children & adults	no
Ladeia-Andrade (2009)[94]	Brazil	Jau river	2003	165	1	166	0	nested	100	-	children & adults	no
Rosanas-Urgell (2010)[95]	Papua New Guinea	Ilahita	2008	452	198	452	115	nested	200	-	children only	no
Satoguina (2009)[96]	Gambia	Basse	2008	841	219	934	97	nested	100	-	children & adults	no
Satoguina (2009)[96]	Gambia	Farafenni	2008	689	185	729	82	nested	100	-	children & adults	no
Satoguina (2009)[96]	Guinea Bissau	Caio	2008	818	194	834	33	nested	100	-	children & adults	no
Lin (2010)[97]	Papua New Guinea	Ilaita	2006	264	131	264	86	PCR-LDR	100	-	children only	no
Steenkeste (2010)[98]	Cambodia	Yasom	2001	204	136	204	75	nested	100	-	children & adults	no

Author (publication year), reference	Country	Location	Year data collected	Number tested by PCR	Number positive by PCR	Number tested by microscopy	Number positive by microscopy	PCR method	Microscopy method*		Age group	Included in previous JID 2009 systematic review, DOI: 10.1086/644781?
									N fields	N leucocytes		
Steenkeste (2010)[98]	Cambodia	Paor	2001	209	126	209	48	nested	100	-	children & adults	no
Steenkeste (2010)[98]	Cambodia	Chet	2001	202	119	202	53	nested	100	-	children & adults	no
Steenkeste (2010)[98]	Cambodia	Tung	2001	141	55	141	20	nested	100	-	children & adults	no
Steenkeste (2010)[98]	Cambodia	Touch	2001	143	88	143	49	nested	100	-	children & adults	no
Steenkeste (2010)[98]	Cambodia	Laing Av	2001	118	80	118	31	nested	100	-	children & adults	no
Steenkeste (2010)[98]	Cambodia	Pahoy	2001	134	87	134	38	nested	100	-	children & adults	no
Katsuragawa (2010)[99]	Brazil	Porto Velho		205	4	205	1	nested	100	-	children & adults	no
da Silva (2010)[100]	Brazil	Granada	2004	386	35	388	6	nested	100	-	children & adults	no
da Silva (2010)[100]	Brazil	Granada	2004	379	33	378	6	nested	100	-	children & adults	no
da Silva (2010)[100]	Brazil	Granada	2005	328	22	329	0	nested	100	-	children & adults	no
da Silva (2010)[100]	Brazil	Granada	2006	334	8	351	1	nested	100	-	children & adults	no
Marfurt (2010)[101]	Papua New Guinea	Karimui	2003	263	102	258	34	nested	-	-	children & adults	no
Marfurt (2010)[101]	Papua New Guinea	Karimui	2004	347	71	346	64	nested	-	-	children & adults	no
Marfurt (2010)[101]	Papua New Guinea	Karimui	2005	359	131	358	82	nested	-	-	children & adults	no
Marfurt (2010)[101]	Papua New Guinea	South Wosera	2003	317	129	314	55	nested	-	-	children & adults	no
Marfurt (2010)[101]	Papua New Guinea	South Wosera	2004	366	147	356	96	nested	-	-	children & adults	no

Author (publication year), reference	Country	Location	Year data collected	Number tested by PCR	Number positive by PCR	Number tested by microscopy	Number positive by microscopy	PCR method	Microscopy method*		Age group	Included in previous JID 2009 systematic review, DOI: 10.1086/644781?
									N fields	N leucocytes		
Pacific Malaria Initiative Survey Group (2010)[102]	Vanuatu	Erromango	2008	413	2	413	0	nested	100	-	children only	no
Liljander (2011)[103]	Kenya	Junju	2005	337	263	337	243	nested	-	-	children only	no
Liljander (2011)[103]	Kenya	Junju	2005	360	212	360	174	nested	-	-	children only	no
Gahutu (2011)[104]	Rwanda	Huye	2010	545	92	545	61	semi-nested	-	-	children only	no
Steenkeste (2009)[105]	Cambodia	Ping	2001	102	73	102	59	nested	-	-	children & adults	no
Steenkeste (2009)[105]	Cambodia	Smach & Pahoy	2001	235	142	235	77	nested	-	-	children & adults	no

* Microscopy method: number of fields or number of leucocytes examined before declaring a slide parasite-negative.

References

61. Vafa M, Maiga B, Berzins K, Hayano M, Bereczky S, Dolo A, et al. Associations between the IL-4 -590 T allele and Plasmodium falciparum infection prevalence in asymptomatic Fulani of Mali. Microbes Infect. 2007 Jul;9(9):1043-8.

62. Roper C, Elhassan IM, Hviid L, Giha H, Richardson W, Babiker H, et al. Detection of very low level Plasmodium falciparum infections using the nested polymerase chain reaction and a reassessment of the epidemiology of unstable malaria in Sudan. Am J Trop Med Hyg. 1996 Apr;54(4):325-31.

63. John CC, McHugh MM, Moormann AM, Sumba PO, Ofulla AV. Low prevalence of Plasmodium falciparum infection among asymptomatic individuals in a highland area of Kenya. Trans R Soc Trop Med Hyg. 2005 Oct;99(10):780-6.

64. Ofulla AV, Moormann AM, Embury PE, Kazura JW, Sumba PO, John CC. Age-related differences in the detection of Plasmodium falciparum infection by PCR and microscopy, in an area of Kenya with holo-endemic malaria. Ann Trop Med Parasitol. 2005 Jun;99(4):431-5.

65. Stich A, Oster N, Abdel-Aziz IZ, Stieglbauer G, Coulibaly B, Wickert H, et al. Malaria in a holoendemic area of Burkina Faso: a cross-sectional study. Parasitol Res. 2006 May;98(6):596-9.

66. Alves FP, Durlacher RR, Menezes MJ, Krieger H, Silva LH, Camargo EP. High prevalence of asymptomatic Plasmodium vivax and Plasmodium falciparum infections in native Amazonian populations. Am J Trop Med Hyg. 2002 Jun;66(6):641-8.

67. Muller DA, Charlwood JD, Felger I, Ferreira C, do Rosario V, Smith T. Prospective risk of morbidity in relation to multiplicity of infection with Plasmodium falciparum in Sao Tome. Acta Trop. 2001 Feb 23;78(2):155-62.

68. Alves J, Roque AL, Cravo P, Valdez T, Jelinek T, Rosario VE, et al. Epidemiological characterization of Plasmodium falciparum in the Republic of Cabo Verde: implications for potential large-scale re-emergence of malaria. Malar J. 2006;5:32.

69. Cortes A, Mellombo M, Benet A, Lorry K, Rare L, Reeder JC. Plasmodium falciparum: distribution of msp2 genotypes among symptomatic and asymptomatic individuals from the Wosera region of Papua New Guinea. Exp Parasitol. 2004 Jan-Feb;106(1-2):22-9.

70. Roshanravan B, Kari E, Gilman RH, Cabrera L, Lee E, Metcalfe J, et al. Endemic malaria in the Peruvian Amazon region of Iquitos. Am J Trop Med Hyg. 2003 Jul;69(1):45-52.

71. Zwetyenga J, Rogier C, Tall A, Fontenille D, Snounou G, Trape JF, et al. No influence of age on infection complexity and allelic distribution in Plasmodium falciparum infections in Ndiop, a Senegalese village with seasonal, mesoendemic malaria. Am J Trop Med Hyg. 1998 Nov;59(5):726-35.

72. Toma H, Kobayashi J, Vannachone B, Arakawa T, Sato Y, Nambanya S, et al. A field study on malaria prevalence in southeastern Laos by polymerase chain reaction assay. Am J Trop Med Hyg. 2001 May-Jun;64(5-6):257-61.

73. Mehlotra RK, Kasehagen LJ, Baisor M, Lorry K, Kazura JW, Bockarie MJ, et al. Malaria infections are randomly distributed in diverse holoendemic areas of Papua New Guinea. Am J Trop Med Hyg. 2002 Dec;67(6):555-62.

74. Owusu-Agyei S, Smith T, Beck HP, Amenga-Etego L, Felger I. Molecular epidemiology of Plasmodium falciparum infections among asymptomatic inhabitants of a holoendemic malarious area in northern Ghana. Trop Med Int Health. 2002 May;7(5):421-8.

75. Felger I, Tavul L, Narara A, Genton B, Alpers M, Beck HP. The use of the polymerase chain reaction for more sensitive detection of Plasmodium falciparum. P N G Med J. 1995 Mar;38(1):52-6.

76. Snounou G, Pinheiro L, Goncalves A, Fonseca L, Dias F, Brown KN, et al. The importance of sensitive detection of malaria parasites in the human and insect hosts in epidemiological studies, as shown by the analysis of field samples from Guinea Bissau. Trans R Soc Trop Med Hyg. 1993 Nov-Dec;87(6):649-53.

77. Ntoumi F, Contamin H, Rogier C, Bonnefoy S, Trape JF, Mercereau-Puijalon O. Age-dependent carriage of multiple Plasmodium falciparum merozoite surface antigen-2 alleles in asymptomatic malaria infections. Am J Trop Med Hyg. 1995 Jan;52(1):81-8.

78. Marques PX, Saute F, Pinto VV, Cardoso S, Pinto J, Alonso PL, et al. Plasmodium species mixed infections in two areas of Manhica District, Mozambique. Int J Biol Sci. 2005;1(3):96-102.

79. Khaminsou N, Kritpetcharat O, Daduang J, Kritpetcharat P. A survey of malarial infection in endemic areas of Savannakhet province, Lao PDR and comparative diagnostic efficiencies of Giemsa staining, acridine orange staining, and semi-nested multiplex PCR. Parasitol Int. 2008 Jun;57(2):143-9.

80. Nsobya SL, Parikh S, Kironde F, Lubega G, Kamya MR, Rosenthal PJ, et al. Molecular evaluation of the natural history of asymptomatic parasitemia in Ugandan children. J Infect Dis. 2004 Jun 15;189(12):2220-6.

81. Toure FS, Mezui-Me-Ndong J, Ouwe-Missi-Oukem-Boyer O, Ollomo B, Mazier D, Bisser S. Submicroscopic Plasmodium falciparum infections before and after sulfadoxine-pyrimethamine and artesunate association treatment in Dienga, Southeastern Gabon. Clin Med Res. 2006 Sep;4(3):175-9.

82. Guerra-Neira A, Rubio JM, Royo JR, Ortega JC, Aunon AS, Diaz PB, et al. Plasmodium diversity in non-malaria individuals from the Bioko Island in Equatorial Guinea (West Central-Africa). Int J Health Geogr. 2006;5:27.
83. Silue KD, Felger I, Utzinger J, Beck HP, Smith TA, Tanner M, et al. [Prevalence, genetic diversity and multiplicity of Plasmodium falciparum infection in school children in central Cote d'Ivoire]. Med Trop (Mars). 2006 Apr;66(2):149-56.
84. Kobbe R, Neuhoff R, Marks F, Adjei S, Langefeld I, von Reden C, et al. Seasonal variation and high multiplicity of first Plasmodium falciparum infections in children from a holoendemic area in Ghana, West Africa. Trop Med Int Health. 2006 May;11(5):613-9.
85. Paganotti GM, Palladino C, Modiano D, Sirima BS, Raberg L, Diarra A, et al. Genetic complexity and gametocyte production of Plasmodium falciparum in Fulani and Mossi communities in Burkina Faso. Parasitology. 2006 May;132(Pt 5):607-14.
86. Mayor A, Saute F, Aponte JJ, Almeda J, Gomez-Olive FX, Dgedge M, et al. Plasmodium falciparum multiple infections in Mozambique, its relation to other malariological indices and to prospective risk of malaria morbidity. Trop Med Int Health. 2003 Jan;8(1):3-11.
87. Vafa M, Troye-Blomberg M, Anchang J, Garcia A, Migot-Nabias F. Multiplicity of Plasmodium falciparum infection in asymptomatic children in Senegal: relation to transmission, age and erythrocyte variants. Malar J. 2008;7:17.
88. Wataya Y, Arai M, Kubochi F, Mizukoshi C, Kakutani T, Ohta N, et al. DNA diagnosis of falciparum malaria using a double PCR technique: a field trial in the Solomon Islands. Mol Biochem Parasitol. 1993 Mar;58(1):165-7.
89. Dal-Bianco MP, Koster KB, Kombila UD, Kun JF, Grobusch MP, Ngoma GM, et al. High prevalence of asymptomatic Plasmodium falciparum infection in Gabonese adults. Am J Trop Med Hyg. 2007 Nov;77(5):939-42.
90. Peyerl-Hoffmann G, Jelinek T, Kilian A, Kabagambe G, Metzger WG, von Sonnenburg F. Genetic diversity of Plasmodium falciparum and its relationship to parasite density in an area with different malaria endemicities in West Uganda. Trop Med Int Health. 2001 Aug;6(8):607-13.
91. Cerutti C, Jr., Boulos M, Coutinho AF, Hatab Mdo C, Falqueto A, Rezende HR, et al. Epidemiologic aspects of the malaria transmission cycle in an area of very low incidence in Brazil. Malar J. 2007;6:33.
92. Dent AE, Yohn CT, Zimmerman PA, Vulule J, Kazura JW, Moormann AM. A polymerase chain reaction/ligase detection reaction fluorescent microsphere assay to determine Plasmodium falciparum MSP-119 haplotypes. Am J Trop Med Hyg. 2007 Aug;77(2):250-5.
93. Mueller I, Widmer S, Michel D, Maraga S, McNamara DT, Kiniboro B, et al. High sensitivity detection of Plasmodium species reveals positive correlations between infections of different species, shifts in age distribution and reduced local variation in Papua New Guinea. Malar J. 2009;8:41.
94. Ladeia-Andrade S, Ferreira MU, de Carvalho ME, Curado I, Coura JR. Age-dependent acquisition of protective immunity to malaria in riverine populations of the Amazon Basin of Brazil. Am J Trop Med Hyg. 2009 Mar;80(3):452-9.
95. Rosanas-Urgell A, Mueller D, Betuela I, Barnadas C, Iga J, Zimmerman PA, et al. Comparison of diagnostic methods for the detection and quantification of the four sympatric Plasmodium species in field samples from Papua New Guinea. Malar J. 2010;9:361.
96. Satoguina J, Walther B, Drakeley C, Nwakanma D, Oriero EC, Correa S, et al. Comparison of surveillance methods applied to a situation of low malaria prevalence at rural sites in The Gambia and Guinea Bissau. Malar J. 2009;8:274.
97. Lin E, Kiniboro B, Gray L, Dobbie S, Robinson L, Laumaea A, et al. Differential patterns of infection and disease with P. falciparum and P. vivax in young Papua New Guinean children. PLoS One. 2010;5(2):e9047.
98. Steenkeste N, Rogers WO, Okell L, Jeanne I, Incardona S, Duval L, et al. Sub-microscopic malaria cases and mixed malaria infection in a remote area of high malaria endemicity in Rattanakiri province, Cambodia: implication for malaria elimination. Malar J. 2010;9:108.
99. Katsuragawa TH, Gil LH, Tada MS, de Almeida e Silva A, Costa JD, Araujo Mda S, et al. The dynamics of transmission and spatial distribution of malaria in riverside areas of Porto Velho, Rondonia, in the Amazon region of Brazil. PLoS One. 2010;5(2):e9245.
100. da Silva NS, da Silva-Nunes M, Malafronte RS, Menezes MJ, D'Arcadia RR, Komatsu NT, et al. Epidemiology and control of frontier malaria in Brazil: lessons from community-based studies in rural Amazonia. Trans R Soc Trop Med Hyg. 2010 May;104(5):343-50.
101. Marfurt J, Smith TA, Hastings IM, Muller I, Sie A, Oa O, et al. Plasmodium falciparum resistance to anti-malarial drugs in Papua New Guinea: evaluation of a community-based approach for the molecular monitoring of resistance. Malar J. 2010;9:8.
102. Malaria on isolated Melanesian islands prior to the initiation of malaria elimination activities. Malar J. 2010;9:218.

103. Liljander A, Bejon P, Mwacharo J, Kai O, Ogada E, Peshu N, et al. Clearance of asymptomatic P. falciparum Infections Interacts with the number of clones to predict the risk of subsequent malaria in Kenyan children. PLoS One. 2011;6(2):e16940.
104. Gahutu JB, Steininger C, Shyirambere C, Zeile I, Cwinya-Ay N, Danquah I, et al. Prevalence and risk factors of malaria among children in southern highland Rwanda. Malar J. 2011;10:134.
105. Steenkeste N, Incardona S, Chy S, Duval L, Ekala MT, Lim P, et al. Towards high-throughput molecular detection of Plasmodium: new approaches and molecular markers. Malar J. 2009;8:86.