A Simple Score to Predict Malaria Occurrence in Keerom, Papua: A Prospective Cohort Study Analyzed by Multivariate Logistic Regression

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Abstract: Keerom regency is the most prevalent malaria in Papua (17.7%). Malaria prevention addressed to the people who lived in Keerom. Hence, it is necessary to start preventing people before entering Keerom. This study aimed to develop a kind of device called scoring system that could be used as a primordial prevention. Methods: A prospective cohort prognostic study followed 606 subjects for three months to find out the malaria dominant risk factors. Prior to constructing a scoring system, bivariate analysis using chi square and multivariate logistic regressions were applied in this study. Results: Among 15 identified risk factors (namely sex, age, ethnic group, education, duration of stay at Keerom, nutritional status, socio economic status, forest activity, drug prevention, using insecticide, using insecticide treated nets, night time activity, animals around the house, the distant of breeding places and health centers from house), respectively, only 6 risk factors considered as dominant risk factors. The dominant risk factors are socio economic status (RR 1,430 95% CI 1,025- 1,995), night time activity (RR 1,624 95% CI 1,030-2,561), sex (RR 1,543 95% CI 1,116-2,133), forest activity (RR 0,587 95% CI 0,369-0,943), nutritional status (RR 1,405 95% CI 1,017-1,941) and duration of stay at Keerom (RR 2,519 95% CI 1,462-4,340), respectively. The scoring system was constructed based on dominant risk factors and could be used to predict malaria occurrence according to someone's characteristics and conditions. Calibration and discrimination test showed that scoring system was a reliable tool (Hosmer Lemeshow test p = 0,337 and AUC 0,633 (95% CI 0,580-0,687)). However there were only 57% risk factors could be included in the system. Therefore it is necessary to take into a consideration to enhance the system by including others risk factors such as genetic and climate risk factors. Conclusion: The scoring system usually used in clinical setting, but it could be used in public health as well. Results show that the model is reliable enough, yet only could be used in Keerom.

Index Terms *- Scoring system, Malaria, Risks factor, Breeding places.*

I. INTRODUCTION

Indonesia was considered has the highest malaria prevalence and incidence in South East Asia. The population at risk was 31,427,995 out of 244,420,912 people or 12.86% and causing Malaria Mortality Rate of 0.83/100,000. This number posted Indonesia as the third country after Timor Leste (4.90/100,000) and Myanmar (2.40/100,000). This condition could be understood since the Annual Parasite Incidence of Indonesia was $4.37^0/_{00.}$ compared to Timor Leste and Myanmar which has the Annual Parasite Incidence of $43.93^0/_{00}$ and $10.21^0/_{00}$ respectively [1].

Based on clinical finding, the national prevalence of malaria in Indonesia was 2.85%. This prevalence mainly contributed by 3 provinces namely West Papua (26.1%), Papua (18.7%) and East Nusa Tenggara (12.0%). A survey conducted by Ministry of Health showed the average prevalence in Papua was 65.5% (diagnosed clinically) or 18.7% (smear examination). Among the 29 regencies in Papua,

Keerom showed the highest prevalence (82.1% clinically and 17.7% smear examination) [2, 3].

Since the launching of its national program in 1963, Papua has not been able to control malaria moreover Keerom newly developed regency. The control program consists of Indoor Residual Spraying (IRS), the use of Insecticide Treated Nets (ITN) and media campaign. These all efforts addressed for preventing people who lived in Keerom. As a newly develop regency, Keerom attracts many people to come for works. Therefore it is also necessary to prevent people before entering Keerom as a primordial prevention.

Scoring system generally used in clinical setting as a simple and reliable device to predict the outcome of a disease in relation to the symptoms and signs. Plenty publications could be found elsewhere regarding the scoring system for several diseases (e g scoring system for malaria [4-7], dengue fever [8], neonatal seizure [9]).

The purpose of this study was to develop a malaria scoring system in a public health setting to predict the malaria occurrence in relation to people's characteristics and conditions. Hopefully the scoring systems could be used as guidance by clinicians, decision makers and lay men for malaria primordial prevention.

II. MATERIAL AND METHODS

2.1 Study Area

The study was carried out at Keerom Regency, Papua, Indonesia. Keerom with 46,282 inhabitants is located in the southern part of Jayapura which is the capital of Papua [12]. Keerom is divided into six districts (Web, Senggi, Waris, Arso, Arso Timur, Skanto). The regency is located in low land area of 4 m above sea level. The climate and weather are homogeneous all over Keerom. Hence, climate and weather are not considered having any influences in this study.

2.2 Subjects

Twenty five blocks census and 10 families in every block census were chosen randomly from 6 districts. The average number of family member is 4.289, so that the number of subjects chosen was around 1.000. However a total of 777 subjects were able to collect in this study.

A questionnaire inquiring for malaria risk factors was administered and physical and smear examination for malaria were done to all subjects (including collection of body weight, height and urine test for β HCG). The positive malaria subjects were excluded from study and the remaining (606 subjects) followed for 3 months for prospective cohort study.

Those considered as malaria risk factors are sex, age, ethnic group, education level, duration of stay at Keerom, nutritional status, socio economic status, forest activity, drug prevention, using insecticide, using insecticide treated bed nets, night time activity, animals around the house, the distant of breeding places and Health Centers from house.

There are many ethnics group who lived in Keerom. Some of them are local people with several tribes and the others are ethnics who came from other part on Indonesia. For simplicity the ethnics in Keerom was divided in two ethnics group, the Papuans (the local people) and Non Papuans (from other part of Indonesia). The Papuans commonly practicing subsistence agriculture and exploit forest product, yet the Non Papuans who are transmigrated from Java mostly work as government official and as peasant in the forest.

The Papuans is more resistant to malaria than the Non Papuans [13]. Therefore ethnics considered as a risk factor of malaria. This condition was in relation with the duration of stay in endemic area and the immunity against malaria. Accordingly people who were stayed longer than 2 years in Papua were more resistant to malaria than those who were stayed less than 2 years [14].

Many studies showed that nutritional status influenced the malaria occurrence and vice versa [15, 16]. The nutritional status in this study was measured by age (0-5; 6-17 and 18+ years), weights and heights according to WHO and Blössner et al [17, 18]. Therefore in this study ages was grouped into this manner. Nutritional status was defined as poor (under nourished and overweight) and normal. People in poor nutritional status prompt to easily getting malaria. There is a relationship between malaria and socio economic status [16, 19, 20]. In Vietnam and some other countries the main malaria risk factor was poverty [20, 21]. The socio economic status in this study defined as the amount of expenses per person per month with the cut off value of IDR.280000 or $23.3 [22].

The education was influencing malaria occurrence as shown in Sulawesi (Indonesia), some countries in Africa and Vietnam [21, 23-25]. Thang divided the education level to None, Primary school and Secondary school or higher. These levels of education were used in this study as well.

2.3 Statistical Analysis

Data were double entered, checked and cleaned. The data set analyzed with Statistical Product for Service Solutions (SPSS) version 19. Descriptive statistics and chi-square test were used to test for significant difference ($p<0.05$). A logistic regression was used to carry out a multivariate analysis for the malaria risk factors. Finally a scoring system was developed based on the result of logistic regression analysis. Calibration and discrimination of the system was tested using Hosmer and Lemeshow and Area Under the Curve (AUC).

2.4 Ethical Consideration

The study was approved by the ethical committee of Faculty Medicine, Hasanuddin University, Makassar, Indonesia. The fundamental principles of ethics in research on human participants were upheld throughout the study. The research procedures were disclosed to the participants and informed consent was sought from them or their legal representatives. Nobody was coerced into the study and if individuals wished to withdraw, they were allowed to do so without prejudice.

III. RESULTS AND DISCUSSION

3.1 Results

There were 777 people in the study, but after checked their malaria condition with blood smear examination, 171 people excluded from the study. The cohort started with 606 negative smear examination people who were then followed up for 3 months to check their malaria condition again.

Among the 606 participants (Table 1), 72.4% were represented by Non Papuans and mostly above 18 years of age. Keerom is new developed regency and inhabited by 76.6% people who stayed no longer than 2 years. Most of the people worked as government officials especially the Non Papuans and only 23.1% as forest workers either as peasant or hunter. People whose living expenses under IDR.280000 were 25.9% and the rest considered living above the poverty line. In total 32.2% of the population were in poor nutrition status (under nourished and overweight). Keerom still a remote area surrounding with jungle, accordingly only 8.1% people have night time activity.

The environment factors in relation with malaria occurrence were the distant of breeding places and the distant of Health Center to house. The distant of breeding places that was less than 500 m from housing (22.8%) considered at high risk. Similarly the distant of health center more than 500 m (23.4%). More than half population (67.3%) used ITN and few additional people were sleeping without a bed net. As commonly happens, animals around the house could protect against mosquito bite especially the zoophilic anopheles and in turn could prevent malaria occurrence. Without understanding of this knowledge more than half people in Keerom breed their animals around their house (56.3%).

Most people have negative blood smear examination after 3 months followed up (80.2%) the additional people (19.8%) were positive. This finding slightly higher than the results of the former survey conducted in Keerom (17.7%) [3].

To find out the malaria risk factors that could be used to develop scoring system, a bivariate and multivariate analysis were done, (Table 2). Bivariate analysis showed that 10 out of 15 risk factors have $p < 0.25$.

Table 1 Baseline characteristic of the study population

	Study population n = 606	**n**	%
1	Ethnic groups		
	- Non Papuans	439	72.4
	- Papuans *)	167	27.6

2	Sex		
	- Female	328	54.1
	- Male*)	278	45.9
3	Age groups		
	- 0-5 years	18	3.0
	- 6-17 years	81	13.4
	- >18 years *)	507	83.7
4	Duration of stay		
	- < 2 years	464	76.6
	- > 2 years *)	142	23.4
5	Education level		
	- None	76	12.5
	- Primary school	207	34.2
	- Secondary school or higher *)	323	53.3
6	Socio economic status (based on the expenses per person per months		
	- < IDR.280,000	157	25.9
	- > IDR.280,000 *)	449	74.1
7	Forest activity		
	- Yes	140	23.1
	- No *)	466	76.9
8	Night time activity		
	- Yes	49	8.1
	- No *)	557	91.9
9	Drug prevention		
	- No	378	62.4
	- Yes *)	228	37.6
10	Using insecticide		
	- No	335	55.3
	- Yes *)	271	44.7
11	Using Insecticide Treated Nets (ITN)		
	- No	198	32.7
	- Yes *)	408	67.3
12	Animals around the house		
	- No	265	43.7
	- Yes *)	341	56.3
13	Nutritional status		
	- Poor	195	32.2
	- Normal *)	411	67.8
14	Distant to breeding places		
	- < 500 m	138	22.8
	- > 500 m *)	468	77.2
15	Distant to health services (health centers)		
	- > 500 m	142	23.4
	- 250-500 m	132	21.8
	- < 250 m *)	332	54.8
16	Blood smear examination		
	- Positive	120	19.8
	- Negative	486	80.2

*) Reference

Table 2 Risk factors, bivariate analysis

Variables	Blood smear examination				p value	RR	95% CI	
	Positive		Negative				Min	Max
	n	%	n	%				
Sex					**0,008**	1,543	1,116	2,133

Male	68	24,5	210	75,5				
Female*)	52	15,9	276	84,1				
Age								
0-5 y	4	22,2	14	77,8	0,804			
6-17 y	18	22,2	63	77,8				
>18 y*)	98	19,3	409	80,7				
Ethnic groups								
Non Papuans	95	21,6	344	78,4	**0,006**	1,446	0,966	2,163
Papuans*)	25	15,0	142	85,0				
Education level								
None	11	14,5	65	85,5	**0,016**			
Primary school	31	15,0	176	85,0				
>Secondary school*)	78	24,1	245	75,9				
Duration of stay								
≤2 years	107	23,1	357	76,9	**0,000**	2,519	1,462	4,340
>2 years*)	13	9,2	129	90,8				
Nutritional status								
Poor	48	24,6	147	75,4	**0,041**	1,405	1,017	1,941
Normal*)	72	17,5	339	82,5				
Socio economic status								
< IDR.280000	40	25,5	117	74,5	**0,038**	1,430	1,025	1,995
> IDR.280000	80	17,8	369	82,2				
Forest activity								
Yes	18	12,9	122	87,1	**0,019**	0,587	0,369	0,934
No*)	102	21,9	364	78,1				
Drug prevention								
No	72	19,0	306	81,0	0,549	0,905	0,653	1,254
Yes*)	48	21,1	180	78,9				
Using insecticide								
No	57	17,0	278	83,0	0,056	0,732	0,531	1,008
Yes*)	63	23,2	208	76,8				
ITN								
No	30	15,2	168	84,8	**0,045**	0,687	0,471	1,001
Yes*)	90	22,1	318	77,9				
Night time activity								
Yes	15	30,6	34	69,4	**0,048**	1,624	1,030	2,561
No*)	237	34,8	445	65,2				
Animals around the house								
No	54	20,4	211	79,6	0,754	1,053	0,763	1,453
Yes*)	66	19,4	275	80,6				
Breeding places distant								
≤500 m	38	27,5	100	72,5	**0,009**	1,572	1,125	2,196
>500 m*)	82	17,5	386	82,5				
Health centers distant								
>500 m	30	21,1	112	78,9	0,898			
250-500 m	26	19,7	106	80,3				
< 250 m*)	64	19,3	268	80,7				

Those with p< 0.25 could be further analyzed by backward stepwise multivariate logistic regression. However, only 6 risk factors considered as the main risk factors connected to the malaria occurrence (Table 3).

Table 3 Backward stepwise logistic regression of the malaria risk factors

								95% C.I.for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	Socio economic status(1)	.389	.257	2.298	1	.130	1.476	.892	2.442
	Night time activity(1)	.717	.358	4.009	1	.045	2.049	1.015	4.136
	Sex(1)	.599	.216	7.665	1	.006	1.820	1.191	2.780
	Education level			1.979	2	.372			
	Education level (1)	-.271	.386	.495	1	.482	.762	.358	1.624
	Education level (2)	-.359	.263	1.864	1	.172	.699	.417	1.169
	Forest activity(1)	-.363	.321	1.280	1	.258	.696	.371	1.305
	ITN(1)	-.325	.257	1.594	1	.207	.723	.437	1.196
	Breeding places distant(1)	.238	.267	.791	1	.374	1.268	.751	2.141
	Nutrition status(1)	.631	.229	7.582	1	.006	1.880	1.200	2.947
	Duration of stay(1)	1.091	.331	10.848	1	.001	2.977	1.555	5.698
	Constant	-2.747	.391	49.447	1	.000	.064		
Step 2[a]	Socio economic status(1)	.483	.234	4.266	1	.039	1.621	1.025	2.563
	Night time activity(1)	.753	.355	4.498	1	.034	2.124	1.059	4.262
	Sex(1)	.597	.216	7.641	1	.006	1.817	1.190	2.774
	Education level			2.274	2	.321			
	Education level (1)	-.311	.383	.660	1	.417	.733	.346	1.552
	Education level (2)	-.377	.261	2.080	1	.149	.686	.411	1.145
	Forest activity(1)	-.402	.318	1.599	1	.206	.669	.359	1.247
	ITN(1)	-.303	.256	1.398	1	.237	.739	.447	1.220
	Nutrition status(1)	.613	.228	7.231	1	.007	1.846	1.181	2.885
	Duration of stay(1)	1.120	.330	11.527	1	.001	3.066	1.606	5.855
	Constant	-2.722	.390	48.838	1	.000	.066		
Step 3[a]	Socio economic status(1)	.492	.233	4.453	1	.035	1.635	1.036	2.583
	Night time activity(1)	.721	.351	4.229	1	.040	2.057	1.034	4.090
	Sex(1)	.614	.215	8.150	1	.004	1.848	1.212	2.816
	Forest activity(1)	-.537	.305	3.107	1	.078	.584	.322	1.062
	ITN(1)	-.332	.250	1.755	1	.185	.718	.439	1.172
	Nutrition status(1)	.562	.225	6.260	1	.012	1.754	1.129	2.724
	Duration of stay(1)	1.210	.325	13.869	1	.000	3.354	1.774	6.340
	Constant	-2.902	.373	60.399	1	.000	.055		
Step 4[a]	Socio economic status(1)	.479	.232	4.243	1	.039	1.614	1.024	2.546
	Night time activity(1)	.725	.352	4.252	1	.039	2.064	1.037	4.112
	Sex(1)	.608	.214	8.042	1	.005	1.837	1.207	2.796
	Forest activity(1)	-.652	.292	4.979	1	.026	.521	.294	.924
	Nutrition status(1)	.564	.224	6.326	1	.012	1.757	1.132	2.726
	Duration of stay(1)	1.219	.324	14.123	1	.000	3.384	1.792	6.391
	Constant	-2.978	.370	64.941	1	.000	.051		

a. Variable(s) entered on step 1: Socio economic status, Night time activity, Sex, Education level, Forest activity, ITN, Breeding places distant, Nutrition status, Duration of stay.

The risk factors which were processed for scoring system were sex, duration of stay, nutritional status, socio economic status, forest activity and night time activity. All these factors were scored with the range of zero to seven. A person with zero score meant having no risk factors and score seven meant having all the risk factors. All the score of the risk factors were then sum up as a total score.

Logistic regression as a mathematical approach explained the relation between risk factors and dependent variable (malaria occurrence) using a regression equation $y = (\alpha+\beta_1x_1+\beta_2x_2+ .....\beta_ix_i)$. In this case the equation was y = -2.703 + 0.434 x total_score. The probability having malaria was shown by the equation of $P = \frac{1}{1+e^{-y}}$

To find the probability of someone getting malaria in Keerom, it was provided a malaria score card. The card is easy to fill in by choosing the condition they may have and the score comes up with certain number and percentage of the probability of malaria occurrence (Figure 1).

Figure 1 Malaria Score Card

MALARIA SCORE CARD KEEROM REGENCY				
Date				
Name				
Please fill in according to your conditions				
1	Sex	Male	Female	Score
		1	0	
2	Nutritional status *)	Poor	Normal	
		1	0	
3	Forest activity	Yes	No	
		1	0	
4	Night time activity	Yes	No	
		1	0	
5	Expenses per person per month	Less than IDR.280000	More than IDR.280000	
		1	0	
6	Duration of stay in Keerom	Less than 2 years	More than 2 years	
		2	0	
	Total Score			

According to the Total Score, the probability you encountered with malaria in Keerom is:

Score	Probability malaria occurrence	Score	Probability malaria occurrence
0	6%	4	27%
1	9%	5	36%
2	13%	6	46%
3	19%	7	57%

*) Nutritional status based on Body Mass Index. BMI between 18.5 -24.9 considered normal otherwise is poor.

3.2 Discussion

Keerom is a new regency and gave a plenty opportunities for works. Many people came to Keerom from other part of Papua and Indonesia for work. Almost all of them were susceptible to malaria and have no immunity at all. Therefore malaria prevalence was very high. Several efforts have been done to control, however the prevalence still very high. The last survey done in this area reveal the prevalence of 17.7% [3]. The main effort to eliminate malaria in Keerom was prevention against mosquito bite such as insecticide, ITN and Indoors Residual Spraying. All these measures addressed to people who were already stayed in

Keerom. However, there was no effort to protect people before coming to Keerom.

A prognostics study aimed to develop a model to predict a malaria outcome of a subject according to his characteristics. According to Royston and Steyerberg, the appropriate design for the study was prospective cohort with the alternative design were case control or nested case control [10, 26] to find the main risk factor of malaria. This study conducted with prospective cohort for 3 months. Some aspects have to be taken into consideration in choosing risk factors used in the model in order the model could be easily used by the lay men, decision makers and clinician. In addition the risk factors have to be chosen statistically and based on the literatures.

The bivariate analysis and logistic regression eliminated some risk factors and 6 remaining used in the model. Based on these 6 factors (sex, socio economic status, night time activity, forest activity, duration of stay and nutritional status) scoring system was developed. Hosmer and Lemeshow test (p=0.337) and AUC (0.633 95% CI 0.580-0.687) showed that the model reliable enough (Figure 2).

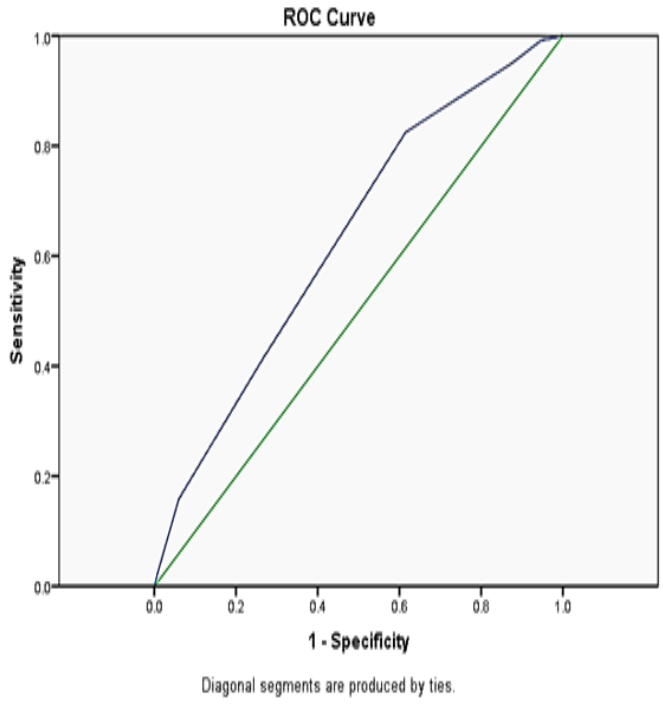

Figure 2. Area Under the Curve of the model

However, this model was not able to accommodate the other 43% risk factors and was only able to predict the 57% risk factors (Figure 1). In order the model could accommodate all risk factors, it has to accommodate more risk factors such as genetics (ovalocytosis, G6PD, Thalassemia, Duffy antigen), environment factors (house condition) and weather factors (temperature, humidity, rainfall). Certainly this scoring system could only be used in Keerom.

IV. Conclusions

We propose this scoring system for people entering Keerom Regency as a primordial prevention. This scoring system needs prospective validation in a new sample of people in other regency. If confirmed with other study, then the scoring system has the potential to become a useful tool for primordial prevention before entering malaria endemic area.

Authors' contributions

All the authors participated significantly in the analysis, drafting of the manuscript and writing the final version of the paper. BS conceptualized the study. NN, AA and AN contributed towards the statistical analysis.

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References

1. WHO: **World Malaria Report 2010.** 2010.
2. Depkes RI: **Report on Basic Health Research (RISKESDAS) 2007.** Jakarta: MOH Indonesia; 2008.

3. Depkes RI: **Report on Basic Health Research Papua Province 2007.** Jakarta: MOH Indonesia; 2008.
4. Mishra SK, Panigrahi P, Mishra R, Mohanty S: **Prediction of outcome in adults with severe falciparum malaria: a new scoring system.** *Malaria Journal* 2007, **6:24**.
5. Hanson J, Lee SJ, Mohanty S, Faiz MA, Anstey NM, Charunwatthana P, Yunus EB, Mishra SK, Tjitra E, Price RN, et al: **A Simple Score to Predict the Outcome of Severe Malaria in Adults.** *Malaria Score • CID 2010* 2010, **50:**679-685.
6. shah V, B.K.Shah, Vadera B, H.K.Acharya: **Clinical Scoring System to Predict Malarial Fever: A Prospective Study.** *Int J Med Public health* 2011, **1:**30-33.
7. Mohapatra M, Das S: **The Malaria Severity Score: a Method for Severity Assessment and Risk Prediction of Hospital Mortality for Falciparum Malaria in Adults.** *Journal of Association of Physicians of India* 2009, **57:**119-126.
8. Chang K, Lu P-L, Ko W-C, Tsai J-J, Tsai W-H, Chen C-D, Chen Y-H, Chen T-C, Hsieh H-C, Pan C-Y, Harn M-R: **Dengue Fever Scoring System: New Strategy for the Early Detection of Acute Dengue Virus Infection in Taiwan.** *J Formos Med Assoc* 2009, **108:**879-885.
9. Pisani F, Sisti L, Seri S: **A Scoring System for Early Prognostic Assessment after Neonatal Seizures.** *Pediatrics* 2009, **124:**580-587.
10. Royston P, Moons KGM, Altman DG, Vergouwe Y: **Prognosis and Prognostics Research: Developing A Prognostic Model.** *BMJ* 2009, **338:**338-604.
11. Altman DG, Vergouwe Y, Royston P, Moons KGm: **Prognosis and Prognostic Research: Validating A Prognostic Model.** *BMJ* 2009, **338:**1432-1435.
12. BPS: *Papua in Figure.* BPS-Statistics of Papua Province; 2010.
13. Baird JK, Basri H, Weina P, Maguire JD, Barcus MJ, Picarema H, Elyazar IRF, Ayomi E, Sekartuti: **Adult Javanese migrants to Indonesia Papua at risk of severe disease caused by malaria.** *Epidemiol Infect* 2003, **131:**791-797.
14. Barcus MJ, Basri H, Picarima H, Manyakori C, Sekartuti, Elyazar I, Bangs MJ, Maguire JD, Baird JK: **Demographic Risk Factors for Severe and Fatal Vivax and Falciparum Malaria Among Hospital Admissions in Northeastern Indonesian Papua.** *Am J Trop Med Hyg* 2007, **77:**984-991.
15. Kouéta F, Dao L, Yé D, Zoungrana A, Kaboré A, Sawadogo A: **Risk factors for death from severe malaria in children at the Charles de Gaulle pediatric hospital of Ouagadougou (Burkina Faso).** *Sante* 2007, **17(4):**195-199.
16. Sachs J, Malaney P: **The Economic and Social Burden of Malaria.** *Nature* 2002, **415:**680-685.
17. WHO: *WHO Child Growth Standards Length/height-for-age, weight-for-age, weight-for-length weight-for-height and body mass index-for-age Methods and development.* WHO, Department of Nutrition for Health and Development; 2006.
18. **Software for assessing growth and development of the world's children. Geneva: WHO, 2010** [http://www.who.int/childgrowth/software/en/]
19. Worrall E, Basu S, Hanson K: **The Relationship Between Socio-Economic Status and Malaria: A Review of The Literature.** In *Ensuring that Malaria Control Interventions Reach the Poor*. London School of Hygiene and Tropical Medicine; 2003.
20. Protopopoff N, Bortel Wv, Speybroeck N, Geertruyden J-Pv, Baza D, D'Alessandro U, Coosewmans M: **Ranking Malaria Risk Factors to Guide Malaria Control Effort in African Highlands.** *Plos One* 2009, **4:**1-10.
21. Thang ND, Erhart A, Speybroeck N, Hung LX, Thuan LK, Hung CT, Ky PV, Coosemans M, D'Alessandro U: **Malaria in Central Vietnam: Analysis of Risk Factors by Multivariate Analysis and**

Classification Tree Models. *Malaria Journal* 2008, **7:28**.

22. BPS: **Data and Poverty Information 2007.** In: Badan Pusat Statistik; 2007
23. Amiruddin R, Sidik D, Alwi A, Islam N, Jumriani, Astuti P, SYafruddin: **Socioeconomic Factor and Access to Health Services for Malaria Control in Mamuju District, West Sulawesi Indonesia.** *Asian Journal Of Epidemiology* 2012, **5(2):**54-61.
24. Guthmann J, Hall A, Jaffar S, Palacios A, Lines J, Llanos-Cuentas A: **Environmental Risk Factors for Clinical Malaria: A Case-Control STudy in the Grau Region Peru.** *Trans R Soc of Trop Med Hyg* 2001, **95:**577-583.
25. Safeukui-Noubissi I, Ranque S, Poudiougou B, Keita M, Traoré A, Traoré D, Diakité M, Cissé M, Keita M, Dessein A, Doumbo O: **Risk factors for severe malaria in Bamako, Mali: a matched case-control study.** *Microbes Infect* 2004, **6(6):**572-578.
26. Steyerberg EW: *Clinical Prediction Models: A Practical Approach to Development, Validation, and Updating.* Springer Science; 2009.

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