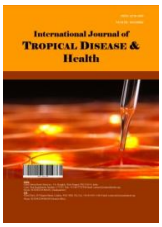

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"House Plasmodial Prevalence Index" Another Relevant Indicator of Evaluating a Malaria Vector Control Operations, Example of Capango Village (Benguela Province, Angola)

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Authors' contributions

This work was carried out in collaboration among all authors. Author PC designed the study, participated to the field work, did statistical analysis, wrote the first draft and finalized the text. Authors JCT and VF participated directly to the field studies. All authors agreed with the document.

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ABSTRACT

The WHO fascicule "Information systems for the evaluation of malaria control programmes" identified as outcome target "the proportion of households targeted for use of nets using at least one impregnated bednet" [1].
The parasitological evaluation of the efficacy of vector control programme is mainly based on the plasmodial prevalence rate evaluated by cross sectional or longitudinal surveys on representative sample of the human population targeted.
For the new "House plasmodial" index we decided to combine the 2 indicators: the classical human plasmodial prevalence and house considering as positive any house with "at least one symptomless inhabitant having at least one positive thick film during the survey". We used this new indicator when analyzing data gained during 24 regularly done parasitological surveys during 5 years in Capango village where a vector control (VC) programme was implemented using both

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Long Lasting Nets PermaNet© 2.0 and deltamethrin treated wall lining called ZeroFly© inside every house. Surveys were done during 2 years before VC and 3 years after.
It appeared that the House Plasmodial positive index showed the same trends and level as the classical human plasmodial prevalence and clearly indicated the impact of vector control in reducing the overall plasmodial prevalence in the targeted village.
On the other hand it appeared repeating surveys identified "frequently positive houses" (=found positive in some 50% of surveys) and therefore *to be prioritized for control* and those "scarcely positive" (20% of surveys).
The House Plasmodial Prevalence index appeared relevant and reliable, interesting to be used in vector control programme while easy to get and should be considered in other epidemiological situation.

Keywords: Vector control; impregnated mosquito nets (LLIN); insecticide treated plastic sheeting; plasmodial prevalence; new indicator household plasmodial index; evaluation.

1. INTRODUCTION

Since their first entomological trial in the experimental huts of the Soumousso field station WHO Collaborative Centre [2] then their first epidemiological evaluation in Karankasso savanna village [3] and villages of the Kou Valley rice field [4] Insecticide Treated Nets ("ITNs"(which became "Long Lasting Insecticide Nets" ("LLINs") appeared as a main tool to reduce malaria transmission, morbidity and overall infants mortality [5].

For Dr M. Chang (former WHO Director) "Long-lasting insecticidal nets are the mainstay of malaria prevention" and "WHO recommends their use for all people at risk of malaria".

For the WHO Malaria Report 2016 [6] "The most commonly used methods to prevent mosquito bites are sleeping under an ITN and spraying the inside walls of a house with an insecticide – indoor residual spraying ("IRS"). Use of ITNs has been shown to reduce malaria incidence rates by 50% in a range of settings, and to reduce malaria mortality rates by 55% in children aged under 5 years in sub-Saharan Africa. These two core vector-control interventions – use of ITNs and IRS – are considered to have made a major contribution to the reduction in malaria burden since 2000, with ITNs estimated to account for 50% of the decline in parasite prevalence among children aged 2–10 years in sub-Saharan Africa". But making an accurate evaluation of vector control implies the choice of pertinent indicators and methods available in field situations.

To overcome the well-known operational issues and short lasting effect of IRS, Insecticide Treated Plastic Sheeting ("ITPS") was recently developped [7] and successfully tested in different situations [8,9]; their acceptability was studied in Angola and Nigeria [10] and Papua New-Guinea [11].

Capango is one of the 8 Angolese villages where we implemented a malaria vector control program (Carnevale et al., unpub. obs.) with multidisciplinary evaluation, entomological, parasitological and immunological [12].

Classically *Plasmodium* parasite prevalence is estimated in making and microscopically examining blood films of sample of targeted population with cross sectional surveys ("CSS") or longitudinal surveys and generally several thousands of thick films are prepared to get statistically reliable data.

Surveys at household level were done to get relevant indicators of population coverage in ITNs such as the recommended "Proportion of *households* with at least one ITN for every two people" [6] or "Proportion of *households* with at least one ITN" and "Proportion of population at risk sleeping under an ITN or living in a *house sprayed* by IRS in the previous 12 months" as outcome indicators.

It can also be noticed that "households" are indicated as an the outcome target and corresponding indicators (such as "proportion of households targeted for use of nets using at least one impregnated bednet") in the WHO Practical guide for "the evaluation of malaria control programmes" [1].

Therefore we decided to combine the two indicators "parasite prevalence rate" and "household" in a new methodological approach for an evaluation of a vector control operation

developing a "*house plasmodial prevalence index*" (HPI) new indicator moreover the usual and classical "plasmodic index" (PI) dealing with human beings (with one blood thick film for one human being).

2. METHODOLOGY

For "house plasmodial prevalence" we considered that *if at least one thick film was positive among all those made from inhabitants of this house during the survey, whatever were the number of inhabitants, the age composition of the family and the number of positive thick films; thus it was classified as "a plasmodial positive house"*; if not a single thick film was positive during the survey then the house was classified as negative.

For each field parasitological survey we counted the number of "plasmodial positive houses" and "plasmodial negative houses" moreover the classical number of plasmodial positive people (= plasmodial prevalence) among the sample of the population of the village involved in the field survey. Results of positive or negative thick films of inhabitants of each house was noticed and information gave to the local "health care worker" so that in case of positive blood film he can give drug according to the National Malaria Control Programme.

In 2007 a long term (10 years) village scale vector control programme was implemented in 8 villages around Balombo (Angola) (12° 3' S; 14°5' E, elevation 1176 m) with classical entomological and parasitological surveys (Carnevale *et al*., in preparation). Among them the most remote one is "Capango" (14°50'E; 12°24'S) a small village located 15 kms SE of Balombo with 64 houses and 137 inhabitants (according to the census made by the "health care worker" of the village) at the beginning of the study. Each house received a number painted on the door to recognize them easily during the trial. In December 2008 we implemented in each house, both insecticide treated plastic sheeting (ITPS) model "Zero Fly" ("ZF") (19.14 m^2, treated with deltamethrin at 360 g a.i.:m^2) pinned on the walls of rooms where people are sleeping and a long lasting insecticide treated nets ("LLIN") model "PermaNet 2.0" ("P2.0") (treated with deltamethrin at the rate of 55 mg a.i./m^2) to cover every "sleeping unit" (bed, mattress etc.). A total of 93 "ZeroFly" and 93 "PermaNet 2.0" were implemented to get a full coverage of sleeping units and walls of sleeping places. Entomological valuation of their efficacy was classically done with CDC Miniature Light Trap inside house (10 traps regularly implemented inside always the same initially randomly selected houses) and cross sectional surveys were made systematically two weeks after entomological survey, with thick blood films examined in the Medical Department of the Sonamet Angolese Company in Lobito in the framework of their "Malaria Control Programme" (MCP).

From March 2007 to December 2011, we did 24 parasitological Cross Sectional Surveys ("CSS"):

- 10 surveys from March 2007 to December 2008 (=*before* the implementation of Vector Control Operations): 4 surveys in 2007 and 6 surveys made every 2 months in 2008, then
- 14 surveys were done *after* the Vector control implementation: 6 surveys regularly made every 2 months in 2009, then 6 surveys in 2010 and 2 surveys in 2011.

For each surveys we analyzed the 2 indicators: the new "House Plasmodial Prevalence Index" (=% Plasmodial positive house among all those "surveyed") ("HPI") and the classical human Plasmodic Index ("PI") which were compared for the 2 periods: "before" and "after" vector control implementation.

3. RESULTS AND DISCUSSION

III-1. Plasmodial Prevalence rate at house and human level.

For the 2 years before the vector control implementation the parasite prevalence rate among human population was 35.3% (n= 652) and 54.5% for the 308 houses surveyed (Table 1).

For the 3 years after the implementation of vector control the overall parasite prevalence rate among the human beings was 6.9% (n= 1202) and the percentage of "positive houses" was 18.2% for 406 "surveyed houses" (Table 2).

Both indicator, at household level and individual human being level, showed comparable values and trends (Fig 1a and 1b) during the whole study.

After the Vector Control Implementation the classical human Plasmodic indice decreased by some 80% while the House Plasmodial

Prevalence Index decreased by some 70% and it could thus be considered as a good proxy for a Vector Control evaluation in checking 3 times less "sampling units" (# 400 instead of # 1200) and considering the whole sample of people without the needed age stratification.

Table 1. Observations done before Vector Control Implementation (H+= number of houses with at least one positive blood film during one of the surveys done during the year; nb H "surveyed" = total number of houses from which thick films were made among inhabitants during the year; nb TF+ = number of positive thick films done during the year; Nb TF made= total number of thick films made during the year in the population of the village)

	Nb H+	Nb H "surveyed"	% H+ (=HPI)	Nb TF+	Nb TF made	% TF+ (=PI)
Year 2007	85	133	63.9%	120	276	43.5%
Year 2008	83	175	47.4%	110	376	29.3%
Total before	168	308	54.5%	230	652	35.3%

Table 2. Observations done after Vector Control Implementation (H+= number of house with at least one positive blood film during one of the surveys done during the year; nb H "surveyed" = total number of houses from which thick films were made among inhabitants during the year; nb TF+ = number of positive thick films done during the year; Nb TF made= total number of thick films made during the year in the population of the village)

	Nb H+	Nb H "surveyed"	% H+	Nb TF+	Nb TF made	% TF+
Year 2009	48	182	26.4%	58	513	11.3%
Year 2010	21	169	12.4%	21	532	3.9%
Year 2011	5	55	9.1%	5	157	3.2%
Total "after"	*74*	*406*	*18.2%*	*84*	*1202*	*6.9%*

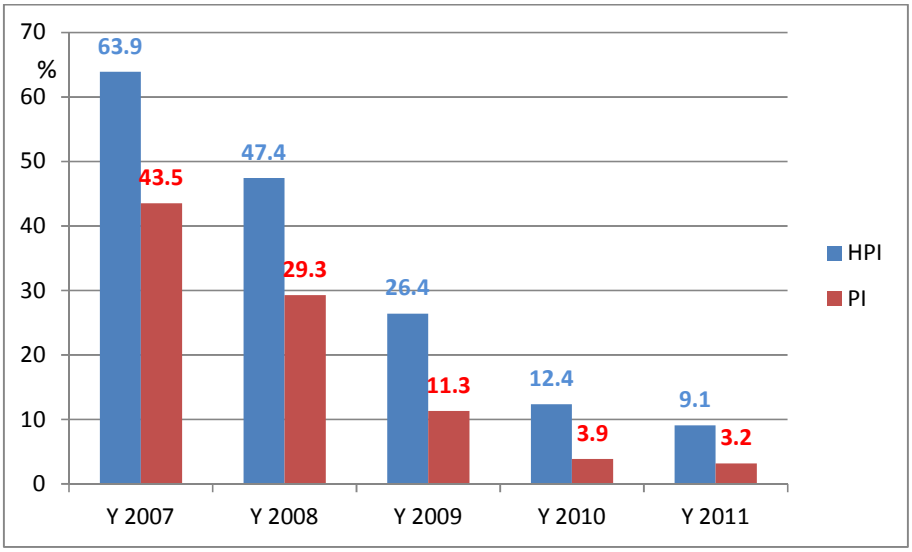


Fig 1a. Evolution of house plasmodial index (HPI) and human plasmodic index (PI) every year before vector control (years 2007 and 2008) and after vector control (years 2009, 2010 and 2011)

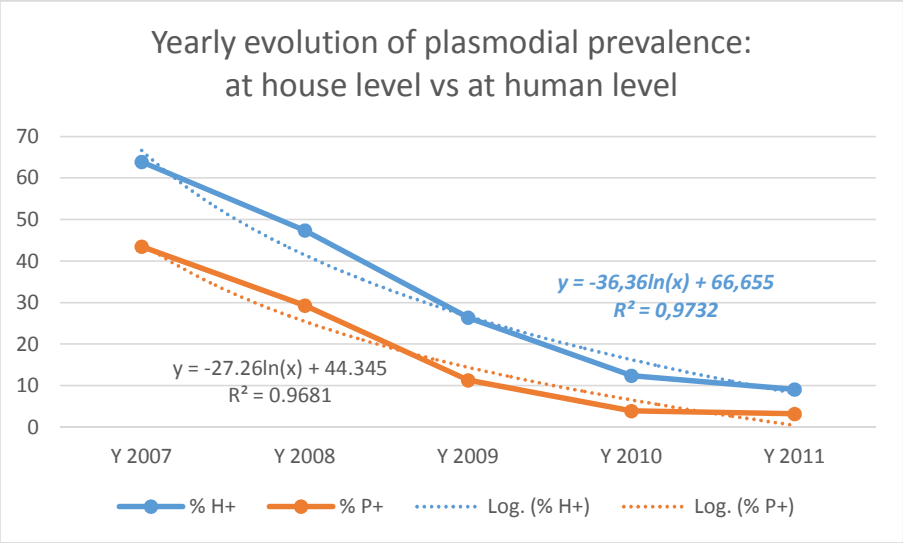


Fig 1b. Trends in the evolution of plasmodial prevalence at house level (blue line) and at individual level (red line) before and after vector control implementation in Capango village<

It has to be underlined that before the full coverage with insecticide treated nets and insecticide treated plastic sheeting Plasmodium carriers were found in more than 50% of the houses of this village while it dropped to less than 10% in three years showing how this simple indicator could be of great usefulness to evaluate the efficacy of the vector control tools implemented, as well as the classical human parasite prevalence rate.

On the other hand it is worth considering the evolution of these 2 indicators every year (Fig. 1b) where it appeared some remarkably similar trends over the 5 years of the trial without having to consider the age composition of parasitological samples to standardize and compare them as it has to be done usually.

It thus clearly appeared that the House Plasmodial Index could be a relevant one deserving a special attention to evaluate a vector control programme in a cost-effective way.

An interesting correlation appeared between the evolution of the human plasmodic indices (PI) and the house plasmodial prevalence index (HPI) (Fig. 2) with a correlation coefficient (Pearson test) of r = 0.995 [0.917-0.999] and R^2 = 0.989.

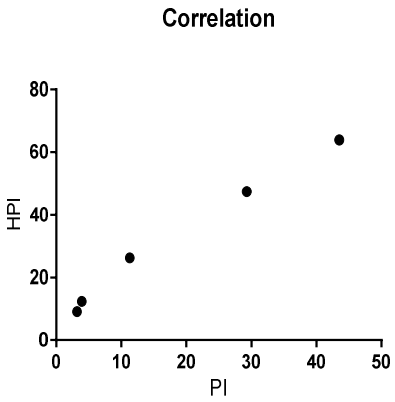


Fig. 2. Correlation between human plasmodic index (PI) and house plasmodial prevalence index (HPI)

On the other hand, it should be emphasized that the values of the Human Plasmodic Index (PI) and the House Positive Index "HPI" analyzed by the non-parametric Mann-Whitney test were similar (Fig. 3), (P = 0.309; Not Significant Difference).

The village of Capango being relatively "small" the regular repetition of surveys for 5 years has made it possible to "revisit" the houses several times, some houses twenty (and more) times; for example, houses 7, 28, 30 were visited in each survey, houses 1 and 10: 23 times.

The analysis of the "parasitological" situations of each of the 64 houses during each of the 24 surveys done showed that:

- all houses surveyed several times have been found, at least once, "positive" showing that the village is in a permanent malaria endemic situation;
- some houses have a high frequency of positive cases (# 50%) and others have a relatively low frequency (# 20%) although they are all built on the same model (Table 3a and 3b) and at a short distance each other in the same environment.

This kind of information is epidemiologically very important to identify the houses to be monitored and treated in priority.

On the other hand, an examination of the distribution of "positive houses" in the village did not reveal any "clusters" (map) as positive and negative houses appeared scattered in the village where the main vector is *Anopheles funestus* and the small size of the village is in the range of the active flight of this species.

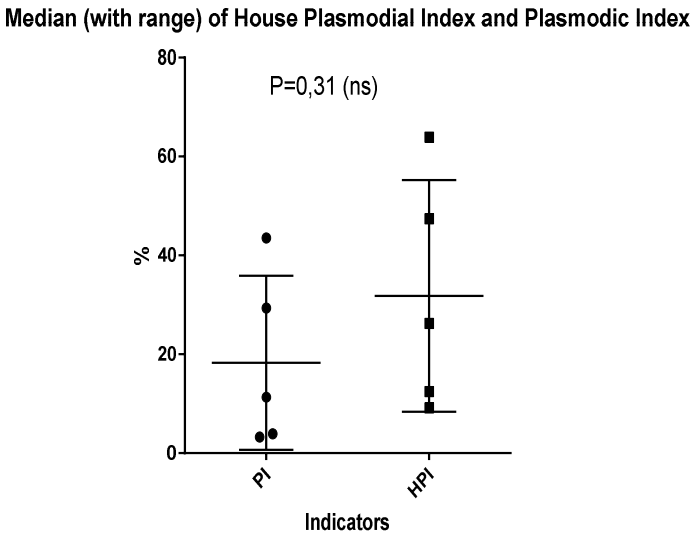


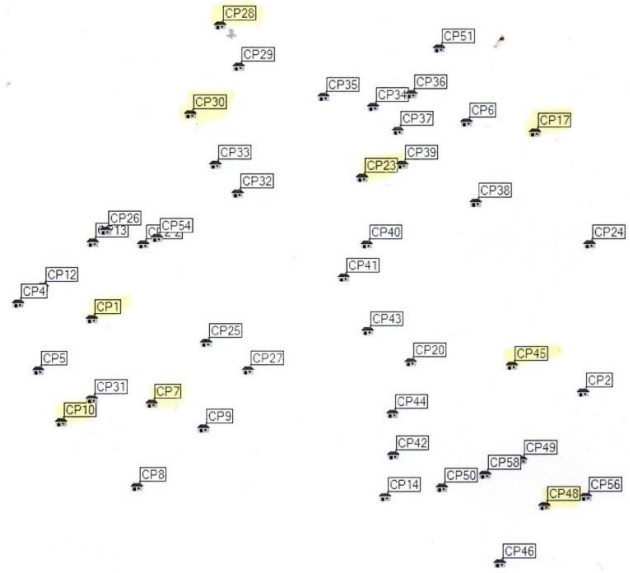
Fig. 3. Comparaison of Human Plasmodic Index and House Plasmodial Index III-2. Incidence-frequency

Table 3a. Examples of frequently positives houses

N° of the house	Nb of surveys	Nb of positive surveys	%*
1	23	10	43,5%
3	22	12	54,5%
7	24	10	41,7%
10	23	13	56,5%
15	19	9	47,4%
17	17	8	47,1%
23	9	4	44,4%
28	24	11	45,8%
30	24	10	41,7%

Table 3b. Examples of houses less frequently positive

N° of the house	Nb of surveys	Nb of positive surveys	%
6	18	4	22,2%
16	14	4	7,5%
29	19	4	21,1%
30	23	6	26,1%
32	16	4	25%
33	12	3	25%
47	17	2	11,8%
51	14	4	28,6%



Repartition in Capango village of the « plasmodial positive houses » (yellow)

4. CONCLUSION

According to the WHO World Malaria Report [13] "In 2018, an estimated 228 million cases of malaria occurred worldwide (95% confidence interval [CI]: 206–258 million)" .and "Half of people at risk of malaria in sub-Saharan Africa are sleeping under an ITN; in 2018, 50% of the population were protected by this intervention. Households with at least one ITN for every two people increased to 72% in 2018, from 47% in 2010". It is interesting to underline the special attention which is officially devoted "at households' level" to evaluate the process of ITN distribution and the fact that 50% of population are protected by ITNs while in our 5 years longitudinal surveys in Capango it appeared that in around 50% of house at least one inhabitants was observed symptomless carrier of *Plasmodium falciparum* before the implementation of vector control in Capango village. The Percentage of positive house dropping to 10% after implementation of both Long lasting insecticide treated nets and Insecticide treated plastic sheeting.

Malaria Elimination is strongly promoted [14] combining vector control (with mainly insecticide treated nets and inside house residual spraying) and parasite control with case management based on Artemisin Combined Treatment (ACT), Intermittent Presumptive Treatment (IPT) for pregnant women, improving diagnosis with Rapid Detection Tests (RDT) etc.

But one of the key point remains the surveillance, monitoring and evaluation of the situation before/after Malaria control programme [15].

Monitoring the situation is classically based upon 2 main methods: Active Case Detection and Passive Case Detection. Passive case detection

(PCD) is the detection of malaria cases among patient in health facility but bias are well known and could procure data not always quite reliable [16] with often great overdiagnosis of "malaria".

Active case detection (ACD) is the detection by health workers of malaria cases in the community and in households, ACD are largely used for example to evaluate the incidence of malaria disease before/after implementation of vector control programme [17].

On the other hand classical parasitological surveys are done for situation analysis to precise the plasmodial prevalence (*Plasmodium* species, plasmodic index, gametocytic index, parasitaemia) among symptomless population on randomized sample or at risk groups [18].

To evaluate the impact of different methods of vector control at village scale level around Balombo classical parasitological surveys were done on a regular basis with microscopical analysis of blood thick films of symptomless people of randomly selected houses (Carnevale et al. unpub.obs.).

Having the number of positive cases and geo localization of each house checked it was possible to make a new retrospective analysis of data aiming to identify where positive thick films were noticed and to localize "positive" house considering that "at least a single positive blood film" among the inhabitants should be enough to consider *the house as Plasmodial positive.* This is similar to the approach of targeting a house for the use of "at least one bednet" as an outcome indicator of vector control programme. But instead of a bednet we considered *a positive thick film as the main parameter*. Comparing the new house plasmodial positive index with the classical human plasmodic index the same trends before and after vector control implementation was observed allowing to consider the house plasmodial prevalence index as a good and interesting proxy and a relevant indicator for the evaluation of a control programme. It also allowed to identify "often positive houses" to be prioritized for vector control for the best cost/effective way and the eventual localization of clusters of positive houses for example more or less close a breeding site or scattered here and there in the village and to plan action accordingly.

It should be interesting to test this House Plasmodial Prevalence Index in several other eco-epidemiological settings and to incorporate it as a relevant indicator for a malaria vector control program targeting houses to be treated and used for evaluation of the efficacy of method used.

CONSENT

It is not applicable.

ETHICAL APPROVAL

This analysis is a part of a comprehensive evaluation of a vector control programme done with the Angola National Malaria Control Programme and Provincial Public Health Authorities.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. AFRO/CTD/MAL. Information systems for the evaluation of malaria control programmes. WHO Regional Office for Africa. 1994;AFRO/CTD/MAL/94.3:72.
2. Darriet F, Robert V, Tho Vien N, Carnevale P. Evaluation de l'efficacité sur les vecteurs de paludisme de la permethrine en imprégnation de moustiquaires intactes et trouées. WHO/VBC/84899 & WHO/MAL/841008; 1984.
3. Carnevale P, Robert V, Boudin C, Halna J-P, Pazart L, Gazin P, et al. La lutte contre le paludisme par des moustiquaires imprégnées au Burkina Faso. Bull Soc Path Exot. 1988;81:832-846.
4. Robert V, Carnevale P. Influence of deltamethrin treatment of bednets on

malaria transmission in the Kou Valley, Burkina Faso. Bull Wld Hlth Org. 1991; 69:735-740.
5. Lengeler C, Cattani J, De Savigny D. Net gain. A new method for preventing malaria deaths. 1996;189.
6. WHO. World Malaria Report. 2016;186.
7. Messenger L, Rowland M. Insecticide-treated durable wall lining (ITWL): Future prospects for control of malaria and other vector-borne diseases. Malar J. 2017; 16(1):213.
8. Chandre F, Dabire R, Hougard J, Djogbenou L, Irish S, Rowland M, et al. Field efficacy of pyrethroid treated plastic sheeting (durable lining) in combination with long lasting insecticidal nets against malaria vectors. Parasit Vectors. 2010; 3(1):65.
9. Burns M, Rowland M, N'guessan R, Carneiro I, Beeche A, Ruiz S, et al. Insecticide-treated plastic sheeting for emergency malaria prevention and shelter among displaced populations: an observational cohort study in a refugee setting in Sierra Leone. Am J Trop Med Hyg. 2012;87(2):242-250.
10. Messenger L, Miller N, Adeogun A, Awolola T, Rowland M. The development of insecticide-treated durable wall lining for malaria control: Insights from rural and urban populations in Angola and Nigeria. Malar J. 2012;18(11):332.
11. Pulford J, Tandrapah A, Atkinson J, Kaupa B, Russell T, Hetzel M. Feasibility and acceptability of insecticide-treated plastic sheeting (ITPS) for vector control in Papua New Guinea. Malar J. 2012;11:342.
12. Brosseau L, Drame P, Besnard P, Toto J, Foumane V, Le Mire J, et al. Human antibody response to Anopheles saliva for comparing the efficacy of three malaria vector control methods in Balombo, Angola. PLoS One. 2012;7:e44189.
13. WHO. World Malaria Report 2019. WHO Ed ISBN 978-92-4-156572-1. 2019:232 pp.
14. WHO. A framework for malaria elimination. WHO ed ISBN 976 924 15 1198 8. 2017;100.
15. WHO. Malaria surveillance, monitoring and evaluation: A reference manual. Wld Hlth Org. 2018;2018:196.
16. Manguin S, Foumane V, Besnard P, Fortes F, Carnevale P. Malaria overdiagnosis and subsequent overconsumption of antimalarial drugs in Angola: Consequences and effects on human health. Acta Trop. 2017;171:58-63.
17. Henry MC, S-A. A, Rogier C, Dossou yovo J, Chandre F, Guillet P, et al. Protective efficacy of lambda-cyhalothrin treated nets in Anopheles gambiae pyrethroid resistance areas of Côte d'Ivoire. Am J Trop Med Hyg. 2005;73(5):859-864.
18. Bruce-Chwatt LJ. Essential Malariology. W Heineman Med Books Ltd London. 1986;452.

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