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Chapter 41

MALARIA: AN ENVIRONMENTAL HEALTH ISSUE WITH TREMENDOUS SOCIOECONOMIC IMPACT ON HOUSEHOLDS IN DEMOCRATIC REPUBLIC OF CONGO

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ABSTRACT

Background and objective. Malaria is a mosquito-borne infectious disease with high morbidity and mortality in tropical regions, caused by Plasmodium parasite and transmitted to humans by female Anopheles mosquitoes. WHO estimates that African households lose about 25% of income to malaria. The aim of this pilot study was to determine the prevalence and socioeconomic impact of malaria on households in the Democratic Republic of Congo (DRC).

Methods. An analytical cross-sectional study was conducted from 16 November through December 2015 in which 152 heads of households took part. They were from a rural (n1=81) and an urban county (n2=71). All participating households made up 1,029 members. The French version of 'Malaria Indicator Survey' questionnaire was completed anonymously.

Results. There were 51.3% of male and 48.7% of female heads of households ($p>0.05$). The mean age was 38.97±9.88, and 22% of them were unemployed. Household size varied from 3 to 18, and more than half (61.7%) of rural households had more than five members (vs. 38.3% for urban households). The estimated household monthly income varied from 10 to 700 $US, and only 10.5% of households earned more than 300 US$ a month (vs. 89.5% earning less than 300US$ and 50.6% less than 100 US$; $p<0.05$). Participants from the urban site had higher level of education, with 37.2% having a college or university degree (vs. 21.6% for rural site); 12.5% either had primary education level or were illiterate. Regarding anti-vector measures for malaria prevention, 15.8% of heads of households reported the existence of a public sanitation activity implemented in their residential area ($p<0.001$); 65.8% used insecticide-treated bed nets (ITN), 13.8% used spray, 0.6% combined ITN and spray, 12.5 used ordinary bed nets, whereas 7.2% did not use any preventive measure. For monthly anti-mosquito expenditure, 50% (76/152) of participants reported that they spent nothing due to lack of money, 24.3% spent 10-20 $US, 15.7% spent 21-30 $US; the remaining participants (9.9%) spent more than 30 $US a month. The availability of nets showed a positive association with socioeconomic status of households. Overall malaria prevalence-rate among heads of households was 92.4% (at least one episode), with an average of 2.5 malaria episodes per person (range: 1–7 episodes). It was equally high in participants from both rural and urban sites, 90.1% and 88.7%, respectively ($p>0.05$). In the group of participants who reported using ITN, malaria prevalence-rate was 89%; it was 90.5% in spray users, 100% in ordinary bed net users and 100% in those who did not use any measure. Heads of households who reported earning less than 300 US$ had 2.76 times malaria risk than those from households with a monthly income of 300 US$ or higher (aOR: 2.76±1.87; 95% CI: 1.73-10.41; $p<0.05$); those who had primary education level (or illiterate) had a 33.87 times risk of developing malaria (vs. higher level; aOR: 33.87±34.42; 95% CI: 2.45-89.49; $p<0.05$); whereas those living in areas without public sanitation program had a 3.01 times malaria risk (aOR: 3.01±2.19; 95% CI: 1.37-24.23; $p<0.05$). Regarding individual malaria care expenditure in the previous 12-month period, the estimated cost was 101.56 ± 10.63 $US per person.

Conclusions. Findings from this pilot study showed high malaria rates in both rural and urban households with a relatively high malaria care expenditure, causing a real socioeconomic burden to Congolese households. There is a necessity to enhance malaria prevention programs with the adoption of an integrated anti-malaria approach aiming at increasing malaria awareness and eliminating its vector in the living environment.

Keywords: Congo, household, malaria, prevalence, socioeconomic status

1. INTRODUCTION

1.1. Definition, Etiology and Epidemiologic Profile of Malaria

Malaria is a mosquito-borne infectious disease caused parasites of the genus *Plasmodium*, transmitted to humans by female *Anopheles* mosquitoes. It is a disease that is well established as a major global health problem (WHO 2011; Bhatt et al. 2015; Wumba et al. 2015). There are four species of *Plasmodium* that infect humans to cause malaria: *P. falciparum*, *P. vivax*, *P. ovale and P. malariae*; of them, *P. falciparum* is considered the most lethal and widespread malaria parasites infecting humans. Other *Plasmodium* species are known to be responsible of infection in rodents and non-human primates (Cai et al. 2010; Liu et al. 2010). The finding of malaria parasites in human red blood cells in 1880 by the French army doctor in Algeria and winner of the Nobel Prize of Physiology and Medicine in 1907, Charles Louis Alphonse Laveran, inaugurated a new era in the understanding of the pathophysiology of the disease (Haas 1999). It also rendered the finding of anti-malaria remedies possible that could help to manage the disease.

Malaria morbidity tended to decrease in some endemic countries during the first decade of the 21st century. In 2010, the World Health Organization (WHO), estimated that there were 219,000,000 documented cases of malaria worldwide, killing between 660,000 and 1,200,000 people (WHO 2010). A similar trend was reported for the year 2012, with 207,000,000 cases of whom 627 died. It has been estimated that 3.3 billion people are at risk of malaria, of whom 655,000–1,200,000 die annually, and more than one case occurring per 1,000 population in high-risk areas. The disease killed about 482,000 children under five years of age; that is 1,300 children every day, or one child almost every minute (Nayyar et al. 2012; WHO 2013).

1.2. Trends of Malaria Prevalence and Cost in the Sub-Saharan Africa

Malaria is prevalent is tropical and sub-tropical regions because of rainfall, warm temperatures and stagnant water that provide habitat for mosquito larvae. Previous works have established a relationship between Malaria and poverty, hindering economic development of many developing countries, particularly in Africa (Worrall et al. 2005). Of the 627,000 deaths due to malaria in the world in 2012, approximately 90% occurred in sub-Saharan African countries, and DRC and Nigeria accounted for 40% of them (WHO 2013; PNLP 2013). According to WHO, households in Africa lose approximately 25% of income to malaria (WHO 2008), and the disease has a tremendous impact on households and businesses. In one hand, malaria increases health-related expenditures and employee absenteeism; on the other hand, it reduces productivity. In Uganda, a recent study conducted in 100 households found an association between socioeconomic status and malaria, with wealth index as a predictor of malaria risk (Tusting et al. 2016).

1.3. Malaria Status in Democratic Republic of the Congo (DRC)

Several anti-malaria drugs have been discovered, however, their efficacy is often challenged by new resistant species of plasmodium, besides the treatment cost that some families cannot afford. Thus, the use of Insecticide Treated Net (ITN) has recently become the most promoted and reliable preventive measure in the Sub-Saharan Africa. Nonetheless, the persistent high morbidity and mortality of Malaria despite the large distribution of ITN suggests that the measure has some limits, and that the hygiene and sanitation promotion approach might be of great contribution in the fight against Malaria.

The DRC National Malaria Program reported about 9,400,000 malaria cases occurring nationwide within the year 2012, resulting in 24,000 deaths (PNLP 2013). In its recent report, the same program reported that annual malaria incidence varied between 13,591-13,155 cases per 100,000 from the year 2010 to 2014; and that malaria mortality accounted for 39% all-causes mortality nationwide in 2013, whereas it was 36% in 2014 (PNLP strategic plan 2016). Considering the context of extreme poverty, particularly in the central African region (DRC included), the absence of a country level health insurance system and the inaccessibility of a poor populations to malaria treatment, malaria prevention and the universal care coverage initiative will continue to face shortcomings in most countries of the region. This suggests the need for a more integrated approach in the fight against malaria.

1.4. Objectives of the Study

To our knowledge, there have been no research that investigated the real socioeconomic impact of malaria on Congolese households. We conducted a pilot cross-sectional study to evaluate the incidence and the socioeconomic impact of malaria and related risk factors in a sample of 152 Congolese households from a semi-rural and urban sites of DRC from 16th November through December 2015. The objectives of this pilot study were the following:

1. Evaluate the malaria knowledge and awareness of Congolese household representatives;
2. Determine the prevalence of malaria among study participants and household members in the previous 12 months, its socioeconomic impact and determinants on Congolese rural and urban households.

2. MATERIALS AND METHODS

2.1. Study Design, Sites and Participants

A pilot analytical cross-sectional study was conducted, from 16 November through December 2015, at two sites of the western DRC's provinces of Kinshasa, the capital, and Kongo central. Participants were enrolled at the urban county of Limete, in the capital Kinshasa, and at Kasa-Ngulu, a rural county located in the Kongo central province. Both sites share quite similar ecological conditions: populous residential areas and proximity to a river.

This was a collaborative study between the University of Kochi in Japan and the Unit of Parasitology, Faculty of Medicine of the University of Kinshasa in DRC.

Local Congolese research team counterpart has visited the study sites weeks prior to conducting the survey and contacted community and social leaders (church and social leaders, district and county administrative and health authorities) in each study site. After a thorough explanation of the study activities, later on, the leaders had to explain to their community members during weekly gatherings and schedule the survey. Only community members who were heads of households, voluntarily accepted to take part in the study and signed the informed consent form were eligible.

In this first phase of the 'Congo Malaria Study', a sample of 150 household representatives (75 from each of the study sites) was expected. In total, 152 heads of households were enrolled in the study (71 from the rural and 81 from the urban sites). The household size varied from 3 to 18 members, and all participating households made up 1,029 members. Each participant had to answer the survey questionnaire on behalf of his/her household. Those with a low educational level were assisted by trained surveyors using local dialects to explain the content of informed consent form, and the questionnaire as well.

2.2. Survey Questionnaire

The French version of 'Malaria Indicator Survey' (Global Fund and Madagascar National Malaria Program, 2013) questionnaire was completed anonymously by each participant. It comprised 49 items related to the following five categories:

1. Clinical and sociodemographic characteristics;
2. Personal and family history;
3. Personal lifestyle characteristics;
4. Household characteristics;
5. Household malaria preventive measures and malaria care options.

However, in this first report, only outcome information related to participants' characteristics, malaria rates, malaria preventive measures and care is provided. Study outcomes in regard to water provision and management, the general hygiene and sanitation (WASH) in the study sites will be included in another report.

2.3. Ethical Considerations and Statistical Analyses

The present study was approved by the ethics committee of the Graduate School of Health Sciences and Nursing, University of Kochi in Japan and the local Congolese district administration officers of participating counties and community leaders. Each of the study participants provided a signed informed consent form after receiving explanations of the study objectives and activities. Survey data are presented as means for continuous variables and proportions for categorical variables; outcome variables are either dichotomized or stratified into three to five categories. Cross-tabulation and paired T test were performed to compare study group, whereas logistic regression test was used to determine predictors of

malaria in the sample of heads of households. P-value for statistical significance was set at 0.05. All analyzes were performed with the use of Stata software version 10 (Stata corporation, TX, USA).

3. RESULTS

3.1. Characteristics of Study Participants

Table 1 shows the demographic and socioeconomic characteristics of the participating heads of households from both study sites. There were 51.3% of male participants (78/152; 32 from urban and 46 from rural sites) and 48.7% of females (39 from urban and 35 from rural study sites) ($p>0.05$). The mean age was 38.97±9.88. Of the participants, 46.7% (71/152) were 30 years or younger, whereas 53.3% (81/152) were over 30 years of age ($p<0.05$). Regarding marital status, overall 65.1% (99/152) were married (37 from urban and 62 from rural study sites), 3.9% (6/152) were divorced, 5.3% [8/152) were widowed, 7.9% (12/152] were single with children, whereas 11.2% (17/152) of participants were single without children ($p<0.05$).

Education is an important factor that may influence the outcomes of health education programs or interventions in communities exposed to a health threat. Of study participants, those from the urban site had higher level of education, with 37.2% (29/71) having a college or university degree (vs. 21.6% for rural participants); 12.5% (19/152) either had primary education level or were illiterate (8 from urban and 11 from rural site).

The highest family size was 18, and more than half (61.7%; 50/81) of rural household had more than five members (vs. 38.3% (31/71) for urban households). Regarding participants' occupation, 21.7% (33/152) were unemployed (18 from urban and 15 from rural site), 5,9% (9/152) were students, 13.8% (21/152) were civil servants, 7.2% (11/152) were teachers, 3.9% (6/162) were health care workers, 11.2% (17/152) were businessmen and the remaining participants (36.2%; 55/152) had other occupations ($p<0.001$) (Table 1).

Considering the economic status of households, no statistically significant difference was found between urban and rural households, in terms of household monthly income ($p>0.05$). The estimated household monthly income varied from 10 to 700 $US; half of households (50.6%; 77/152) had a monthly income below 100 $US and only 10.5% (16/152) earned more than 300 US$ a month (10.3% for urban and 11.1% for rural households) (Table 1).

3.2. Anti-Malaria Preventive Measures Used in the Previous 12-Month Period

As for malaria prevention, 15.8% (24/152) of household representatives (9.9% of rural and 23.9% of urban participants) reported the existence of a public service or volunteer group that implemented public sanitation activity in their residential area ($p<0.05$) (Figure 1a); 65.8%, (100/152) used insecticide-treated bed nets (ITN), 13.8% (21/152) used spray, 0.6% (1/152) combined ITN and spray, 12.5 (19/152) used an ordinary bed nets, whereas 7.2% (11/152) did not use any preventive measure (Figure 1b). Regarding monthly anti-mosquito

expenditure, 50% (76/152) of participants reported that they spent nothing due to lack of money, 24.3% (37/152) spent 10-20 $US, 15.7% (24/152) spent 21-30 $US; the remaining participants (9.9%; 15/152) spent more than 30 $US; and the availability of nets showed a positive association with socioeconomic status of households ($p<0.05$) (not shown).

Table 1. Characteristics of participating household representatives

Characteristics of household heads	Study site		P-value
	Urban (n, %)	Rural (n, %)	
Gender M	32 (41.0)	46 (59.0)	0.149
F	39 (52.7)	35 (47.3)	
Age ≤ 30 y.	14 (19.7)	57 (80.3)	0.722
> 30	17 (21.0)	64 (79.0)	
Marital status			
Married	37 (37.4)	62 (62.6)	
Divorced	4 (66.7)	2 (33.3)	0.032
Widowed	6 (75)	2 (25)	
Single with children	4 (63.6)	8 (6.4)	
Single without child	10 (58.8)	7 (41.2)	
Education			
None	5 (6.4)	6 (8.1)	
Primary	3 (3.8)	5 (6.8)	
High school	22 (28.2)	41 (55.4)	0.013
Technical school	19 (24.4)	6 (8.1)	
College/university	29 (37.2)	16 (21.6)	
Household size			
2 – 5	29 (40.8)	42 (59.2)	0.996
6 - 18	31 (38.3)	50 (61.7)	
Family type			
Single-parent	18 (27.3)	29 (35.8)	0.466
Single-parent/extended	10 (15.2)	10 (12.4)	
Bi-parental/not extended	19 (28.8)	28 (34.6)	
Bi-parental/extended	16 (24.2)	12 (14.8)	
Polygamic	3 (4.5)	2 (2.4)	
Occupation Unemployed	18 (25.4)	15 (18.5)	< 0.001
Student	4 (5.6)	5 (6.2)	
Civil servant	5 (7.0)	16 (19.8)	
Teacher	2 (2.8)	9 (11.1)	
Health care worker	3 (4.2)	3 (3.7)	
Businessmen	14 (19.7)	3 (3.7)	
Other	25 (35.2)	30 (37.0)	
Household monthly income (US$)			
< 50	21 (30.8)	19 (23.5)	0.887
50 -99	16 (23.5)	21 (25.9)	
100-150	8 (11.8)	12 (14.8)	
151-200	8 (11.8)	10 (12.3)	
201-300	8 (11.8)	10 (12.3)	
'> 300	7 (10.3)	9 (11.1)	
Total	71 (100)	81 (100)	-

Overall malaria prevalence-rate (both study sites; at least one episode) was 92.4%, with an average of 2.5 malaria episodes per person in the previous 12 months (range: 1–7 episodes). It was equally high in participants from both rural and urban areas, 90.1% (74/81) and 88.7% (63/71), in participants from household with small and big family size [47 (87%) and 90 (91%)], in males and females [68 (89.5%) and 64 (90.1%)], and in those with low and

high education level [15 (93.7) and 122 (95.3)], respectively (p>0.05). Similarly, no significant difference was found when comparing groups of participants according to marital status and occupation (p>0.05) (Table 3).

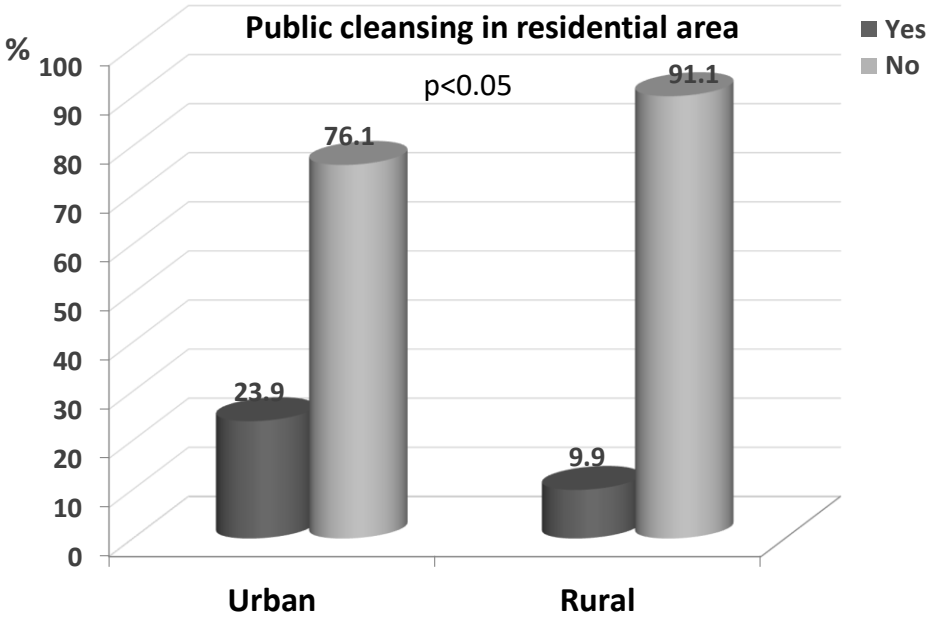

Figure 1a. Periodic public sanitation activity in the residential area.

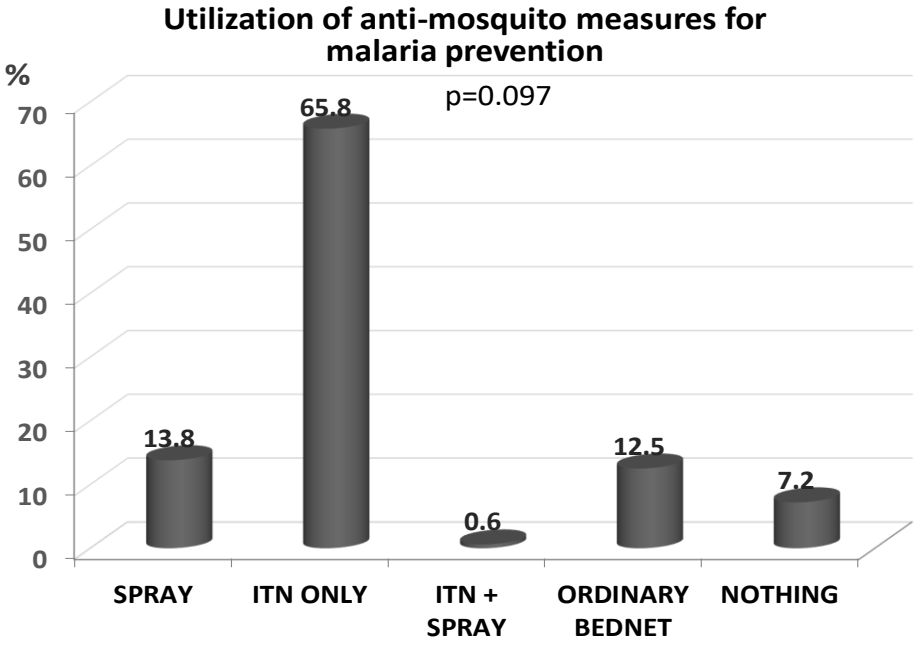

Figure 1b. Anti-mosquito measures used by participants for malaria prevention.

3.3. Malaria Prevalence among Heads of Households According to Socio-Demographic Characteristics and Study Site

Table 3. Malaria prevalence according to study sites and socio- demographics

Sociodemographics	Malaria (1 episode at least) N (%)	P
Gender		
M	68 (89.5)	0.556
F	64 (90.1)	
Age		
20 – 30	27 (93.1)	0.957
> 30	110 (89.4)	
Marital status		
Married	96 (93.2)	0.160
Divorced	3 (75)	
Widowed	6 (75)	
Single with children	13 (85.7)	
Single without child	14 (87.5)	
Occupation		
Unemployed	37 (97.4)	0.332
Student	6 (66.7)	
Civil servant	17 (89.5)	
Teacher	9 (81.8)	
Health care worker	5 (83.3)	
Businessmen	13 (86.7)	
Others	45 (94.3)	
Education		
None – Primary	15 (93.7)	0.549
High school or higher	122 (95.3)	
Family size		
2 – 5	47 (87.0)	0.326
6 - 18	90 (91.8)	
Residential area		
Rural	74 (90.1)	0.548
Urban	63 (88.7)	
All participants	132 (89.8)	-

3.4. Malaria Prevalence (at Least One Episode) According to Anti-Vector for Malaria Prevention

Figure 2 shows the trend of malaria-rate according to anti-mosquito preventive measures implemented by the study participants. In the group of participants who reported using ITN, malaria prevalence-rate was 89% (89/100), 100% in those who used ordinary bed-nets, 100% in ITN and spray users, 90.5% in spray users and 100% in those using none of anti-vector measures. No statistically significant difference was found between those subgroups in terms malaria rates ($p>0.05$) (Figure 2). Furthermore, regarding the question on the implementation of public sanitation or environment cleaning in residential area, a relatively high (not significantly) malaria-rate was found in the group of participants who reported the absence of such activities, 91.9% (122/124) [vs. 76.7% (23/30; $p>0.05$) for areas where such program existed] (not shown).

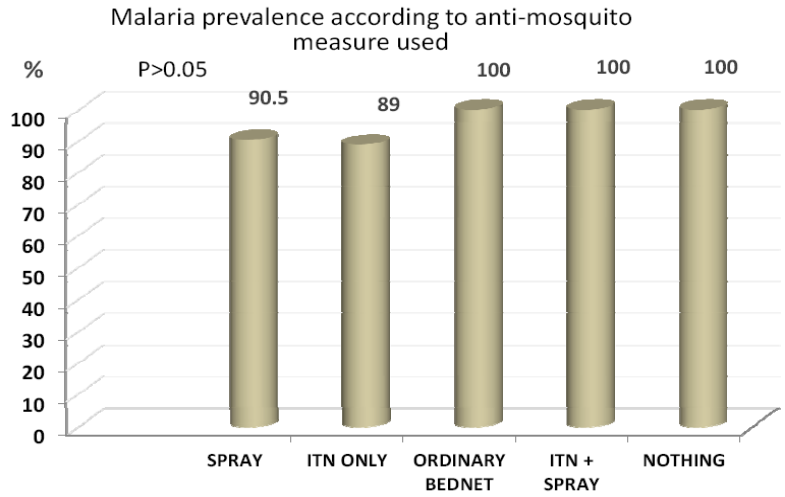

Figure 2. Trend of malaria rate according to anti-mosquito measure.

3.5. Malaria Prevalence According to Household Economic Status and Estimation of Malaria Care Expenditure

Figure 3 shows the trend of malaria-rate according to household monthly income. Relatively high malaria-rate was reported by participants with a monthly household income between 100-150 US$, 97.3%, followed by those with an income between 151-200 US$ (90%), less than 100 US$ and more than 300 US$ (87.5%) and 201-300 US$ (82.4%) ($p>0.05$). Regarding individual malaria care expenditure in the previous 12-month period, the estimated mean cost was 101.56 ± 10.63 $US (range: 0-500$US) per person; it was lower in participants from rural area, 87.75 ± 9.24 $US (range: 10-200 $US) as compared to urban area, 101.58 ± 16.87 $US (range: 25-500 $US; $p<0.05$) (not shown).

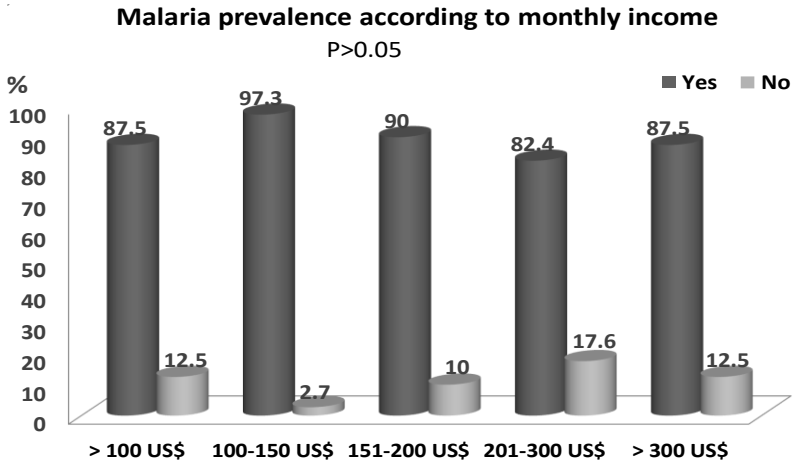

Figure 3. Malaria rate among study participants according to household monthly income.

Table 4. Association between preventive measures, demographics, socioeconomic characteristics and malaria episodes

Variable	OR (SE)	95% CI	P	aOR (SE)	95% CI	P*
Gender (M vs. F)	0.93 (1.32)	0.05-15.21	0.961	1.08 (0.57)	0.06-18.54	0.953
Age (younger vs. older)	1.04 (0.08)	0.89-1.23	0.553	1.05 (0.81)	0.89-1.23	0.552
Marital status (married vs. others)	0.57 (0.25)	0.23 -1.37	0.211	0.59 (0.28)	0.23-1.49	0.267
Occupation	1.08 (0.25)	0.69-1.71	0.711	1.07 (0.24)	0.67-1.68	0.771
Education (Low vs. high)	22.50 (33.17)	1.25-404.81	**0.035**	33.87 (34.42)	2.45-89.49	**0.028**
Household size (< 6 vs. 6-18)	1.71 (0.12)	1.51-1.99	**0.049**	1.58 (1.85)	1.35-1.98	0.052
Residential area (rural vs. urban)	1.81 (1.03)	0.58-5.53	0.305	1.05 (0.14)	0.79-1.39	0.711
Electric power (No vs. yes)	0.48 (0.39)	0.09-2.37	0.373	0.43 (0.37)	0.08-2.33	0.331
Radio/TV (No vs. yes)	0.71 (0.34)	0.27-1.85	0.489	0.72 (0.35)	0.27-1.88	0.500
Telephone (No vs. yes)	0.48 (0.41)	0.25-3.61	0.941	0.96 (0.64)	0.26-3.56	0.960
Anti-vector/environm. (No vs. Yes)	3.98 (1.36)	2.37-2.38	**0.033**	3.01 (2.19)	1.37-24.23	**0.010**
Anti-vector/ household (No vs. Yes)	1.21 (0.22)	0.84-1.75	0.296	1.21 (0.22)	0.83-1.75	0.314
Income (>300$ vs. > 300$)	2.98 (2.08)	1.75-11.72	**0.018**	2.76 (1.87)	1.73-10.41	**0.034**

Notes: p, p-value without adjustment; p*, p-value after adjusting for age and gender; OR, odds ratio; aOR, adjusted odds ratio.

3.6. Association between Malaria, Demographics, Anti-Vector Measures and Socioeconomic Status

Participants who had primary education level or not educated had a 33.87 times risk of developing malaria compared to those with a higher education level (aOR: 33.87+/-34.42; 95% CI: 2.45-89.49; $p<0.05$). Participants living in areas without public sanitation program had a 3.01 times risk of developing malaria than subjects whose households were from areas with such a community health program (aOR: 3.01+/-2.19; 95% CI: 1.37-24.23; $p<0.05$). An association was also found between household monthly income and malaria. Participants who reported earning less than 300 US$ had 2.76 times risk of developing malaria than those from households with a monthly income of 300 US$ or more (OR: 2.76+/-1.87; 95% CI: 1.73-10.41; $p<0.05$). No association was found between malaria and marital status, malaria and occupation, malaria and study site, and between malaria and anti-vector (mosquito) measures used by participants (Table 4).

4. DISCUSSION

4.1. High Malaria Prevalence in Congolese Rural and Urban Households

DRC is known as a malaria hyper endemic country; this infectious disease has a high morbidity and mortality and causes a real socioeconomic burden on Congolese households. In the present study, we searched to determine the prevalence-rate and the socioeconomic impact of malaria on households in two counties located in a rural and urban areas in DRC. Results showed that malaria prevalence-rate was high in both study sites and that effective anti-vector products are not easily affordable for poor households.

This study showed an overall malaria prevalence of 92.4% among heads of household (approximately 90% in those from rural and urban counties); whereas the mean number of malaria episodes per household was 4.35 (3.98 and 4.66 for urban and rural households, respectively) in the previous 12 months, with a minimum of zero and a maximum of 20 episodes (not shown). These household malaria rates are unexpectedly very high.

Of the numerous anti-vector measures aimed at preventing mosquito bites, the majority (65.8%) of heads of households reported using ITN. Similar results have been reported by other authors in the Sub-Saharan Africa. The Ethiopian 'Malaria Indicator Survey 2007' found that 65.6% of ITN coverage; however, ITN utilization was low, varying from 25.3% to 35.9% according to household members' age (Jima et al., 2010). Another household survey conducted in rural Mozambique on long-lasting insecticide treated bed nets showed 62.5% of coverage (Quive et al. 2015). A lower coverage was reported by a Sudanese study, 59.3% (Eyobo et al. 2014). The same study also found that only 2% of households were covered by indoor spraying the previous 12 months; in our study, however, a higher proportion of heads of households (13.8%) used anti-mosquito spray.

Despite the use of the above mentioned preventive measures, malaria rates were high even among ITN and anti-mosquito spray users (89% and 90.5%, respectively), the most commonly used anti-vector measures in the country. Nonetheless, these results are in contrast with findings from studies conducted in DRC's neighbor countries which concluded that ITN coverage was related to the reduction of malaria rate and associated with malaria risk-protective effect (Alemu et al. 2011; Mulligan et al. 2008; Rulisa et al. 2013). This contrast might suggest the existence of an issue related either to the quality, the efficacy of products used or a negligence in their utilization.

Considering the context of extreme poverty for a large majority of households in DRC, which makes it quite difficult for most households to regularly purchase ITN and/or insecticide, there is a necessity to revisit ITN distribution policy. The fact that some households cannot continuously afford related cost limits the efficiency of such community health interventions. Another obstacle is the huge mosquito population in residential areas. During the post-survey anti-malaria education sessions conducted in both study sites, some of the participants testified about realities they face daily in regard to malaria prevention. For example, some said that "mosquitoes are ubiquitous in their residential area and the mosquitoes can bite outside and inside the houses or apartments prior to going to bed"; thus, without eliminating mosquitoes in the living environment, no sustainable progress can be made.

In our study, we found an inverse association between education and malaria. The group of illiterate and heads of households with primary school level had a 33.8 times risk of malaria than those with higher education. Improving literacy in communities is one of the factors that make health interventions successful. And community and individual knowledge and awareness have an influence on malaria control (Yadav et al. 2014). However, a study conducted in Nigeria showed no association between education and malaria infection in pregnant women (Amogo et al. 2013).

4.2. Environment Cleansing as a Community Health Measure for Malaria Control

A better way to control an endemic or epidemic disease is to fight against its cause and related risk factors or behaviors. Thus, in case of malaria, one of the community health strategies should be targeting mosquitoes, particularly *Anopheles* mosquito, the vector that transmit malaria parasites to humans. And this fight should not only focus on avoiding mosquito bites within the homes or during bedtime, but also reduce mosquito populations in the living environment.

Our study also showed an inverse association between malaria and the implementation of public sanitation or environment cleansing activity in residential areas, with a 3 times high malaria risk for households from area without such activities. Considering the persistent malaria burden in DRC, the Congolese health minister has only recently recommended families and communities to improve sanitation status in their living environment as one of the measures against malaria (Radio Okapi-UN Mission in DRC, 2016).

4.3. Poverty Undermines Malaria Prevention Efforts and Increases Malaria Risk in Congolese Households

Malaria has been reported to be associated with poverty; it affects households through spending on anti-vector products (ITN, mosquito repellent spray and lotion), income losses by diseased house hold members and malaria treatment cost; thus, poor households are tremendously affected. The disease affects households directly through spending on treatment, income losses by the sick persons and their careers; it imposes significant costs on households and the poor are disproportionately affected (Sonko et al. 2014).

The present study showed an inverse association between malaria and household socioeconomic status. Households with low monthly income (less than 300 USD) had a 2.76 times malaria risk compared to those earning more money. Our findings are in line with some previous studies. For example, a study by Krefis et al. in Ghana and the "Gambia Malaria Indicator Survey (MIS) 2010/11" showed that children form rich households were significantly less likely to have malaria compared to those from poor households. Kazembe and Mathanga also reported an association between high income with reduced malaria risk in households in Malawi (Krefis et al. 2010; Sonko et al. 2014; Kazembe and Mthanda, 2016).

Malaria economic impact on Congolese households is overwhelming. With an average of 4.35 episodes per household and an estimated mean malaria care expenditure of 101.56 ±

10.63 $US per person during the previous 12 months (see results), each household should have spent at least 396 - 488 US$ in malaria care within a year. Given that 90% of households earned less than 300US$ a month (50.6% earned less than 100 US$ per month), these results confirm the fact that malaria imposes a real economic burden to poor families.

4.4. Need of a More Integrated Malaria Prevention Approach in Hyper Endemic Zones

Several countries of the western world (USA, some European nations) and Japan have successfully achieved malaria elimination through implementation of effective anti-malarial interventions adapted to their environment and socioeconomic development. Currently, with the ongoing of outbreak of Zika virus infection in the Americas, huge resources have been mobilized to eliminate its vector (*Aedes* mosquito) in the living environment in the fight against this new epidemic. By the same token, malaria, a disease that threatening millions of lives every year and claiming the lives of hundreds of thousands people annually, should have been considered a global health threat and the fight against this deadly disease must take into account the elimination of its vector in the living environment as one of top priorities.

African countries, with their rich natural resources, have a great economic potential that could help to improve the living conditions of their populations. As a consequence, housing quality and provision of necessary effective anti-malarial preventive tools could be made affordable to most households. On the other hand, with the participation of communities, the elimination of malaria vector in the living environment could be possible by avoiding the presence of mosquito breeding sites in residential areas (stagnant water, used bottles, cans and bins) and a better management of waste water and rain water. These interventions, combined with the improvement of the general sanitation in households' living environment, a good governance that ensures a sound distribution of the country's resources to improve daily living conditions of Congolese people, the promotion of human security through the restoration of peace in the entire DRC territory are likely to reduce disease burden in DRC and improve malaria control in the country.

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