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Factors Associated with Persistent malaria transmission in urban Peripheral Areas Dar es Salaam Region, Tanzania

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Abstract

Africa Region has the highest burden of malaria with an estimated of 3.5 million more malaria cases in 2017 compared 212 million cases in reported in 2016. Data collected from 2015 to 2017, shown no global progress in reducing malaria cases. In Mainland Tanzania, malaria control interventions have significantly led to the reduction in malaria prevalence from 18.1% in 2008 to 7.3% in 2017. Despite of these achievements, malaria burden is still highly heterogonous with some regions including urban peripheral areas of Dar es Salaam, presenting persistent malaria transmission ranging from 2 to 57%.

Material and Methods

A cross- sectional population based survey was carried out in Ilala Municipality in Dar es Salaam; data was collected from 2nd to 31 April, 2019. Multistage cluster sampling was used to select the households where individual member were conveniently selected to participate in the study. Structured questionnaire were administered by the trained researcher assistants to assess individual risk factors for malaria. Rapid Malaria diagnostic test (mRDT) was used to identify individual exposed to malaria infection. Measure of association used was prevalence odds ratio (POR). Multivariate regression model used to determine prevalence odds ratio, variable with p- value < 0.05 were considered as independent risk factor for persistent malaria transmission.

Results

A total of 830 participants were recruited in the study, mean age was 24yrs ±20.4SD. Majority 489 (58.9%) were female, 459 (55.3%) were >18 yrs old, primary or no education were 687 (82.8%), farmer or unemployed were 639 (77%). Msongola ward contributed 406 (48.9%). Overall malaria prevalence in the study areas was (4.5%). Nets ownership was 141 (16.9%), usage was 121 (85.8%).Low proportion of net ownerships [POR: 7.67, 95% CI: 4.23, 24.6], residing in the households surrounded by mosquito breeding sites POR: 20.07, 95% CI: 7.03, 57.29) and residing in houses with unscreened windows [POR: 1.21, 95% CI: 1.26, 3.40] were independently associated with malaria infection.

Conclusion

Low nets ownership, residing in the households surrounded by mosquito breeding sites and in households with unscreened windows was independent factors associated with risk of malaria in the areas. Promotion of ITNs coverage, application of biolarvicides through community engagement and house screening was recommended to reduce the risk of malaria infection in the areas.

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Introduction

In most of the endemic countries, malaria is highly heterogeneous with great disparities between urban and rural areas. Urban malaria reported to account for 6-28% of the global malaria burden [3]. Several factors are attributed to persistent risk of malaria infection in urban areas, including, increasing urban agricultural activities, which is quite common in the African cities due to increasing need to feed the ever growing population [4] which in turn increases the mosquitoes vector breeding environment, hence risk of malaria. A study conducted in the peri urban coast areas of Benin in West Africa, showed high parasite prevalence and spleen rates of between 40% to 60%, indicating high transmission levels of between meso- endemic to hyper- endemic [5]. This reflects the heterogeneity of urban area in Africa and the highly focal nature of malaria transmission in cities. The transmission risk in urban areas is associated with proximity to breeding sites due to the presence of water bodies, urban agriculture and proximity to rural areas that are more likely to support mosquitoes vector breeding [6,7]. Risk of malaria infection is likely within the densely populated urban setting, in particular because *Anopheles gambiae s.l* is more likely to breed in urban aquatic habitats [9] than other vector species and has been found in domestic containers and highly organic polluted water in urban areas [10].

Huge investments and scaling up of effective malaria control interventions including Artemisinin Combination Therapy (ACT) to target the parasites, Indoor Residual spraying (IRS) and Insecticide Treated Nets (ITNs) targeting the malaria vectors that feeds and rest indoors, has resulted in the significant reduction in malaria morbidity and mortality worldwide [11]. Global malaria data for the period 2015 to 2017 indicates no significant progress in reducing global malaria cases [1]. However, in Mainland Tanzania, such investment has resulted into significant reduction in malaria prevalence from 18.1% in 2008 to 7.3% in 2017 [13,14]. Despite this achievement, new cases and people dying of malaria are still being reported across the country, with wide range of regional variations in transmission.

In Dar es Salaam Region, although the regional average malaria prevalence is 1.1% [15], there is great heterogeneity in term of geographical disparities of malaria prevalence where urban peripheries seems to bear higher burden than urban centre. Study conducted in Dar es Salaam predicted increased risk of malaria infection in the administrative units in the urban- peripheries urban centre [17]. Also School Malaria Parasitological Survey conducted in Mainland Tanzania in 2017 indicated high malaria prevalence in peripheral areas ranging from 2% to 57% as compared to urban centres ranging from 0 to 1% [12], despite several control efforts implemented across the gradient of urbanization which included; application of larviciding through community based, malaria case management using ACT, distribution of ITNs through mass campaigns and to pregnant and infants when attending antenatal clinic [22].

A number of factors are attributed to variations in malaria risks among households and individuals [25]. Some of these factors include access to health facilities [26], type of housing that people live in [27] proximity of human settlement to vector breeding sites [28] , vector abundance [29], socio- economic status [30], gender, occupation, residential mobility, travel [31–34] presence of domestic animals near homestead [33,35] and use of preventive methods such as mosquito nets [36]. Information on how these factors interact to expose communities and individuals to malaria infection is important and have to be identified for spatial targeted malaria interventions [37]. Our objective was to investigate factors associated with persistent malaria transmission in urban peripherals in Dar es Salaam, Tanzania.

Material and Methods

This was a cross- sectional population based survey, individuals stayed in that household for a period of not less than 10 days prior to the day of data collection were enrolled in the study to rule out imported malaria individual cases**.** Children less that 3 months and individual who were unable to communicate were excluded from the study. The study was conducted in Ilala Municipality councils, one of the five Municipalities in Dar es Salaam Region; administratively the council is divided into 4 divisions, 36 wards and 109 streets. It covers an area of 210 km^2 with an estimated population of 1,648,861 living in 256,357 households (2017 population projections). Multistage sampling was used to select study areas, three wards out of 36 were selected conveniently based on malaria prevalence. Number of respondents in each study areas was selected based on the probability proportion to size of the total number of the households in each study areas. Individual member of the households who consented were tested using Malaria Rapid Diagnostic test (mRDT) to provide evidence on the presence of asymptomatic individual cases of malaria at the household level. Both positive and negative tested individuals were interviewed using structured questionnaires to provide information on social demographic characteristics, individual risk behaviour for malaria infection. Individuals tested positive to mRDT were treated using first line recommended ACT drug. Observations checklist was used to assess house characteristics for risk exposure to mosquito bite. Tools for data collection were pre tested for validity and reliability. Sample size calculation based on the prevalence of malaria in urban peripheral.

The estimated sample size was 628 individuals with 80% power (a = 0.05). The formula; N = g X Z2 p [1-p]/E2 for single proportion sample size cross- sectional study was used with 10% non response rate. STATA version 14.2 was used for analysis. Bivariate logistic regression was used to determine association between exposure and outcome variables using Prevalence Odds ratio [POR]. Variables showed association in bivariate analysis were fitted into multivariate logistic regression model to control for confounders. The variable with p value ≤ 0.05 was regarded as causal factor for persistent malaria transmission in the study areas. Confidentiality was observed during data collection and written informed consent was obtained followed by data collection.

Results

A total of 830 participants were recruited in the study, mean age was 24yrs ±20.4SD. Majority 489 (58.9%) were female, 459 (55.3%) were >18 yrs old, primary or no education were 687(82.8%), farmer or unemployed were 639 (77%). Msongola ward contributed 406 (48.9%). Table 1 below shows demographic characteristics of the study population.

The overall prevalence of malaria infection in the study areas was 4.5%. The prevalence was higher among residents in Msongola (7.4%) than the other wards. It was also high among those <18 years of age (5.9%), those with secondary education and above (6.3%), and among farmers or unemployed (5.5%). The difference in prevalence of malaria by age, sex and education level was not significant (p > 0.05). However for occupation and residence was significant (p< 0.05). Table 2 shows the prevalence of malaria by demographic characteristics of study participants.

Overall, 16.9% admitted to have nets, 83.0% did not have nets., 57.4% had ITNs among those with nets and 19.9% had non-ITNs, and 22.7% didn't know if their nets were treated or not. Net use was 85.8% among those with nets and 14.9% were not using their nets. Majority of those who reported not to have nets reported their nets were torn beyond repair. The prevalence of malaria among those with nets was 2.8%, and among those without nets was 4.8%. The prevalence of malaria among these not using nets was 15.0%. The difference in prevalence of malaria by ownership and use of nets was not significant. Table 3 below shows the prevalence of malaria by ownership of nets.

The prevalence of malaria was also assessed based on travel history outside, duration of stay outside, outdoor activities after dusks and time of going to bed/ sleep (Table 4). Only 6.2% of the study subjects had a history of travel outside Dar es Salaam, and prevalence of malaria among them, was 3.9%, while for those with no history of travel outside Dar es Salaam prevalence

Table 1. Socio demographic characteristics of study participants in the study areas

Variable	Number	%
Residence/Ward		
Chanika	206	24.8
Msongola	406	48.9
Zingiziwa	218	26.3
Age group		
<18 years	371	44.7
≥18 years	459	55.3
Sex		
Male	341	41.1
Female	489	58.9
Education		
Primary and below	687	82.8
Secondary and above	143	17.2
Occupation		
Farmer or unemployed	639	77.0
Employed or business man/woman	191	23.0

Table 2. Prevalence of malaria by Socio-demographic characteristics of the study population (n= 830)

Variable	*mRDT results		Number
	Positive (%)	**Negative (%)**	
Residence/Ward			
Chanika	1 (0.5)	205 (99.5)	206
Msongola	30 (7.4)	379 (92.6)	406
Zingiziwa	6 (2.8)	212 (97.2)	218
Age group			
<18 years	22 (5.9)	349 (94.1)	371
≥18 years	15 (3.3)	444 (96.7)	459
Sex			
Male	17 (4.9%)	324 (40.9)	341
Female	20 (4.1%)	469(51.1%)	489
Education			
Primary and below	28 (4.1)	659 (95.9)	687
Secondary and above	9 (6.3)	134 (93.7)	143
Occupation			
Farmer or unemployed	35 (5.5)	604 (94.5)	639
Employed or business man/woman	2 (1.0)	189 (99.0)	191

Table 3. Prevalence of malaria by ownership and use of bed nets

Variable	mRDT Results		Number
	Positive (%)	Negative (%)	
Have Net (All types) n= 830			
Yes	4 (2.8)	137 (97.2)	141
No	33(4.8)	656 (95.2%)	689
Use Nets (All types) (n=141)			
Yes	1 (0.83)	120 (99.2)	121
No	3 (15.0)	17 (85.0)	20
Type of Net (n=141)			
ITN	2 (2.5)	79 (97.5)	81
Non-ITN	1 (3.8)	25 (96.2)	26
Don't know	1 (3.1)	31 (96.9)	32
Use ITN (n= 81)			
Yes	1 (1.7)	58 (98.3)	59
No	1 (4.5)	21 (95.5)	23

Table 4. Prevalence of malaria by travel history, duration of stay, outdoor activities and time of going to bed/ sleep of the study participants

Variable	mRDT results		Number
	Positive (%)	Negative (%)	
Travel out Dar es salaam (n= 830)			
Yes	2 (3.9)	50 (96.2)	52
No	35 (4.5)	778 (93.7)	778
of stay out Dar es salaam (n= 52)			
< 1 week	1 (3.5)	28 (96.6)	29
>2weeks	1(4.4)	22 (95.7)	23
Outdoor activities after dusk (n= 830)			
Social gathering and studies	14 (6.5)	200 (93.5)	214
No outdoor activities after dusk	23 (1.4)	593 (96.3)	616
Time of going to bed/ sleep (n= 830)			
19:00 – 21:00 hours	9 (2.9)	305 (97.2)	314
23:00 – mid night	28 (5.4)	488(94.6)	516

was 4.5%. The prevalence was high (6.5%) among individuals with outdoors activities after dusk compared to 3.7% for individuals with no outdoor activities after dusks. The prevalence was high (5.4%) among individuals who going to bed between 23.00 to mid night), compared to 2.9% individuals who go to bed between 19:00 to 21:00 hours. The difference in prevalence of malaria among participants with history of travel outside Dar es Salaam was not statistically significant (p=0.825) and also the difference in prevalence of malaria by duration of stay outside Dar es Salaam was not statistically significant (p=0.87). Table 4 below shows the relationship between malaria prevalence with individual travel history, duration of stay, outdoor activities and time of going to bed/sleep.

Table 5 below shows malaria prevalence in relations to the presence of mosquito breeding sites near the house and the distance of breeding site from the house. The findings show that, majority (71.7%) of the study individuals reside in households surrounded by mosquito breeding sites and that 95.6% their households were located less than 5 kilometres from the mosquitoes breeding sites. The most commonly types of mosquito breeding sites present in the study areas were; terrace cultivation, small scale rice padding, mud brick holes, small streams, open bore holes and pools of stagnant water. Malaria prevalence among the individuals residing in households surrounded by mosquitoes breeding sites was 5.5% and was 4.4% for the individuals stayed in the households located less than 5 kilometres from the mosquito breeding sites. The Pearson chi square test (x^2) was used to test for significance. The results showed statistically significant difference in malaria by presence of mosquito breeding sites around the house (p=0.001). There was no statistically significant difference by distance of the households from the mosquito breeding sites (p=0.833). The relationship between household and presence of mosquito breeding sites, the distance of the households and malaria is shown in Table 5 below.

Table 6 below shows malaria prevalence by characteristics of the houses where households reside. These characteristics were presence, whether there were open eaves on top of the wall, the type of building/ roofing material and window screening. The findings have revealed that 45% of the individuals resided in households with open eaves on top of the walls and 26.1% of the individuals reside in the households with unscreened windows. Malaria prevalence among individuals resided in households with open eaves on top of the walls was 8.3% and was 14.7% for individuals residing in households with unscreened windows. Only twenty people (2.4%) resided in houses whose walls were made up of earth or thatches/grass, and prevalence of malaria among them was 30.0%. The Pearson chi square test (x^2) was used to test for significance. The results showed statistically significant difference in malaria prevalence by presence of open eaves on top of the walls (p= 0.000), presence of unscreened windows (p= 0.000), and type of building materials used for walls (earth or thatches/grass) (p=0.000). The relationship between household characteristics and malaria prevalence is shown in Table 6 below.

Bivariate Analysis

The relationship between socio-demographic and malaria was explored in a bivariate analysis. Only occupation was found to have an association with malaria, with farmers and unemployed being at a higher risk than business and employed people (p=0.02). Table 7 shows relationship between socio-demographic characteristics of the study population and malaria prevalence.

The relationship between possession of nets and malaria prevalence as individual risk behaviour was explored in a bivariate analysis. Low ownership of nets was associated with an increased risk of infection (p=0.031), as shown in the bivariate analysis table 8 below.

The relationship between travel histories, duration of stay outside, time of going to bed/ sleep and outdoors activities at night was explored in a bivariate analysis were all not associated with malaria infection, as shown in the bivariate analysis table 9 below.

The relationship between malaria prevalence presence of mosquito breeding sites, distance of the households from the breeding sites, house characteristics (open eaves, screening of the windows and material used to build the house were explored table 10. Presence of breeding sites around the house, open eaves on top of the wall, absence of window

Table 5 Presence and distance of mosquito breeding sites in relation to malaria prevalence

Variable	**+mRDT results**			
	Positive (%)	**Negative (%)**	**Total #**	**p-value**
Presence of breeding sites				
Yes	4 (1.7)	231 (98.3)	235	0.001
No	33 (5.5)	562 (94.5)	595	
Distance of the breeding sites from the households				
<5[2]km	34 (4.4)	736 (95.6)	770	0.833
>5km	3 (5.0)	57 (95.0)	60	

[2]Km = Kilometre

= Number of observation

Table 6. Prevalence of malaria by characteristic of the houses where households resided

	+mRDT results			
Variable	**Positive (%)**	**Negative (%)**	**Total #**	**p-value**
House characteristics				
Open eaves on top of the walls				
Yes	31(8.3)	341 (91.7)	372	0.001
No	6(1.3)	452 (98.7)	458	
Type of walls and roofing materials				
Made up of bricks(blocks or burnt)	31 (3.8)	779 (96.2)	810	0.001
Made up of earth or thatch/ grass	6 (30.0)	14 (70.0)	20	
Screened windows				
Yes	5 (0.8)	608 (99.2)	623	
No	32 (14.8)	185 (85.3)	217	0.001

= Number of observation

Table 7. Relationship between socio-demographic characteristics of the participants and malaria

Variable	*COR (95% CI)	p- value
Age group		
> 18 yrs	Reference	Reference
4 month- 17 yrs	0.54 (0.27, 1.05)	0.069
Education level		
Secondary or college	Reference	Reference
No education or primary	1.58 (0.73, 3.43)	0.246
Occupation		
Businessman or employed	Reference	Reference
Farmers or unemployed	0.18 (0.044, 0.77)	0.020

Table 8. Relationship between ownership and use of nets and malaria

Variable	COR (95% CI)	p- value
Have Net (All types)		
Yes	Reference	Reference
No	1.72 (0.60, 4.94)	0.031
Use Nets (All types		
Yes	Reference	Reference
No	2.76 (0.16,4.62)	0.48
Use ITNs		
Yes	Reference	Reference
No	0.76 (0.26, 2.22)	0.622

Table 9. Relationship between individual risk behaviours (travel history, duration of stay and outdoor activities after dusk) and malaria prevalence

Variable	* COR (95% CI)	p- value
Travelled outside Dar es Salaam		
Yes	Reference	Reference
No	1.18 (0.28, 5.05)	0.825
Duration of stay outside Dar es Salaam		
>2weeks	Reference	Reference
<1week	1.27 (0.75, 21.51)	0.87
Time of going to bed/sleep		
19:00 – 21:00 hours	Reference	Reference
22:00 - midnight	1.05 (0.66,1.68)	0.84
Outdoor activities after dusk		
No outdoor activities after dusk	Reference	Reference
Social gathering and studies	0.99 (0.86, 1.15)	0.93

Table 10. Relationship between house characteristics and malaria

Variable	COR (95% CI)	p- value
Presence of mosquito breeding		
No	Reference	Reference
Yes	20.07. (7.03, 57.29)	0.001
Distance from the breeding sites		
>5km	Reference	Reference
<km	1.14 (0.34, 3.82)	0.833
House ccharacteristics		
Open eaves on top of the wall		
No	Reference	Reference
Yes	0.15 (0.06, 0.35)	0.001
House with screened windows		
Yes	Reference	Reference
No	21.0 (8.08, 54.76)	0.001
Type of wall and roofing materials		
Made up of bricks (block or burnt	Reference	Reference
Made up of earth or thatch/grass	10.8 (3.88, 29.91)	0.001

screen and type of wall/roofing material were all associated with an increased risk of malaria infection ($p<0.001$). However, distance of the house from the breeding site was not associated with malaria.

Multivariate Analysis

Six variables shown to be associated with malaria prevalence in bivariate analysis were included in multivariate analysis, only low ownership of nets (17%), absence of window screens and presence of mosquito breeding sites around the households were found to be associated with increased risk of malaria infection as shown in the table 11 below.

Discussions

Generally our study found that, majority of the study participants 48.9% were from Msongola ward, 58.9% of the study participants were female, 55.3% were more than 18 years of age, 82.8% were primary or no education and 77.0% were farmer or unemployed.

Prevalence of malaria by socio – demographic characteristics of study population

Our findings have revealed overall malaria prevalence of 4.46%, higher than the average regional malaria prevalence of 1.1%. Msongola ward had the highest (7.4%), followed by Zingiziwa (3.21%) and Chanika the least (0.49%) prevalence than the other study sites. This finding is consistent with a previous study conducted in Mainland Tanzania which revealed variations in malaria prevalence in urban peripherals of Dar es Salaam Region [12,43]. A previous study conducted in Dar es Salaam showed increased risk of malaria infection in the administrative units of peri urban Dar es Salaam Region as compared to the urban centre [17]. Low malaria prevalence observed in Chanika (0.49%) might be due to the fact that Chanika ward is characterized by more of urban setting than urban peripheral.

High malaria prevalence have been observed among the age <18 years (5.9%), which is consistent with the previous study conducted in Mainland Tanzania which showed high malaria prevalence in the school going age group [43]. Similarly, a study conducted in Congo showed a relationship between malaria infection and age and high prevalence was also observed in the age above 5 years [53]. Malaria Indicator Survey conducted in Mainland Tanzania in 2017 has also revealed age shift of malaria burden from under five to school aged children [69], similar a study conducted in Rwanda showed a relationship between older age group with *Plasmodium* infection [70]. The findings of this study have also shown malaria prevalence of 6.3% for secondary education and colleges individuals. This finding is inconsistent with studies conducted in Burkina Faso and Rwanda, In Burkina Faso the findings showed households with mother who had higher education, had low risk of malaria as compared to households with mother with primary education or no education [71]. In Rwanda, the findings showed reduced odds of malaria infections for the households with parents that had secondary or higher education level [70].

Prevalence of malaria by individual risk behaviour of the study population

Only a small number of individuals 141/830 (17%) admitted to own nets, and these included ITNs (54.7%), non-ITNs (19.9%) and 22.7% were not sure if their nets were treated or not.

The prevalence of malaria was low among those with nets than among those without nets (2.8% vs. 4.8%), although the difference was not significant, but higher malaria prevalence among non user of nets (15.0%) and the difference was significant ($p = 0.01$). This finding is consistent with study conducted in Morogoro Municipality in Tanzania which showed a low prevalence of asymptomatic malaria (5.4%) among 90.6% school children users of ITNs [72].

Study conducted in Central India showed reduction in overall malaria prevalence to 1% for users of ITNs [73]. In Tanzania, study conducted in Ifakara showed positive relationship between increased coverage of ITNs and malaria burden and that an increases of 10% ownership of mosquito nets at village level had an average of 5.4% and 10% decrease of malaria deaths in children under five years [65].

Our study showed no relationship between malaria infection with history of travel and duration of stay outside Dar es Salaam (p- value = 0.825 and 0.87). This finding is not consistent with, other previous studies conducted in Mainland Tanzania [37] and also with World Health Organization report [55], which associated mobility, occupation and travel with malaria infection. Study conducted by Martens and Hall also associated

Table 11. Multivariate analysis of individual risk factors shown to be associated with malaria infection

Variable	COR (95% CI)	P- value	[4]A OR (95% CI)	p-value
Occupation				
Businessman or employed	Reference		Reference	
Farmer or unemployed	0.18 (0.044, 0.77)	0.020	0.31 (0.043, 2.32	0.25
Have Nets				
Yes	Reference		Reference	
No	1.72 (0.60, 4.94)	0.031	7.76 (4.23, 24.6)	0.001
House characteristics				
Open eaves				
No	Reference		Reference	
Yes	0.15 (0.06- 0.35)	0.001	0.29 (0.065- 1.36)	0.118
Screened wwindows				
Yes	Reference		Reference	
No	0.048 (0.018- 0.12)	0.001	1.21 (1.26 , 3.4)	0.001
Type of walls				
Made up of blocks or burnt bricks	Reference		Reference	
Made up of earth or thatch/grass	10.8 (3.88- 29.91)	0.001	2.06 (0.207, 20.61)	0.537
Presence of mosquito breeding sites				
No	Reference		Reference	
Yes	20.07(7.03, 57.29)	0.007	5.08 (3.20, 20.5)	0.005

[4]AOR= Adjusted Odds ratio

population movement (trading, fishing and labouring) with malaria infections [58]. Other study associated travels to rural areas as a risk for malaria in urban areas [32]. The difference in our findings from other studies could be attributed by a small proportion of individuals (6.3%) who had a history of travel outside Dar es Salaam. Hence implies that individuals who tested positive for this study, got malaria infection in their areas of domicile, not outside Dar es Salaam. Our findings also indicated higher malaria prevalence (6.5%) among individuals with outdoor activities after dusk compared with those with no outdoor activities after dusk, although bivariate analysis revealed no association in malaria risk with outdoor activities after dusk (p- value = 0.93), a study conducted in Dar es Salaam showed high risk of malaria infections among adults participated in outdoor activities after dusk and that, the risk of malaria infection was 1.8 times than individuals who had not participated in outdoor activities [74].

Our findings also observed higher malaria prevalence (5.4%) among individuals who go to bed/ sleep late, than among early sleepers. However, bivariate analysis indicated no association between malaria prevalence and time of going to bed (p- value= 0.84). A previous study conducted in Dar es Salaam, found high proportion of malaria infection for individuals who rested outdoor after dusk (9.7%) [74]. The difference in the findings of the two studies could be due to the fact that our study included all age groups, while the other study was done among adults only.

Prevalence of malaria in relationship to the presence of mosquito breeding sites in the study areas

Findings from our study also revealed an association between malaria prevalence and residing in the households surrounded by mosquito breeding sites (p- value = 0.005). This finding is consistent with the study conducted in Gambia [67] and Ifakara in Mainland Tanzania which revealed that distribution of malaria vectors, transmission rates and malaria incidence varies widely depending on the distance of the households from the mosquito breeding sites [75]. Also, study conducted in Northern Botswana showed that households close to mosquito breeding sites were more exposed to mosquitoes bites [33]. Also in Uganda, study showed households close to mosquito breeding sites were the risk factor for clinical malaria episodes [27].The findings of our study has also revealed that households surrounded by mosquito breeding sites had 5.08 odds of malaria infection compared to households not surrounded by mosquito breeding sites.

Prevalence of Malaria in Relationship with House Characteristics in the Study Areas

The findings of this study revealed higher malaria prevalence among individuals residing in the households with open eaves on top of the walls, and among individuals residing in the households with unscreened windows. While these two variables were shown to be significantly associated with malaria in bivariate analysis, only unscreened windows were still a significant factor in multivariate logistic regression models (p- value 0.001). Our findings is consistency with study conducted in Gambia which also showed that house screening substantially reduced the number of mosquitoes inside houses by 59% hence clinical episode of malaria infection [67], also in Uganda, study conducted showed reduced incidence of malaria episodes in children living in modern homes than in traditional homes [66]. Also, the findings have indicated no association between malaria infections and the type of building materials used for walls and roofs (p- value = 0.537). This findings is inconsistent with the study conducted in Northern Batswana, which showed less chance of malaria cases in households residing in houses made up of bricks walls as compared to individuals member households residing in the houses, walls made up of dug and earth or thatch/ grass [33]. The difference in the findings with our finding might be attributed by small proportion (2.4%) of houses in the study areas which their walls were made up of earth or thatch/grasses.

Conclusion

Low nets ownership, residing in the households surrounded by mosquito breeding sites and in households with unscreened windows was independent factors associated with risk of malaria in the areas.

Recommendations

Low Net Ownership

A mini mass ITNs distribution campaign is recommended in these areas to increase ITNs coverage and access by individual members of the households followed by Social Behavioural Change Communication to educate individuals on the importance of ITNs use, to prevent malaria even if the nets are torn, as some individuals reported not using nets because they are torn.

Unscreened Windows

Community should be educated on the importance of screened windows with mosquito gauze to prevent mosquitoes from entering the houses, hence reducing man - mosquito contact and potentially reduce malaria transmission in the areas. Alternatively, community in these areas should be educated on the alternative use of torn ITNs for screening the windows to reduce the chance of mosquitoes getting into the houses as this being one among the recommended alternative use of torn ITNs.

Presence of Mosquito Breeding Sites

Since most of the households were surrounded by mosquitoes breeding sites, most commonly found were; terrace cultivation, small scale rice padding, mud brick holes, small streams, open bore holes, pools of stagnant water and abandon fish ponds, larviciding is recommended through community engagement in the areas taking advantage of the availability of bio-larvicides factory in country and government support of larviciding operations. Application of larviciding should go in line with environmental management and sanitation particularly for mud bricks holes and for potential accumulated pools of stagnant water that can be dried or drained to prevent accumulation of water for long time that can allow mosquito breeding sites.

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