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Prevalence and socio-demographic factors associated with malaria infection among children under five years in Tanzania

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Malaria is one among four main infectious diseases leading in death for the under-five children in Africa. This study aim to determine prevalence of malaria and social demographic factors related with children under-five in Tanzania. The study used cross section data extracted from Tanzania demographic health survey collected from 2015 to 2016. A sample of 9,322 under five children with malaria rapid diagnostic test results was obtained from 10,899 households. Complimentary log-log model was used to determine factors associated with malaria among children under five years. The study reveals that malaria prevalence increases with increase in age, varies with place and zone of residence, being highest to the rural areas compared to urban. Complementary log-log model estimates has also indicated that Western zone was having a highest mean occurrence of children with malaria compared to all other zones whereas Zanzibar (Adjusted Parameter estimates = -4.521, CI: -5.92,-3.13) was having a lowest mean occurrence compared to Western zone and all other zones. The risk of malaria among under-five children was positively related with family wealth index. The results show that malaria decreases with an increase in wealth. Other explanatory variables which include; child sex, mother's age, marital status and education level, as well as mosquito net ownership were not statistically significant associated with malaria at 5% level. Therefore children's age, place of residence, zone of residence and wealth index are significant predictors of malaria in Tanzania. Particular emphasis on education and interventions across the groups need to be prioritized for continued improvements in targeting high prevalent areas to reduce malaria risks, especially to the children under-five years.

Key words: Malaria, children under five years, complementary log-log model.

INTRODUCTION

Globally there is a tremendous decrease in malaria infections, accounting 18% reduction from estimated 262 million malaria cases in 2000 to 214 million in 2015 (WHO, 2018). These contributed to a 60% reduction of

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mortality from the year 2000 to 2015. Malaria remains highest in Africa, and it is the fourth most significant cause of death for the children aged under-five years (WHO, 2015a, 2013). In the year 2015, about 306,000 deaths occurred globally and about 292,000 deaths in Africa (WHO, 2015b). Plasmodium falciparum is the main species causing malaria infections in children around sub-Saharan Africa. It is estimated that 90% of the mortality is caused by *Plasmodium falciparum* (Anstey et al., 2002; Nyarko and Cobblah, 2014; Walldorf et al., 2015).

In Tanzania, malaria is one of the leading cause of morbidity and mortality accounted for about one-third of all deaths for children under five years (Roach, 2012; Mboera et al., 2007). In the year 2007/2008 malaria indicator survey results reveal that 1(one) in every 5 (five) children were having malaria (URT, 2009). Research conducted in Muleba by Mushashu in the year 2012 shows that malaria prevalence for the under-five children was 26.3% (Mashashu, 2012). The work of Willilo et al. (2016) conducted in the lake zone (that is, Mara, Mwanza and Kagera Regions) reveals that the prevalence of Malaria for the infants was 11% (Figure 1). This calls for a need to use data covering all over Tanzania to find out the countrywide malaria prevalence and assess socio-demographic factors associated with malaria infections.

According to Nyarko and Cobblah (2014), there is an association between malaria of children under five with a region of residence, age, and mosquito net ownership. Another research conducted in Uganda by Roberts and Matthews (2016), found out that there is a relationship between Malaria infection of children under-five with mothers/caretaker education, and age of the children. The recent work of Nwoke et al. (2017) has shown that there is a relationship between income, mothers' occupation, and non-use of ITNs with under five malaria prevalence. That is why this study illuminates the socio-demographic factors associated with children under-five years in Tanzania by re-analysing recently Tanzania Demographic Health Survey of 2015-2016.

METHODS

Sources of data

This study used Tanzania demographic health survey data of 2015 to 2016. The children data were extracted from the Tanzania Demographic and Health Survey (TDHS) data which consists of all household members. The information extracted from the survey includes age, sex, marital status of the mother, education of the mother, and a relationship of the family member to the head of the household. Another information collected by these questionnaires were a source of water, type of toilet facilities, materials used for the floor, roof, and exterior walls of the dwelling unit, ownership of various durable goods and assets, and ownership and use of mosquito nets. Furthermore, information on malaria rapid test results and malaria using microscopy for the children aged 6-59 months were also extracted (TDHS, 2016).

In this study, a rapid diagnostic test (RDT) results for children aged 6-59 months was used as the response variable. According to WHO (2015), this measure is used to provide accurate, and it is a good proxy for measuring malaria in malaria-endemic areas. The selected independent variables were age of the child (grouped into five categories: less than 12; 12-23; 24-35; 36-47;48-59 months), sex of the child, age of the mother, place of residence, zone of residence, marital status of the mother; mother's level of education, wealth status, and ownership of mosquito net. These factors have been chosen based on the recent results presented by Anstey et al. (2002), Willilo et al. (2016) and Roberts and Matthews (2016).

Sample collection and procedure

According to the TDHS 2015-2016 report (Nwoke et al., 2017), the survey included 30 regions of which 25 were from Tanzania Mainland and five from Zanzibar. The 608 sample points were identified from those 30 regions based on 2012 Tanzania Population and Housing Census. A complete household listing for all 608 sample points identified was done. From the complete list, 22 households were systematically selected from each sample point (more detailed procedures are well elaborated in TDHS, 2015/2016 report). In our analysis, from 10,899 eligible under-five children, we excluded 1,577 children whose RDT malaria results were not properly recorded which leads to 9,322 under-five children to be selected.

Data analysis

A preliminary analysis was performed in which the relationship between each socio-demographic factor and malaria prevalence was examined using the chi-square test. The second analysis was done to determine predictors of malaria among children aged under-five years (Anstey et al., 2002) using the complementary log-log model. The data were analyzed using STATA Version 12. The complementary log-log model has been used because it is useful in epidemiological investigations when risk is of keen interest (Wacholder, 1986). The model was also used because of the malaria cases have asymmetrical distribution nature (Long, 1997) and the fact that, the outcome variable which has a dichotomous result that is either the children test positive(coded as 1) to malaria or negative (coded as 0). In many settings, a commonly model applied is to relate the mean response E(Y) and the explanatory variables linearly:

$$E(y) = \eta = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k$$

When the dependent variable is dichotomous, E(Y) is the probability of response p. The associated linear model can be generalized to

$$\begin{aligned} g(E(y)) &= g(\pi) \\ &= \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k \end{aligned}$$

Where g is known as the link function (Mc- Cullagh and Nelder, 1989, sec. 2.2). The complementary log-log (CLL) model considered here is a variant under the assumption of binary response link functions such that:

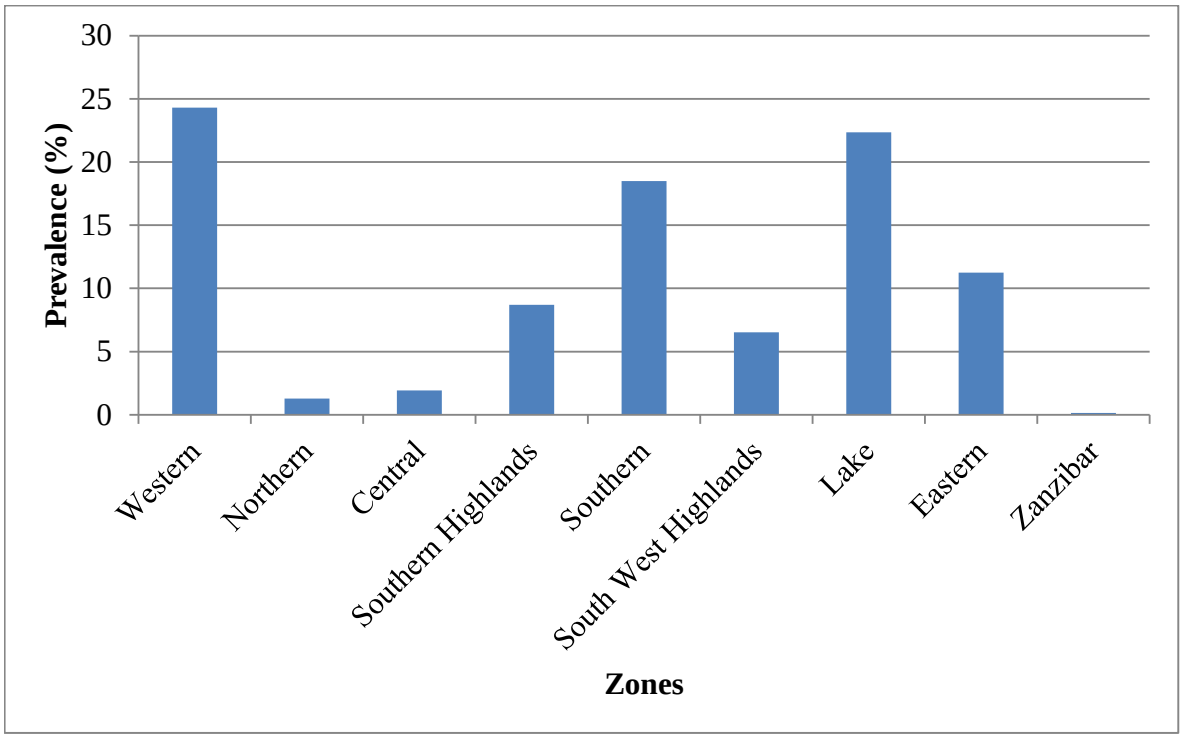

Figure 1. Prevalence of malaria for children under five years by zones.

$$\pi(y) = 1 - \exp[-\exp(\mathbf{X\beta})]$$
$$\log[-\log(1-\pi(y))] = \mathbf{X\beta}$$

Ethical issues

Tanzania's National Institute for Medical Research (NIMR), the Zanzibar Medical Ethics and Research Committee (ZAMREC), the Institutional Review Board of ICF International and the Centers for Disease Control and Prevention in Atlanta gave ethical clearance to the study. The re-analysis of the 2015-2016 TDHS data was requested from the measure Demographic and Health Survey (DHS) website, and we got approval to download the data.

RESULTS

Socio-demographic characteristics

According to Table 1, the result reveals that malaria prevalence increases with increase in age, its minimum to the children aged less than 12 months (6.7%) and highest to the children aged 48-59 months (14.8%). Regarding gender, although there was no significant difference noticed between males and females children (p=0.1), malaria prevalence was highest for the males at 12.53% compared to the females at 11.4%. No significant relationship also noticed between mothers age and malaria prevalence (p>0.05). Under five malaria occurrences were highest to those children mother's aged 40-49 years and lowest to those aged 15-19 years. There is a relationship between malaria prevalence with a place of residence and zones children belongs (p<0.05). The prevalence was highest in rural 14.4% whereas lowest in urban 3.6%. Malaria was also varied with zones. The Western zone was having the highest occurrence of 24.3% followed by Lake Zone 22.4% whereas it was lowest in Zanzibar with about 0.1%.

According to the result of statistical analysis, there was no significant relationship between mother's marital status and education level (p>0.05) in children infected with malaria while a statistically significant relationship between malaria of the children with wealth index (p<0.05). There were also changes in malaria prevalence with changes in mosquito net ownership. The occurrence being lowest to the families owning zero (6.8%) and highest being reported those owning more than four (18.4%).

Complementary log-log model

In univariable (unadjusted) analysis children age, place of residence, zone children belongs, marital status of the mother, wealth index and number of mosquito net

Table 1. Distribution of socio-demographic characteristics among the study group.

Variable	Frequency (%)		Chi-square P-Value
	RDT- Positive Results	RDT-Negative Results	
Children age (Months)			<0.0001
<12	71 (6.66)	995(93.34)	
12-23	218 (9.53)	2023 (90.27)	
24-35	252 (12.49)	1765 (87.51)	
36-47	274 (13.95)	1690 (86.05)	
48-59	301 (14.80)	1733 (85.20)	
Child Sex			0.1
Male	582 (12.53)	4064 (87.47)	
Female	534 (11.42)	4142 (88.58)	
Mother's age			0.434
15-19	67 (10.98)	543 (89.02)	
20-29	545 (11.91)	4031 (88.09)	
30-39	375 (11.80)	2804 (88.2)	
40-49	129 (13.48)	828 (86.52)	
Place of residence			<0.0001
Urban	74 (3.55)	2012 (96.45)	
Rural	1042 (14.40)	6194 (85.60)	
Zones			<0.0001
Western	216 (24.32)	672 (75.68)	
Northern	9 (1.29)	690 (98.71)	
Central	17 (1.91)	871 (98.09)	
Southern Highlands	57 (8.69)	599 (91.31)	
Southern	71 (18.49)	313 (81.51)	
South West Highlands	65 (6.52)	932 (93.48)	
Lake	592 (22.36)	2055 (77.64)	
Eastern	87 (11.25)	686 (88.75)	
Zanzibar	2 (0.14)	1388 (99.86)	
Marital status of the mother			0.126
Never Married	65 (15.08)	366 (84.92)	
Married/Living together	930 (11.82)	6939 (88.18)	
Widowed/Divorced/Not living together	121 (11.84)	901 (88.16)	
Mother's education status			
No education	230 (11.26)	1812 (88.74)	0.695
Primary	157 (12.41)	1108 (87.59)	
Secondary	522 (12.03)	3817 (87.97)	
Higher	207 (11.97)	1469 (88.03)	
Wealth index			<0.0001
Poorest	437 (20.56)	1688 (79.44)	
Poorer	353 (18.31)	1575 (81.69)	
Middle	229 (12.40)	1618 (87.60)	
Richer	97 (2.83)	3325 (97.25)	
Richest	10 (0.66)	1512 (99.34)	

Table 1. Contd.

Mosquito net ownership			<0.0001
0	135 (6.83)	1842 (93.17)	
1 – 2	330 (10.8)	2726 (89.2)	
3 – 4	375 (13.44)	2415 (86.56)	
>4	276 (18.41)	1223 (81.59)	

ownership was statistical significant ($p<0.05$) with children malaria prevalence (Table 2). The other variables which were child sex, age of the mother and mother's education level were not significant ($p>0.05$). In the adjusted Complementary log-log model only four variables were significant; child age, place of residence, zone which the under-five children belong and wealth index since $p<0.05$. Whereas child sex, mother's age, marital status and education level of the mother, as well as mosquito net ownership were not significant ($p>0.05$). However marital status and mosquito net ownership were significant in unadjusted Complementary log-log final model.

Malaria prevalence for the children increases with increase in age being lowest to the children under 12 months and highest for those aged 48-59 months (Adjusted Parameter Estimate (PA) =0.88, Confidence Interval (CI): 0.62-1.14). Although child sex was not significant, female children were having lower mean prevalence (PA=-0.099, CI: -0.22-0.02) compared to the male which was taken as the reference category. Malaria to the children varies with place and zone of residence, being highest to the rural areas (PA=0.481, CI: 0.21-0.75) compared to urban.

Complementary log-log model reveals that Western zone were also having highest mean occurrence of children malaria compared to all other zones. There were significant relationship between children malaria incidences with Northern (PA=-2.733, CI=-3.41,-2.06), Central (PA=-2.62, CI: -3.13,-2.11), Southern Highlands (PA= -0.787, CI: -1.10,-0.48), South West Highlands (PA= -1.291, CI: -1.58,-1.01), and Zanzibar (PA= -4.521, CI: -5.92,-3.13) zones. The remaining three zones that is Southern (PA= -0.233, CI: -0.51, 0.04), Lake (PA=-0.021, CI: -0.19, 0.14) and Eastern (PA= -0.064, CI: -0.33, 0.20) were not significant ($p>0.05$). The study reveals that Zanzibar was having lowest mean malaria children incidence (PA= -4.521, CI: -5.92,-3.13) compared to their counterparts from Western zone and all other zones.

DISCUSSION

The study re-analyzed 2015/2016 Tanzania Demographic Health Surveys data. It was noted that malaria cases were lowest for the children under one-year-old and cases were increased with increase in age. The fact that under one year children were having lowest cases of malaria may be due to antibodies acquired from their mother during pregnancy as the result they are capable of fighting malaria before their immunity wane (WHO, 2017; Michael-Phiri, 2017). This finding is also supported by Nyarko and Cobblah (2014) which was conducted in Ghana. Females experience lowest malaria cases as compared to their males counterpart. This may be due to biological reasons in which male are more susceptible to disease compared to female children. This study is consistent with the study conducted by Roberts and Matthews (2016) in Uganda and also with another conducted in Kenya by Sultana et al. (2017) which reveals that malaria cases were higher to males children compared to females.

It was also observed that malaria cases were highest in rural areas this may be due availability of good vector condition to multiply, lower housing quality, poverty, and poor drainage systems (Oladeinde et al, 2012). A similar result was obtained in Kenya by Sultana et al. (2017) which shows malaria cases were higher in rural areas than in urban setting. Furthermore, a study conducted in Sri-Lanka reveals that malaria is a disease for poor community living in rural areas (Fernando et al., 2003). This means the highest malaria cases rural Tanzania may be due to poverty which limits them to have modern houses and every family member to sleep in insecticide-treated bed nets. Malaria cases were also varying from one zone to the other being lowest in Zanzibar and highest in Western zone. The study by Hagenlocher and Castro (2015) supported this study in which they identified zones of high malaria risk cases being in the south-eastern and north-western part of the country. Their study also reveals that concentrations of high malaria cases were in north-western, western, and south-eastern zones. Although stable marriages are one among factors for physical well-being and healthier children (Staton, 2008) this study was contrary to this which shows there is no statistically significant relationship between malaria cases with marital status. Moreover, the results are supported by a study conducted in Ghana (Asiedu and Okwabi, 2014) which found a similar result.

The finding of this study regarding marital status was

Table 2. Estimates of a Complementary log-log model of the malaria for the Children under-five with socio-demographic characteristics.

Variable	Unadjusted			Adjusted		
	Parameter estimate	95% CI	P-Value	Parameter estimate	95% CI	P-value
Children age (Months)						
<12*						
12 to 23	0.395	[0.13,0.66]	0.004	0.423	[0.15,0.69]	0.002
24-35	0.661	[0.40,0.92]	<0.0001	0.654	[0.39,0.92]	<0.0001
36-47	0.779	[0.52,1.04]	<0.0001	0.779	[0.52,1.04]	<0.0001
48-59	0.843	[0.58,1.10]	<0.0001	0.88	[0.62,1.14]	<0.0001
Child sex						
Male*						
Female	-0.099	[-0.22,0.02]	0.1			
Mother's age						
15-19*						
20-29	0.086	[-0.17,0.34]	0.506			
30-39	0.076	[-0.18,0.34]	0.568			
40-49	0.219	[-0.08,0.51]	0.147			
Place of residence						
Urban*						
Rural	1.459	[1.22,1.70]	<0.0001	0.481	[0.21,0.75]	<0.0001
Zones						
Western*						
Northern	-3.068	[-3.74,-2.40]	<0.0001	-2.733	[-3.41,-2.06]	<0.0001
Central	-2.669	[-3.16,-2.17]	<0.0001	-2.62	[-3.13,-2.11]	<0.0001
Southern Highlands	-1.12	[-1.41,-0.83]	<0.0001	-0.787	[-1.10,-0.48]	<0.0001
Southern	-0.31	[-0.58,-0.04]	0.024	-0.233	[-0.51,0.04]	0.1
South West Highlands	-1.419	[-1.7,-1.14]	<0.0001	-1.291	[-1.58,-1.01]	<0.0001
Lake	-0.096	[-0.25,0.06]	0.228	-0.021	[-0.19,0.14]	0.797
Eastern	-0.848	[-1.10,-0.60]	<0.0001	-0.064	[-0.33,0.20]	0.635
Zanzibar	-5.266	[-6.66,-3.87]	<0.0001	-4.521	[-5.92,-3.13]	<0.0001
Marital status of the mother						
Never Married*						
Married/Living together	-0.262	[-0.51,-0.01]	0.041	-0.169	[-0.42,0.08]	0.191
Widowed/Divorced/Not living together	-0.26	[-0.56,0.04]	0.091	-0.176	[-0.48,0.13]	0.257
Mother's education status						
No education*						
Primary	0.103	[-.10,0.31]	0.318			
Secondary	0.07	[-0.09,0.23]	0.376			
Higher	0.098	[-0.09,0.29]	0.306			
Wealth index						
Poorest*						
Poorer	-0.13	[-0.27,0.01]	0.071	-0.148	[-0.29,-0.005]	0.043

Table 2. Contd.

Middle	-0.553	[-0.71,-0.39]	<0.0001	-0.393	[-0.56,-0.23]	<0.0001
Richer	-1.592	[-1.82, -1.36]	<0.0001	-1.074	[-1.32,-0.82]	<0.0001
Mosquito net ownership						
0*						
1 to 2	0.48	[0.28,0.68]	<0.0001	0.198	[-0.01,0.41]	0.067
3 to4	0.713	[0.52,0.91]	<0.0001	0.081	[-0.14,0.30]	0.475
>4	1.057	[0.85,1.26]	<0.0001	0.074	[-0.16, 0.31]	0.541

*Reference category.

different from that conducted by Houmsou et al., (2014) which found out that there was statistical significant relationship between children under five malaria status with mother's marital status. It was also observed that malaria cases were highest for the poorest families and decrease with increase in income. A study conducted in rural Uganda (Tusting et al., 2016) reveals the same results in which poorest families were more affected with malaria compared to the richest. Furthermore, a study conducted by Nonvignon and Jacob (2012) from four selected Sub-Saharan African countries found out that children from wealthier household were having the lowest risk as compared to poorest households. It should also be noted that Malaria in Africa is termed as an infectious disease of the poorest rural population and communities (Malaney et al., 2004).

Regarding the mosquito net, the findings are contrary to the study conducted in Ghana (Nyarko and Cobblah, 2014) which shows a significant association between mosquito net ownership with under-five malaria cases. In a study carried out in Nigeria (Yusuf et al., 2010) shows that malaria cases for children under-five were lowest to the household with mosquito bed net compared to those without nets. This study is also contrary to another study which was done in Tanzania (Somi et al., 2007) which shows that families owned mosquito nets or insecticide-treated bed nets were more likely to be protected from malaria parasites hence less malaria cases compared to the families without mosquito nets. Therefore, this need to be interpreted with care as most studies (Nyarko and Cobblah, 2014; Yusuf et al., 2010; Somi et al., 2007) concluded that there is highly relationship between mosquito net ownership with malaria cases of the under-five children.

Conclusion

The study concluded that the key determinants of the children under five malaria prevalence in Tanzania are children age, place of residence, zone in which respondents belong, and wealth index. Based on the finding, we recommend further research to be conducted to identify hot spots of malaria cases for targeting interventions. Adequate education should be given to mothers to make sure inclusive breastfeeding be maintained particularly during the first six months of the infants. Furthermore, the study recommends more initiative should be taken towards income-generating activities, especially to the rural population. This will potentially improve their access to interventions and proper treatment timely.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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