

Malaria Prevalence and Economic Determinants in Khartoum State, Sudan (2019)

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Summary: This study was conducted in 2019. It aimed to investigate the relationship between malaria prevalence and some of the economic determinants in Khartoum state. We achieved this aim through a primary source, which was collected by questionnaire and randomly selected interviews. The final sample size consisted of 256 households; it consisted of 1330 individuals. The study adopts both the analytical descriptive approach and econometric methods.

The study used the Qui square (χ^2) test and multiple logistic regression model. The results revealed that 17.9 % of the sample size is infected by malaria. The results showed a significant negative correlation between the logarithm of income and malaria prevalence. The results showed a positive relationship between the logarithm of expenditure and malaria prevalence.

It also found a negative relationship between using mosquito nets and malaria. Also, the study found the relationship between malaria prevalence and the tip of the toilet.

The study dealt with the types of toilets in some detail and their effect on the spread of malaria. There have not been enough studies in this area before.

KEYWORDS: Malaria; Income; Expenditure; Mosquito Nets; Toilet.

I- Introduction :

Malaria poses a significant and persistent public health challenge in Sudan, particularly in Khartoum State. (WHO, 2008). Despite ongoing efforts to combat the disease, it remains a leading cause of morbidity and mortality, disproportionately affecting vulnerable populations like children and pregnant women. Ahmed Elagali et al. (2022). Recent data underscores the severity of the situation, with Sudan bearing the heaviest malaria burden in the Eastern Mediterranean Region. (WHO,2022).

Beyond the health consequences, malaria imposes a substantial economic burden on households, encompassing direct medical costs and indirect losses due to reduced productivity. This study, conducted in 2019, aims to investigate the complex relationship between malaria prevalence and specific economic determinants within Khartoum State. By employing both descriptive and econometric methodologies, including the Chi-square test and logistic regression models, we seek to analyse the impact of income, expenditure, access to preventative measures like mosquito nets, and sanitation infrastructure, particularly toilet types, on malaria incidence. This research builds upon existing knowledge by providing a detailed examination of the role of sanitation and economic factors in malaria transmission within an urban context, a crucial aspect often under-explored in previous studies. Ultimately, this study intends to provide valuable insights for developing targeted interventions and policies to mitigate the health and economic consequences of malaria in Khartoum State.

The importance of the study comes from answering the following question:

Is there a relationship between economic variables and malaria prevalence?

1.1. Importance of this study:

Research on malaria prevalence and its economic determinants is exceptionally important for Sudan due to several critical factors:

- **High Burden & Risk:** Sudan faces a severe malaria burden, demanding targeted control.
- **Economic Strain:** Malaria causes significant economic losses through treatment costs and lost productivity.
- **Adapting to Change:** Studies track evolving malaria patterns due to climate and population shifts.
- **Informing Policy:** Data guides effective public health strategies and resource allocation.
- **Crisis Response:** Current conflicts emphasize the need for research to guide aid efforts.
- **Overall Goal:** Improve public health, reduce poverty, and protect vulnerable Sudanese populations.

II - Literature Review:

This review examines existing literature on malaria prevalence and its economic determinants in Sudan, highlighting key findings and positioning the current study's contribution.

a. Socioeconomic Factors and Malaria Incidence:

- **Abdelmahmoud (2005)**, in a study of Elmanagil town, the study aimed to examine the impact of some economic and demographic determinants of malaria incidence in Elmanagil town. The analyses are based on primary data collected using a questionnaire from a simple

random sample of 196 individuals. The analysis considers respondents' age, income, and education.

- The OLS technique is used to estimate the regression equation. found a complex relationship between income, age, and malaria incidence. While higher income might reflect strenuous labor leading to vulnerability, increasing age also correlated with higher susceptibility. This study demonstrates the nuanced ways socioeconomic factors can influence malaria risk.
- **Mahgoub (2017)** in Khartoum State, a few studies have evaluated the associations between environmental factors, the economic status of families and the prevalence of malaria among their children. A prospective population-based study on malaria was carried out in Khartoum State. The sample size was 400 families, distributed between three different socioeconomic strata. Different quantitative and qualitative methods of data collection were used (questionnaires, interviews and observations). The prevalence of malaria was performed for children under five years old. The study found that income was the strongest influencing factor, negatively affecting the prevalence of Malaria among children by affecting the standard of living. corroborated the strong inverse relationship between income and malaria prevalence among children under five. This research emphasized the role of income in improving living standards and, consequently, reducing malaria risk. It also highlighted the impact of environmental factors, such as pit latrines and home size, on malaria prevalence, reinforcing the link between poverty, poor sanitation, and disease.
- **Onwujekwe et al. (2005)** To determine levels of socioeconomic inequities in the prevention of malaria, and to examine the implications of the findings for improving the equitable control of malaria in the Sudan.

A cross-sectional survey using a pre-tested interviewer-administered questionnaire was administered to 720 randomly selected householders from six localities in Gezira and Khartoum States. A socioeconomic status (SES) index, developed using principal components analysis, demonstrated clear socioeconomic inequities in malaria prevention in and Khartoum States. Their findings revealed that poorer households spent less on vector control tools and were less likely to own mosquito nets, underscoring the financial barriers to effective malaria prevention.

Economic Consequences of Malaria and Healthcare Financing:

McIntyre et al. (2006) provided a comprehensive review of the economic consequences of illness and healthcare costs in low- and middle-income countries. They highlighted the impoverishing effects of out-of-pocket healthcare payments, particularly when combined with income loss due to illness. This study underscores the need for alternative healthcare financing strategies to mitigate the financial burden of malaria and improve access to care.

b. Malaria Prevention and Control Interventions:

- **Dræbel et al. (2008)**, The study assessed aspects of malaria infection, prevention and treatment in a population of resettled pregnant women in South Sudan.
- During April and May Gezira 2008, a cross-sectional study was carried out to estimate malaria prevalence and assess the use of malaria risk reduction measures and their associations with selected background characteristics. Two hundred and twenty women were tested for malaria parasitemia and questioned about their malaria prevention and treatment practices.
- The results showed a prevalence of *Plasmodium falciparum* parasitemia of 9.1%. No statistically significant associations were observed between selected background characteristics and malaria infection status. found that school attendance was significantly

associated with insecticide-treated net ownership and access to malaria diagnosis and treatment. This study emphasizes the importance of education and information dissemination in promoting the use of malaria prevention measures.

c. Key Observations and Research Gap:

- Previous studies have consistently demonstrated the significant impact of socioeconomic factors, including income, poverty, and access to resources, on malaria prevalence and prevention in Sudan.
- The economic burden of malaria, particularly on vulnerable populations, has been well-documented.
- **However, a significant gap exists in the detailed analysis of the relationship between specific sanitation infrastructure, particularly toilet types, and malaria prevalence.** This study aims to address this gap by providing a more comprehensive examination of this aspect, which previous research has largely overlooked. This focus on toilet types, and their effect on malaria prevalence, constitutes the key contribution of this research.

III- Methodology:

3.1. Objective:

The main objective of this study is to shed the light on health challenges in Sudan, with special focus on some economic determinants of communicable diseases.

3.2. Research Hypotheses:

- i) The spread of Malaria in Khartoum state is high.
- ii) Household expenditure reduces the spread of Malaria.
- iii) Using mosquito nets impacts negatively on the prevalence of Malaria.
- iv) There is association between Malaria prevalence and type of toilet.

3.3. Study area:

Khartoum State, Sudan's capital and economically vital region, was selected as the study area. This densely populated area, with a population of over 5 million, spans 28,000 km², consists of 7 localities, and is located at the confluence of the White and Blue Nile rivers, encompassing Khartoum, Omdurman, and Khartoum Bahri. The population is predominantly Muslim and Arabic-speaking (Dermographia, April 2018).

3.4. Statistical Method Used:

The study employed an Analytical Descriptive Approach and Econometric Methods. Descriptive statistics, proportions, and Chi-Square tests assessed associations between malaria prevalence and economic variables. Multivariate Logistic Regression was used to analyze the relationship between malaria prevalence and its determinants. SPSS version 26 was used for data analysis.

IV- STATISTICAL ANALYSIS:

4.1. Methodology and Data Collection:

4.1.1.1. Sources of Data:

This study utilized primary data collected via structured questionnaires from a random household sample in Khartoum State (Jan 20 - Feb 8, 2019). Data was gathered from household heads, spouses, or other adults. Variables included numerical (income, expenditure) and categorical (malaria prevalence, toilet type, mosquito net use).

4.1.2. Sample Size:

The study sampled 1330 respondents from 256 households per locality, using the family (defined as a cohabiting group) as the sampling unit. Questionnaires were administered to household heads, spouses, or other available adult members

The sample size is determined based on the following formula: -

Where :

n: Sample size

z: Critical value for achieving $(1-\alpha)$ % confidence level, here we use $z = 1.96$.

p: Anticipated population proportion, which is always chosen from previous studies.

$q = 1-p$

Deff: Design effect, an indicator used when the sample is designed as non-simple sampling assumed to be from 1.5 to 2.

d: Desired margin of error .

4.1.3. Model Used:

A Multivariate Logistic Regression Model was used to analyze the relationship between malaria prevalence (binary: affected=1, not affected=0) and economic determinants (independent variables). This model estimates the parameters of a logistic model, designed for binary dependent variables.

The specified Logistic regression model takes the following form.

$$\text{Logit}(P_i) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_k X_k$$

Where:

P_i : The probability of $y = 1$

α : Intercept

β : Regression coefficients

V- RESULTS:

Firstly, Analyzed the relationship between the dependent and independent variables separately to see their effect on the dependent variable.

The currency used in this study was the Sudanese pound (SDG).

Statistically significant Chi-square results indicated a clear inverse correlation between income and malaria prevalence. The infection rate was highest (31.5%) among those with incomes below 200 SDG and lowest (7.4%) among those with incomes exceeding 1000 SDG, suggesting a strong association between higher income and reduced malaria risk, likely due to improved prevention and environmental control." See Table (1) and Table (2) in Appendices.

Chi-square analysis indicated a significant association between expenditure and malaria prevalence. However, the effect is unclear due to varied spending and potential recall bias. (Tables 3 & 4, Appendices).

Chi-square analysis showed no significant relationship between toilet type and malaria prevalence. However, descriptive statistics indicate varying infection rates: pit latrines (19.1%), improved pit latrines (21.5%), and flush toilets (15.1%). The study suggests improved toilet types may reduce malaria incidence by limiting mosquito breeding. (Tables 5 & 6, Appendices)

Table (7) and (8) Chi-square showed a significant relationship between mosquito net use and malaria prevalence. Net users had a 15% infection rate, compared to 20% for non-users. Overall infection was 17.9%, indicating nets reduce malaria risk.

Based on table (9), Logistic regression showed a significant model fit (Chi-square). Variable importance: income (strongest, negative association), expenditure (positive), mosquito nets (negative), and toilet type. Income: a 1-unit increase reduces malaria odds by 29%. Expenditure: a 1-unit increase raises malaria odds by 2.5 times. Mosquito net use reduces malaria odds by 0.73. Improved pit latrines increase malaria odds by 1.6 compared to flush toilets. Pit latrines showed no significant correlation

- **DISCUSSION:**

This analysis provides valuable insights into malaria prevalence in Khartoum State, Sudan, and offers both support for existing literature and novel findings that contribute to the field. Let's break down how each finding relates to the literature review:

- **1. Income is Highly Significant and Negatively Associated with Malaria Prevalence:**

- **Support for Literature:**

- This finding directly supports the work of Mahgoub (2017), which highlighted the inverse relationship between income and malaria prevalence. Higher income allows for better living conditions, improved access to healthcare, and resources for prevention.
- It also aligns with Onwujekwe et al. (2005), who demonstrated that poorer households have limited access to vector control tools.
- And it does not agree with the study by Abdelmahmoud (2005).

- **Contribution:**

- Quantifying the odds ratio (29% reduction in malaria prevalence with a unit increase in income) provides a specific measure of this relationship, which can be valuable for policy and intervention planning.

- **2. Expenditure is Highly Significant and Positively Associated with Malaria Prevalence:**

- **Contradiction and Explanation:**

- This finding appears to contradict the expected inverse relationship between economic well-being and malaria. However, the explanation provided (recalled bias, broad expenditure categories) offers a plausible explanation.
- This highlights the difficulties of using expenditure data in these types of studies.

- **Contribution:**

- This finding serves as a cautionary note regarding the use of expenditure data in epidemiological studies, especially in recall-based surveys. It emphasizes the importance of carefully defining and collecting expenditure data.
- It also shows the complexity of socioeconomic factors, and that not all economic indicators will react as expected.

- It also can be interpreted that when a family member gets sick, the family will have to spend more money, thus the sickness causes the expenditure increase, and not the other way around.

3. Negative Association Between Malaria Prevalence and Mosquito Nets:

- **Support for Literature:**

- This aligns with Dräbel et al. (2008) and Onwujekwe et al. (2005), who emphasized the importance of insecticide-treated nets (ITNs) in malaria prevention.
- It supports the information that providing the tools for prevention is very effective.

- **Contribution:**

- Quantifying the protective effect of mosquito nets (0.73 odds ratio) strengthens the evidence base for promoting their use.

4. No Significant Correlation Between Malaria Prevalence and Pit Latrine Type:

- **Gap Addressed and Novelty:**

- This finding directly addresses the research gap identified in the literature review. The study specifically investigated the relationship between toilet types and malaria prevalence, which previous studies had largely overlooked.
- The finding that improved pit latrines with slabs are slightly more likely to have malaria than flush toilets is a very interesting result.

- **Contribution:**

- This finding directly addresses the research gap identified in the literature review. The study specifically investigated the relationship between toilet types and malaria prevalence, which previous studies had largely overlooked.
- The finding that improved pit latrines with slabs are slightly more likely to have malaria than flush toilets is a very interesting result.

Overall Contribution:

1. This study reinforces the importance of economic factors, particularly income and access to preventive measures, in malaria control.
2. It provides a nuanced understanding of the relationship between economic indicators and malaria prevalence, highlighting the challenges of using expenditure data.
3. Most importantly, it addresses a critical research gap by examining the role of sanitation infrastructure, specifically toilet types, in malaria prevalence.
4. The findings regarding toilet types, while showing no significant correlation, are still very important, and provide a new avenue of research.
5. By combining quantitative analysis with a thorough literature review, this research contributes valuable insights to the ongoing efforts to combat malaria in Sudan

- **Recommendations:**

Based on the findings, here are some brief recommendations that could be drawn from the study:

- **Prioritize Income-Based Interventions:**

- Focus on poverty reduction and income-generating programs to improve living standards and reduce malaria vulnerability.
- **Promote Mosquito Net Usage:**
 - Continue and expand efforts to distribute and encourage the consistent use of insecticide-treated mosquito nets.
- **Refine Expenditure Data Collection:**
 - Exercise caution when using expenditure data in malaria studies. Implement clear definitions and minimize recall bias.
- **Investigating Alternative Environmental Factors:**
 - Explore other environmental determinants of malaria prevalence beyond toilet types, such as stagnant water sources and urban planning.
- **Further Research:**
 - Conduct additional studies to understand the complex interplay of socioeconomic factors and environmental variables in malaria transmission in Khartoum State.

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VII- Appendices

Table (1): Examining the Correlation between Household Income and Malaria Incidence

		Income					Total	
		lowest than 200	[200-399]	[400-599]	[600-799]	[800-999]		higher than 1000
Did name have Malaria in the last 12 months	No	13	277	538	179	46	25	1078
	Yes	6	89	104	19	8	2	228
Total		19	366	642	198	54	27	1306

Source: Field Survey, 2019.

Table (2) Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.931 ^a	5	.000
Likelihood Ratio	26.296	5	.000
Linear-by-Linear Association	20.527	1	.000
N of Valid Cases	1306		

a. 2 cells (16.7%) have been expected to be counted less than 5. The minimum expected count is 3.32

Relationship between Household Expenditure and Malaria Prevalence

Table (3)

		Expenditure			Total	
		lowest than 400	[400-649]	[650-800]		higher than 800
Did name have Malaria in the last 12 months	No	188	713	168	23	1092
	Yes	36	181	16	5	238
Total		224	894	184	28	1330

Source: Field Survey, 2019.

Table (4):

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	14.469 ^a	3	.002
Likelihood Ratio	16.366	3	.001
Linear-by-Linear Association	2.165	1	.141
N of Valid Cases	1330		

a. 0 cells (.0%) have an expected count of less than 5. The minimum expected count is 5.01.

Association of Malaria Prevalence with the Type of Toilet

Table (5):

Crosstab

Count

		Type of toilet			Total
		Pit latrine	Improved pit latrine with slap	Flush to Siphon	
Did name have Malaria in the last 12 months	No	432	193	467	1092
	Yes	102	53	83	238
Total		534	246	550	1330

Source: Field Survey, 2019

**Table (6):
Chi-Square Tests**

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.702 ^a	2	.058
Likelihood Ratio	5.718	2	.057
Linear-by-Linear Association	3.000	1	.083
N of Valid Cases	1330		

a. 0 cells (.0%) have an expected count of less than 5. The minimum expected count is 44.02.

The survey included a question regarding the association between prevalence of malaria within the household over the past 12 months and the presence of mosquito nets in the home. The findings are summarized below:

Table (7):

Crosstab

Count

		Do you have mosquito nets in the house		Total
		Yes	No	
Did name have Malaria in the last 12 months	No	404	688	1092
	Yes	71	167	238
Total		475	855	1330

Source: Field Survey, 2019.

Table (8):

Chi-Square Tests

	Value	df	Asymptotic Significance (2- sided)	Exact Sig. (2-sided)	Exact Sig. (1- sided)
Pearson Chi-Square	4.369 ^a	1	.037		
Continuity Correction	4.062	1	.044		
Likelihood Ratio	4.465	1	.035		
Fisher's Exact Test				.037	.021

Linear-by-Linear Association	4.365	1	.037		
N of Valid Cases	1330				

a. 0 cells (.0%) have an expected count of less than 5. The minimum expected count is 85.00.

b. Computed only for a 2x2 table

Logistic Regression for Malaria Prevalence

Table (9):

Variables in the Equation

Step		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
1 ^a	Log Income	-1.249	.244	26.252	1	.000	.287	.178	.462
	Log Exp	.906	.343	6.972	1	.008	2.474	1.263	4.847
	Do you have mosquito nets in house (1)	-.310	.160	3.748	1	.053	.734	.536	1.004
	Type of toilet			6.470	2	.039			
	Type of toilet (1)	.134	.175	.588	1	.443	1.143	.812	1.610
	Type of toilet (2)	.508	.202	6.300	1	.012	1.661	1.118	2.470
	Constant	-.418	1.304	.103	1	.749	.659		

a. Variable(s) entered on step 1: Log Income, Log Exp, do you have mosquito nets in house, Type of toilet.

Source: Field Survey, 2019.

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