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Factors Associated with Malaria Infections among Children Under 5 Years in Rwanda Using 2019/2020 Rwanda Demographic and Health Survey Data

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Abstract

Malaria continues to be a serious global public health burden especially in sub-Saharan Africa where Children under the age of 5 and pregnant women were the most affected. This study aimed to determine factors associated with malaria infections among children under 5 years in Rwanda using the 2019/2020 Rwanda Demographic and Health Survey data. It was a cross-sectional study using data from the 2020 Rwanda Demographic and Health Survey (DHS) collected from November 9, 2019 to July 20, 2020. The findings of this study will inform efforts to prevent malaria infections among under 5 years of age. Using STATA 17, data were analyzed at univariable, bivariable, and multivariable logistic regression levels to answer current research questions. Of the 3,708 children with full malaria information, about 2.7% were diagnosed with malaria or treated for the infection in the past 2 weeks preceding the survey. On one hand, sociodemographic factors that predicted malaria infections among children under 5 years include living in houses with earth, dung, or bricks without cement as the main floor material [aOR:2.9 with 95% C.I:1.2-7.0], having no health insurance [aOR: 1.5 with 95% C.I:1.0-2.4], and having a mother with no education [aOR: 2.5 with 95% C.I: 1.0-6.1]. On the other hand, ITN-related factors include having one or zero ITN [aOR:1.9 with 95% C.I: 1.2-3.0], and sleeping under ITN [aOR:1.7 with 95% C.I: 1.1-2.7]. Based on these findings, interventions aiming to combat malaria infections among children under 5 years should focus on empowering households to cement the floors of houses, which improves hygiene and reduces mosquitoes within houses, promoting education for women, and fostering better attitudes towards healthcare-seeking and having health insurance. Moreover, the distribution and promotion of ITN use should be done regularly, with a particular focus on households with children under 5 years.

Key words: Children under 5 years, malaria, Insecticide treated nets

1.Introduction

Malaria remains a major global public health challenge, particularly affecting tropical and sub-tropical regions, with substantial impacts on economic development. According to the World Health Organization (WHO, 2021), malaria cases increased sharply from 227 million in 2019 to 247 million in 2020, indicating that nearly half of the world's population remains at risk (WHO, 2017). Sub-Saharan Africa bears the highest burden, accounting for over 200 million cases and 403,000 deaths in 2020. Countries such as Nigeria (27%), Democratic Republic of Congo (12%), Uganda (5%), Angola (3.4%), Burkina Faso (3.4%), and Mozambique (4%) contributed disproportionately to global cases (WHO, 2022). Despite a decline in malaria-related deaths from 896,000 in 2000 to 558,000 in 2019, 2020 witnessed an unexpected 12% increase, totaling 627,000 deaths, with children under five and pregnant women being the most vulnerable (WHO, 2021; Schantz-Dunn & Nour, 2019).

In Rwanda, malaria remains a leading cause of morbidity and mortality, especially among children under five. Strategic interventions, including distribution of insecticide-treated nets (ITNs), indoor residual spraying (IRS), and prompt diagnosis and treatment, have contributed to reductions in malaria incidence from 400 per 1,000 in 2016 to 148 per 1,000 in 2020, and malaria-related deaths from 700 to 148 over the same period (NISR, 2021; Rwanda Ministry of Health, 2021). ITN usage among households with children under five reached 70% in 2017, highlighting Rwanda's progress relative to the region (WHO, 2017). Nonetheless, gaps remain, with 34% of households lacking ITNs and 2.7% of children under five still diagnosed with malaria in 2020 (RDHS, 2020).

Globally and in Rwanda, factors influencing malaria infections among children under five are not fully understood, despite extensive prevention measures. Sociodemographic characteristics, household practices, and access to preventive interventions like ITNs are likely to influence infection risk, yet evidence on their associations remains limited (Gupta et al., 2018; Rudasingwa & Cho, 2020). Identifying these factors is critical for designing targeted interventions to further reduce morbidity and mortality in this vulnerable population. Therefore, this study aimed to identify factors associated with malaria infections among children under five years in Rwanda. Specifically, the objectives were to: i) determine the prevalence of malaria infections among children under five, ii) identify sociodemographic factors associated with malaria infections, and iii) assess the association between ITN use and malaria infections among children under five. The findings of this study are intended to inform policy and programmatic strategies to strengthen malaria prevention and control in Rwanda and contribute toward global efforts to reduce malaria-related morbidity and mortality.

2. Theoretical Literature

2.1 Empirical Literature

Several studies have examined factors associated with malaria infections among children under five years (U5C), focusing on socio-demographic characteristics, parenting experience, and ITN utilization.

2.1.1 Socio-demographic Factors

Globally, 84 countries remain malaria-endemic, including Nigeria, the Democratic Republic of Congo, Uganda, and Mozambique, which collectively accounted for nearly half of global cases in 2020 (WHO, 2022). In Asia and Oceania, malaria prevalence is generally lower but localized areas remain high-risk. For instance, in Vietnam, children aged 3–5 years, families with five or more members, and households built with wood were more susceptible to malaria (Abe et al., 2009). India, despite a low national prevalence (1.7%), accounted for over half of malaria cases in Asia (Remora, 2023). In Papua New Guinea, areas below 1,600 meters altitude were disproportionately affected (Seidahmed et al., 2021).In sub-Saharan Africa, socio-demographic factors significantly influence U5C malaria infections. In Cameroon, children whose parents lacked formal education were 3.3 times more likely to contract malaria, while female caregivers reduced the risk (Isah et al., 2020). Similarly, in Ghana and Malawi, lower parental education and poor household wealth were associated with increased malaria risk among children under five (Chilanga et al., 2020). Older mothers (≥25 years) were less likely to have infected children in Ghana and Zambia (Dosoo et al., 2020; Tembo et al., 2018). Rural residence, poor housing, lack of indoor residual spraying, and inadequate sanitation further increased infection risk (Sarfo et al., 2023; Tembo et al., 2018). Other factors include exposure to intimate partner violence, outdoor sleeping at night, female child gender, and higher altitudes reducing risk (Debash et al., 2022; Aychiluhm et al., 2020; SIMON-OKE, 2019). In Uganda, older U5C in rural areas were at higher risk, while richer households and those with sprayed dwellings had reduced infection rates (Kooko et al., 2023).In Rwanda, studies revealed similar patterns. Older children in Huye district had 3.6 times higher risk compared to younger U5C, while rural residence, Eastern Province location, and non-sprayed households nearly doubled the infection risk (Nyirakanani et al., 2018; Habyarimana & Ramroop, 2020).

2.1.2 Parenting Experience

Parenting experience, including maternal parity and access to health information through media and antenatal care, influences child malaria risk. Multigravida mothers in Ghana were less likely to have children infected with malaria (Dosoo et al., 2020). Similarly, in Ethiopia, mothers owning radios or televisions had lower U5C malaria risk (Aychiluhm et al., 2020). Literature on parenting experience in Rwanda remains limited.

2.1.3 ITN Use Factors

ITN utilization is a critical malaria prevention strategy in sub-Saharan Africa. Factors promoting ITN use include knowledge of malaria prevention, household characteristics, maternal education, female-headed households, and antenatal care attendance (Konlan et al., 2022). Barriers include hot weather, perception of low mosquito presence, cost, and fear of insecticide chemicals (Konlan et al., 2022). In Ethiopia, ITN use varied by region, with 58.2% in Gurage Zone versus 37.2% in Gamo-Gofa Zone, influenced by household size and sleeping arrangements (Kebede et al., 2023; Admasie et al., 2018). In Malawi, maternal decision-making autonomy and proximity to health facilities increased ITN use (Nkoka et al., 2018). In Nigeria, children under one year were 1.8 times more likely to sleep under ITNs compared to older children, suggesting waning protection after weaning (Esuabom et al., 2021).

2.1.4 Association Between ITN Use and Malaria Infections

Evidence consistently indicates that ITN use reduces malaria prevalence. In Nigeria, malaria prevalence among non-ITN users was 83.6% versus 74.4% among ITN users (Ali et al., 2020). Similar trends were observed in Imo State, Ethiopia, Cameroon, and Uganda, with non-users consistently at higher risk (Ogomaka & Ukaga, 2020; Tsegaye et al., 2021; Isah et al., 2020; Kooko et al., 2023). In Rwanda, children not sleeping under ITNs in Huye district were 15.3 times more likely to be diagnosed with malaria (Nyirakanani et al., 2018).

Overall, socio-demographic characteristics, maternal experience, and ITN utilization significantly influence malaria infections among children under five, highlighting areas for targeted interventions to reduce morbidity and mortality in Rwanda and similar endemic settings.

2.2. Theoretical framework

This study applies the Health Belief Model (HBM) to understand factors influencing the use of insecticide-treated nets (ITNs) and other malaria prevention measures. The HBM posits that behavior change depends on modifying factors (demographics, socio-economic status, and malaria knowledge), individual beliefs (perceived susceptibility, severity, and benefits versus barriers), and cues to action (external influences such as health workers, media, and social networks). When perceived benefits of ITN use outweigh barriers, individuals are more likely to adopt preventive behavior. This framework helps explain why some individuals use ITNs while others do not (Mckellar & Sillence, 2020).

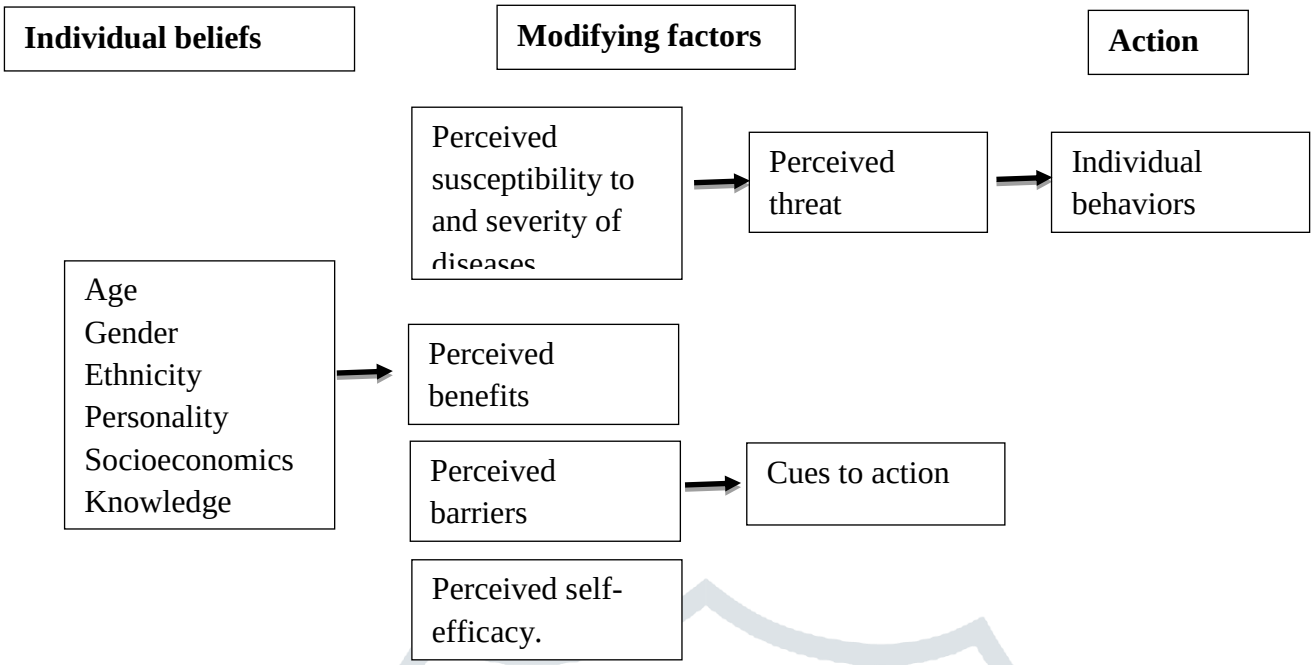

Figure 2.1: Constructs of the Health-belief Model (Ghorbani-Dehbalaei et al., 2021)

2.3. Conceptual framework

This study is conceptualized by considering participants demographic, spouse, parenting experience, children under 5 years and source of health information characteristics as predictor variables which lead to being diagnosed with malaria. Social demographic characteristics include baby, mother and father's age, gender, and occupation among others while parenting experience covers mother's number of pregnancies and access to information from media and healthcare providers.

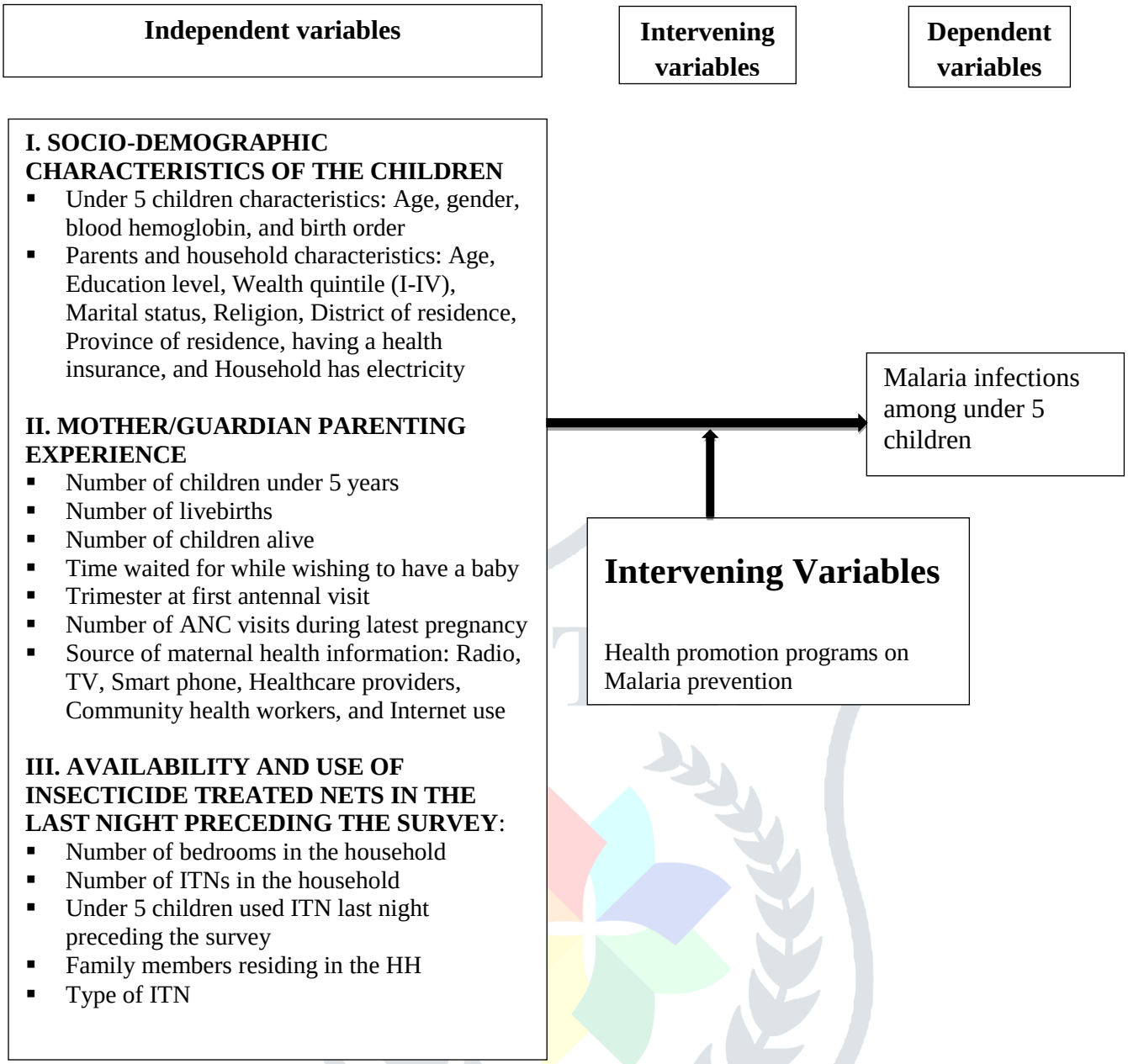

Figure 2.2: Conceptual framework for factors associated with malaria infections among children aged under five years

3.Research Methodology

3.1.Study design

This study was a cross-sectional study using secondary data collected from November 9, 2019 to July 20, 2020 during the 2019/2020 Rwanda Demographic and health survey (RDHS). The 2019/2020 Rwanda Demographic and health survey (RDHS) is a cross-sectional survey gathering population based data. DHS is conducted every 5 years in over 90 countries across the globe including Rwanda (DHS program, 2023). DHS in Rwanda has been done 6 times including that done in1992, 2000, 2005, 2010, 2014-2015, and 2019-2020. This study will use the latest (2019-2020) Rwanda Demographic and Health Survey (RDHS) data. It is done by the Rwanda National institute of statistics under technical support of International Coaching Federation (ICF). Training on biomarker testing is facilitated by the Rwanda National reference laboratory (NRL) under technical support of the ICF and the Centers for disease control and prevention (CDC).

3.2.Target Population and Sampling

The study population were infants aged below 5 years old. According to most recent national census (2022) in Rwanda, this population is estimated at 476,206 (NISR, 2022). However, during RDHS about 3,764 children under 5 years of age were sampled and reached. This study analyzed data collected in Rwanda is in the east central Africa and is known as a country of thousand hills due to its hilly geography. It is divided into 5 regions including 4 provinces (East, South, West, and North), and Kigali City. Its neighboring countries include Burundi in South, Uganda in North, Tanzania in East and Democratic Republic of the Congo (DRC) in West. Appendix D illustrates the five regions and 4 neighbor countries of Rwanda. The

current study analyzed the Rwanda Demographic and Health Survey (DHS) data. DHS 2020 used two stage sampling strategy: selection of sample points using cluster sampling and systematic sampling of households. All mothers in the selected households were interviewed during data collection. This study consider 3,764 under f years children (U5C) as its sample populations where 122 U5C were reported to had used antimalarial drugs as per 2019/2020 Rwanda DHS (RDHS, 2021).vThe 2019-2020 RDHS gathered population-based data and used two (2) stages sampling approach; (1st) selection of five hundred (500) clusters encompassing 112 sample points in urban and 388 rural sample points, and (2nd) systematic sampling of households to enroll. Questionnaire guided interview was done to collect information about all members in the selected households after providing informed consent. Similarly, biomarkers including malaria testing were performed among all people in the households including children under 5 years.

3.3.Data collection methods

The study utilized secondary data from the 2019/2020 Rwanda Demographic and Health Survey (RDHS), collected using computer-assisted personal interviewing (CAPI) by trained field staff. Household questionnaires captured demographic, socio-economic, and household characteristics, while women's questionnaires collected information on demographics, behaviors, and health indicators. Biomarker testing, including malaria, anemia, and HIV, was conducted for children under 5 years and women. Questionnaires were developed in English and translated into Kinyarwanda to ensure accuracy and quality. RDHS datasets were accessed via the DHS program website with proper approval, ensuring standardized, reliable, and valid data collection consistent across DHS countries.

3.4.Data analysis

DHS data were analyzed using STATA 15 at mono-variable, bivariable, and multivariable (using logistic regression) levels. Univariable analysis was performed to characterize study participants by their demography and other relevant information to malaria, bivariate analysis was done by cross-tabulation participants characteristics with malaria infection among children under 5 years along with association of ITN use and having malaria infection or not. The prevalence of malaria infection was calculated by dividing total number of malaria cases by total number all children tested for malaria in the univariable analysis. Furthermore, during bivariable analysis, chi-square test was done to test statistical significance assuming 95% confidence interval and statistical significance at a *p* value less than 0.05. Lastly, logistic regression analysis with odd ratios was done on factors associated with malaria infections, and to establish likelihood of non-use of ITN to result in malaria infection (if they will be statistically associated at bivariable analysis). Results were displayed in tables and graphs.

3.5.Ethical considerations

DHS surveys are ethically reviewed and approved by national ethical review boards. Particularly, the 2019/2020 Rwanda DHS, was reviewed and ethically approved by Rwanda Ethical review council (RNEC). DHS datasets are public datasets which do not contain personal identifiers like names, phone numbers, and national identification card numbers. Moreover, the datasets were accessed from the official DHS website upon an official request. Lastly, the datasets were stored in a password-encrypted computer and used to answer research questions for the current study only.

4.Presentation of Findings

4.1. Description of the study population

This study analyzed 2020 Rwanda Demographic and health Survey (DHS) data. In Table 4.1, participants are described based on their sex, education, province of residence, household, and mother characteristics.

Table 4. 1: Socio-demographic characteristics of the study participants

Variable	Frequency	Percent
Baby's characteristics		
Sex		
Male	1,869	50.3
Female	1,839	49.7
Level of education		
Pre-primary	432	96.0
Primary	16	4.0
Relationship to head of the household		
Son or daughter	3,064	83.2
Others*	644	16.8

Variable	Frequency	Percent
Province		
Kigali	416	13.6
South	865	20.3
West	914	23.5
North	595	15.5
East	918	27.1
Type of place of residence		
Urban	786	17.2
Rural	2,922	82.8
Household		
Number of rooms used for sleeping		
1 to 3	3,287	88.8
4 to 9	421	11.2
Number of household members		
2 to HH members	2,122	57.5
6 and more	1,586	42.5
Sex of head of household		
Male	2,761	74.9
Female	947	25.1
Wealth index combined		
Poorest	879	22.6
Poorer	769	20.7
Middle	695	19.5
Richer	687	18.8
Richest	678	18.4
Main floor material		
Earth, dung, or bricks without cement	2,565	68.6
Cement, tiles, carpet, or polished wood	1,143	31.4
Mother characteristics		
Mother's highest educational level		
No education	412	11.9
Primary	2,239	64.2
Secondary	651	19.7
Higher	167	4.2
Name of the main type of health insurance		
Community health insurance	2,536	67.9
RSSB, MMI, Private, Employer, Other type	261	6.7
None or not reported	911	25.4
Total	**3,708**	**100**

*Other relationship with the head of the household: grandchild, adopted, brethren, or not related

Table 4.1 shows that of the 3,708 children under 5 years; both sex were nearly equally represented (50.4% males and 49.6% females) while majority of them were in pre-school education (96.4%), living in rural area (78.8%), living in household headed by a male (74.5%), had a mother with primary as highest education level reached (64.5%), and living in house with earth, dung, or bricks without cement as main floor material (69.2%).

4.2. Prevalence of malaria infections among children under 5 years

The prevalence of malaria among children under 5 years was estimated based on survey malaria testing and a history of taking antimalarial drugs in the past 2 weeks preceding the interview date.

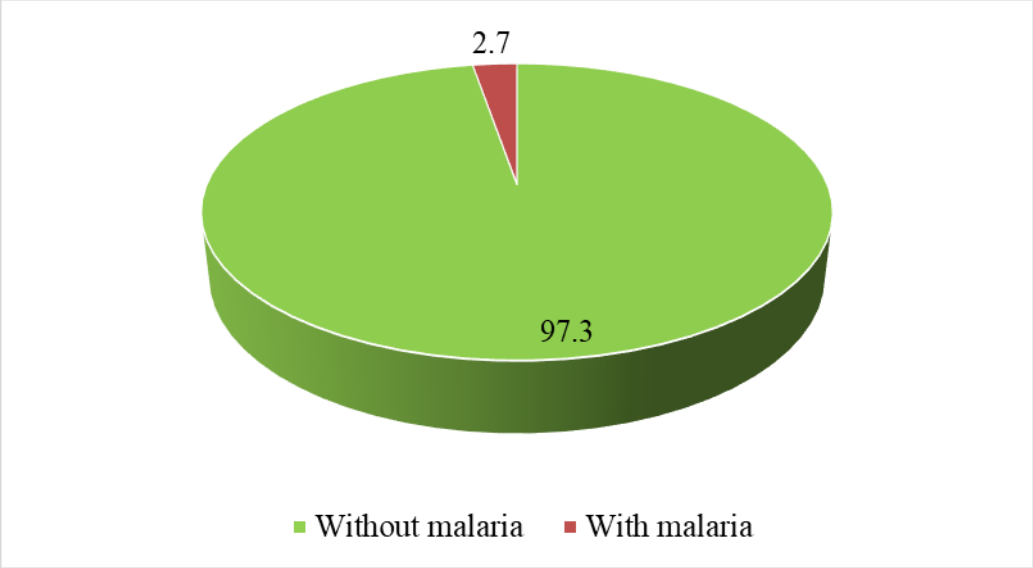

Figure 4. 1: Prevalence of malaria infection among children under 5 years

Figure 4.1 shows that about 2.7 % (n=106) of the 3,708 children aged under 5 years in the RDHS were diagnosed with malaria or had a history of taking antimalarial drugs in the past 2 weeks.

4.3. Sociodemographic factors associated with malaria among children under 5 years

Socio-demographic characteristics of the children were cross-tabulated with malaria infection status with option to compute chi-square test to assess statistical significance of the association. The characteristics encompassed information of the baby, household, mother and area of residence among others. Table 4.2. provides information on statistical association status of the cross-tabulation.

Table 4.2: Sociodemographic factors associated with malaria among children under 5 years

Variables	Total	Diagnosed or treated for malaria		X^2 value*	*p* value
		No	Yes		
Baby's characteristics					
Baby sex					
Male	1,856	1809(97.5)	47(2.5)	1.6367	0.201
Female	1,822	1763(96.8)	59(3.2)		
Level of education attending					
Pre-Primary	429	418(97.4)	11(2.6)	0.7986	0.371
Primary	16	15(93.8)	1(6.3)		
Relationship to head of the household					
Son or daughter	3,039	2,953(97.2)	86(2.8)	0.1698	0.680
Others**	639	619(96.9)	20(3.1)		
Region					
Kigali	412	404 (98.1)	8(1.9)	6.9464	0.139
South	857	823(96.0)	34(4.0)		
West	906	877(96.8)	29(3.2)		
North	593	580(97.8)	13(2.2)		
East	910	888(97.6)	22(2.4)		
Type of place of residence					
Urban	774	761(98.3)	13(1.7)	5.0637	**0.024**
Rural	2,904	2811(96.8)	93(3.2)		
Name of the main type of health insurance					
Community health insurance	2,517	2455(97.5)	62(2.5)	18.4732	**<0.001**
RSSB, MMI, Private, Employer, Other type	255	254(99.6)	1(0.4)		
None or Not reported	906	863(95.3)	43(4.8)		
Mother's highest educational level					

Variables	Total	Diagnosed or treated for malaria		X^2 value*	*p* value
		No	Yes		
No Education	411	390(94.9)	21(5.1)	18.1925	<**0.001**
Primary	2,227	2159(97.0)	68(3.0)		
Secondary	642	635(98.9)	7(1.1)		
Higher	162	161(99.4)	1(0.6)		
Household					
Number of household members					
2 to HH members	2,098	2043(97.4)	55(2.6)	1.1837	0.277
6 and more	1,580	1529(96.8)	51(3.2)		
Number of rooms used for sleeping					
1 to 3	3,262	3159(96.8)	103(3.2)	7.8248	**0.005**
4 to 9	416	413(99.3)	3(0.7)		
Main floor material					
Earth, dung, or bricks without cement	2,549	2453(96.2)	96(3.8)	23.1941	<**0.001**
Cement, tiles, carpet, or polished wood	1,129	1119(99.1)	10(0.9)		
Sex of head of household					
Male	2,737	2653(96.9)	84(3.1)	1.3373	0.248
Female	941	919(97.7)	22(2.3)		
Wealth index combined					
Poorest-poorer	1,637	1564(95.5)	73(4.5)	26.2237	<**0.001**
Middle to richest	2,041	2008(98.4)	33(1.6)		
Sex of household member					
Male	1,856	1809(97.5)	47(2.5)	1.6367	0.201
Female	1,822	1763(96.8)	59(3.2)		
Share toilet with other households					
No	2,962	2874(97.0)	88(3.0)	1.3768	0.241
Yes	616	603(97.9)	13(2.1)		
Household has a separate room used as kitchen					
No	230	221(96.1)	9(3.9)	1.7418	0.187
Yes	580	567(97.8)	13(2.2)		

X^2: Chi-square test value **Other relationship with the head of the household: grandchild, adopted, brethren, or not related

Table 4.2 shows that from various variables included in the two by two analysis, only 6 showed statistical significance at a p value below 0.05. The table shows that significantly higher prevalence of malaria among children under 5 years were among those living in rural areas (3.2%), without health insurance (4.8%), mother with no education (5.1%), lower number of rooms used to sleep (3.2% among household with 1 to 3 rooms), poorest to poorer wealth index (4.5%), and those living in a house with eearth, dung, or bricks without cement as a main floor material. All factors associated having malaria infection among the children were included in one logistic regression producing adjusted odd ratios as shown in Table 4.3.

Table 4.3: Logistic regression of sociodemographic factors associated with malaria infection among children under 5 years

Factors	aOR*	95% C.I** Lower	Upper	p value
Type of place of residence				
Urban	Ref			
Rural	0.8	0.4	1.5	0.52
Wealth index combined				
Poorest-poorer				
Middle to richest	0.7	0.4	1.2	0.177
Number of rooms used for sleeping				
1 to 3	Ref			
4 to 9	0.4	0.1	1.4	0.17
Main floor material				
Earth, dung, or bricks without cement	2.9	1.2	7.0	**0.017**
Cement, tiles, carpet, or polished wood	Ref			
Name of the main type of health insurance				
Community health insurance	Ref			
RSSB, MMI, Private, Employer, Other type	0.5	0.1	5.2	0.597
None or Not reported	1.5	1.0	2.4	**0.045**
Mother's highest educational level				
No Education	2.5	1.0	6.1	**0.045**
Primary	1.8	0.8	3.9	0.168
Secondary	Ref			
Higher	1.8	0.2	18.6	0.632

*aOR: adjusted odd ratios **C.I: Confidence interval

Table 4.3 shows that among six factors analyzed, only three significantly predicted malaria infection among children under 5 years: main floor material, type of health insurance, and mother's education. Children living in homes with earth, dung, or uncemented brick floors were 2.9 times more likely to contract malaria (aOR: 2.9; 95% CI: 1.2–7.0) compared to those with cement, tile, or polished wood floors. Households without health insurance had 1.5 times higher odds of malaria (aOR: 1.5; 95% CI: 1.0–2.4), and children of mothers with no formal education were 2.5 times more likely to be infected (aOR: 2.5; 95% CI: 1.0–6.1). Subsequent analysis focuses on ITN use.

4.4. Association between use of insecticide treated nets and malaria infections among children under 5 years

Variables related with to having and using insecticide treated nets (ITNs) were cross-tabulated with having malaria infection and they Table 4.4 shows results on the association.

Table 4.4: Insecticide treated net related factors associated with malaria infection among children under 5 years

Mosquito net related variables	Total	Diagnosed with or treated for malaria No	Yes	Chi2	*p* value
Number of mosquito bed nets					
Zero or one	2,022	1944(96.1)	78(3.9)	15.2704	**<0.001**
Two to Seven	1,656	1628(98.3)	28(1.7)		
Months ago net obtained					
0-24 months	1,426	1395(97.8)	31(2.2)	1.6246	0.202
24 months+	604	596(98.7)	8(1.3)		
Insecticide-Treated Net (ITN)					
No, don't know	23	23(100)	0(0.0)	0.4557	0.500
Yes	2,007	1968(98.1)	39(1.9)		
Observe or ask shape of mosquito net					
conical	1,589	1564(98.4)	25(1.6)	4.859	0.088
triangle	438	424(96.8)	14(3.2)		
not observed	3	3(100)	0(0.0)		

Person slept under an long-lasting insecticidal (LLIN) net					
No	1,947	1872(96.2)	75(3.85)	13.9092	**<0.001**
Yes	1,731	1700(98.2)	31(1.8)		
Net has holes equal to or larger than the tip of your thumb					
No	1,541	1516(98.4)	25(1.6)	3.9074	**0.048**
Yes	454	440(96.9)	14(3.1)		
Number of children under mosquito bed net previous night					
0	1,462	1406(96.2)	56(3.8)	8.2255	0.144
1	1,468	1434(97.7)	34(2.3)		
2	667	653(97.9)	14(2.1)		
3	68	66(97.1)	2(2.9)		
4	4	4(100)	0(0.0)		
5	9	9(100)	0(0.0)		

Table 4.4 shows that higher prevalence rates of malaria were among children living in household with zero or one ITNs than in those with 2 and more ITNs. Similarly, higher rates were among those who reported not to sleep under a long-lasting insecticidal (LLIN) net (3.8%) and those whose mosquito net had holes equal to or larger than the tip of your thumb (3.1%) than those who reported otherwise. In multivariable analysis, after controlling confounding variables, two variables remained and showed statistical significance in one logistic regression model. Table 4.5 shows the findings.

Table 4.5: Logistic regression of mosquito net related factors associated with malaria infection among children under 5 years

Factors	**aOR**	**95% C.I**		**p value**
		Lower	**Upper**	
Number of mosquito bed nets				
Zero or one	1.9	1.2	3.0	**0.009**
Two to Seven	Ref			
Person slept under an LLIN net				
No	1.7	1.1	2.7	**0.020**
Yes	Ref			

Table 4.5 shows that number of Insecticide Treated Nets (ITNs) that a household has and reporting that someone slept under a long-lasting insecticidal (LLIN) net were uniquely predicting malaria infections among children under 5 years. The findings show that households which were having zero or one mosquito bed nets were nearly twice [aOR:1.9 with 95% C.I: 1.2-3.0] more likely to have children suffering from malaria along with those who reported none who slept under an ITN the night preceding the survey [aOR:1.7 with 95% C.I: 1.1-2.7].

5. Discussion

This study aimed to determine the prevalence of malaria and examine socio-demographic and Insecticide-Treated Net (ITN) factors predicting malaria infections among children under five years in Rwanda. The prevalence of malaria among children under five was 2.7%, indicating that malaria continues to pose a public health threat despite national efforts to reduce infections. Factors significantly associated with malaria included living in houses with earth, dung, or uncemented brick floors, having no health insurance, and mothers with no formal education. ITN-related factors included insufficient ITNs, not sleeping under ITNs, and damaged nets.

5.1. Malaria prevalence among children under five years

The observed prevalence of 2.7% in Rwanda is substantially lower than the Sub-Saharan African average, which ranges between 15.4% and 30.5% (Oshagbemi et al., 2023). Neighboring countries such as Ethiopia, Malawi, the Democratic Republic of Congo, and Mozambique reported higher prevalence rates, ranging from 15.4% to 37% (Gaston & Ramroop, 2020; Mwandagalirwa et al., 2017; Kunihya et al., 2016). These differences may reflect variations in endemicity, effectiveness of national malaria control programs, and implementation of preventive interventions such as ITNs and indoor residual spraying. Rwanda has achieved a significant decline in malaria prevalence, dropping from 14.5% in 2017 to 2.7% in 2020 (Habyarimana &

Ramroop, 2020), suggesting that the country's robust malaria control strategies are effective. However, seasonal variation and survey timing may affect prevalence estimates, warranting cautious interpretation.

5.2. Socio-demographic factors associated with malaria

Children living in houses with earth, dung, or uncemented brick floors had 2.9 times higher odds of malaria infection compared to those in houses with cement, tiles, or polished wood floors. Poor housing conditions are often correlated with low economic status, limited access to clean water, and poor sanitation, all of which increase malaria risk (Sarfo et al., 2023). Similarly, children of mothers with no formal education were 2.5 times more likely to contract malaria. Education enhances knowledge about preventive measures and appropriate health-seeking behaviors, reducing malaria risk (Dosoo et al., 2020; Isah et al., 2020). Lack of health insurance, which may indicate low socio-economic status and limited access to healthcare, was also associated with higher malaria risk. Comparable findings have been reported in Uganda and Rwanda, where rural residence and poverty were significant risk factors for under-five malaria (Kooko et al., 2023; Habyarimana & Ramroop, 2020). These findings emphasize that structural and socio-economic determinants remain critical in malaria prevention.

5.3. ITN-related factors associated with malaria

The study confirmed that ITN availability and proper usage significantly reduce malaria risk. Children not sleeping under ITNs or using damaged nets faced higher infection odds. Similar trends were observed in Ethiopia, Cameroon, and Uganda, where regular ITN use reduced malaria risk 2–5 fold (Debash et al., 2022; Tsegaye et al., 2021; Nyirakanani et al., 2018; Kooko et al., 2023). In Rwanda, children not using ITNs were 15.3 times more likely to be diagnosed with malaria, underscoring ITNs' critical role in malaria control (Nyirakanani et al., 2018). These results highlight the need to ensure both access to sufficient ITNs and proper usage, including timely replacement of damaged nets. The findings demonstrate that malaria infections among under-five children in Rwanda are influenced by socio-demographic vulnerabilities and ITN-related behaviors. Strengthening housing conditions, promoting maternal education, expanding health insurance coverage, and improving ITN distribution and use are essential strategies for further reducing malaria prevalence among children under five in Rwanda.

6. Conclusions and Recommendations

This study shows that malaria infection remains a major public health concern with out 2.7% of the children estimated to suffer from malaria in 2020. On one hand social demographic factors that predicted malaria infections among children under 5 years include living in house with Earth, dung, or bricks without cement as main floor material, having no health insurance and a mother with no education. On the other hand, ITN related factors that include having one or zero ITN, sleeping under ITN, and having an ITN with holes equal to or larger than the tip of a thumb. Based on these findings, interventions aiming to combat malaria infections among children aged 5 years and below should focus on empowering households to cement floor of houses which improve hygiene and reduce mosquitoes within houses, promoting education for women and better attitudes towards healthcare seeking and health insurance. Moreover, distribution and promotion of ITN use should be done regularly with particular focus on households with children under 5 years.

Based on the study findings, current recommendations are directed to the ministry of health and community. The ministry of health should ensure regular distribution of ITNs to mothers and households with children under 5 years of age based on number of household sleeping rooms Health promotion programs aiming to combat malaria among children under 5 years should focus on women education and information communication session (IEC) for better attitudes towards healthcare seeking and health insurance. Spraying efforts should focus in rural areas focusing in houses with un-cemented floors and walls. Community should ensure that all children under 5 years sleep under ITNs every day Due to the fact that mosquitoes are attracted by carbon dioxide, community should do their best to their floor compact by cementing or using other tiles to promote hygiene and reduce carbon dioxide inside the house. Further studies should have done to explore the role knowledge, attitudes, and practice towards malaria prevention among people with children diagnosed with malaria in health facilities.

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