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# CLIMATIC PATTERNS AND THEIR RELATIONSHIP WITH MALARIA MORBIDITY AMONG PREGNANT WOMEN IN BUGESERA DISTRICT, RWANDA:

# A SEVEN-YEAR TREND STUDY

**Solange Uwera**

**Email: usong55@gmail.com**

**Department of Public Health, Mount Kenya University, Kigali-Rwanda**

# ABSTRACT

Malaria is a widespread infectious disease especially in areas with tropical climate. Despite being preventable and treatable, malaria remains prevalent, particularly in Africa. It is evidently a climate driven disease and has aggravated the Rwanda's public health burden. For instance, in 2020, Rwanda recorded 149 malaria-related deaths, and malaria during pregnancy is a notable cause of maternal morbidity and mortality. Changes in climatic patterns affect malaria's spread, but experts argue about its future under various climate scenarios, therefore understanding how changes in climatic patterns relate with malaria in pregnancy is key to design better strategies to control it. This study investigated the relationship between malaria morbidity among pregnant women in Bugesera District, in Rwanda, and the changes in three climatic patterns including temperature, humidity, and rainfall, from January 2015 to December 2021. Malaria data were obtained from Nyamata Level II Teaching Hospital while climate data (temperature, rainfall, and humidity) were sourced from the Rwanda Meteorological Agency. Monthly time series data were considered for seven years, from January 2015 to December 2021, for all variables. Pearson correlation coefficient was used to study how humidity, rainfall, temperature, and malaria rates were related. The results of this study show that November is the peak month for malaria in pregnancy in Bugesera District and 2017 was the year with highest number of malaria cases among pregnant women. The R-squared value proves that the change in the dependent variable (malaria morbidity) was explained by 13% of the independent variables of interest, while the rest was explained by other potential contributing factors. The regression analysis also shows that minimum temperature had a negative and non-significant effect on malaria morbidity ($\beta$= -0.18407, t=-1.63, p= 0.106), while maximum temperature and rainfall have positive but negligible effect on malaria morbidity ($\beta$= 0.086893, t=0.58, p=0.563; $\beta$= 0.000357, t=0.12, p=0.901 respectively). However, malaria morbidity among pregnant women in Bugesera District was positively and significantly related to humidity ($\beta$= 0.045785, t2=0.14, p=0.036).The findings of this study show a critical need to improve malaria control efforts, especially in Bugesera district focusing on designing local, place-based strategies, targeting best time for interventions such as November as a peak month for malaria, and the most affected population including pregnant women.


Key Words: Malaria, Bugesera District, Pregnant Women, Climatic Patterns, Temperature, Humidity, Rainfall.

# 1. INTRODUCTION

The current global issue of climate change arguably is having detrimental effects on human health, as supported by scientific research. The significant increase in greenhouse gas emissions triggered by anthropogenic activities has contributed to global warming and various climate change impacts (Piao et al., 2010). Consequently, this is expected to have diverse implications for human health and worsen the prevalence of infectious diseases (Babaie et al., 2018). A considerable proportion of infectious diseases in humans have been linked to climate change (Mora et al., 2022). Moreover, extreme weather conditions and fluctuations in annual weather patterns, such as those associated with vector-borne diseases like malaria, play a major role in the occurrence of various infectious diseases. Therefore, climate-proofing can be one of potential malaria eradication strategies (Nissan et al., 2021).

Malaria stands as a significant global health problem, and has been plaguing human populations in Africa (Fana et al., 2015; Mbacham et al., 2019; Tarning, 2016; Wang et al., 2022), being one of the most important and deadly tropical diseases. According to the World Health Organization (WHO) report, 619,000 deaths worldwide among 247 million cases were reported in the year 2021(WHO, 2022). Both the lifecycle of the malaria parasite and the reproduction of mosquitoes are highly sensitive to climate factors, including temperature, humidity, and rainfall. Research has shown that transmission of malaria is induced by both human and climatic conditions (Kayle, et al., 2012).

In the WHO Africa region where there has been increase from 534 000 in 2019, to 602 000 in 2020 (deaths per 100 000 population at risk) and this caused the malaria mortality rate to increase from 56 in 2019 to 62 in 2020 (WHO World Malaria report, 2021). The burden of malaria is higher in Africa with 33 countries rated as having moderate and high transmission, for instance, in 2020, 34% of pregnant women were exposed to malaria according to the World Malaria Report, 2021.

Numerous studies have established a connection between changes in climatic patterns, such as temperature, humidity, and rainfall, and the prevalence of malaria over time (Guo et al., 2015; Nyawanda et al., 2023). One significant analysis by Dr. Mercedes Pascual, published in 2006, explored the impact of the El Niño Southern Oscillation (ENSO) on malaria incidence in the highlands of East Africa. The research revealed a strong association between ENSO, which brings about extreme weather conditions like droughts and floods, and an increased occurrence of malaria in the highlands of East Africa. Specifically, the study demonstrated that ENSO led to higher temperatures and reduced rainfall, creating more breeding sites for mosquitoes, prolonging their lifespan, and intensifying malaria transmission.

Climate change also influences the geographic circulation of vector borne diseases, which increases morbidity and mortality (Berglar et al., 2019; Kumar et al., 2022; Rossati, 2017). Several researchers including Bauserman et al., (2019) have revealed that MIP (malaria in pregnancy) is associated with other health issues which put pregnant women at risk of mortality and other adverse health outcomes. For instance, adverse maternal, fetal, and early childhood effects caused by MIP. In addition to that, there are several studies about malaria among pregnant women with a focus on malaria endemic countries that have clearly enlightened the associated health impacts including maternal mortality, infant mortality or other negative maternal and birth outcomes (Suliman et al., 2021; Tarning, 2016). It is obvious that pregnant women and unborn babies are especially at risk for malaria among others (Bauserman et al., 2019).

In Rwanda, malaria poses a significant public health concern because the entire country's population is exposed. For example, 3,298 deaths which accounted 5.69% of total global malaria deaths in 2020 (WHO, 2020). Moreover, 443,000 malaria cases in pregnant women and 1.8 million cases of children under five in 2016 (NISR, 2021). Rwanda has also experienced a significant increase of malaria incidence from 48 per 1,000 in 2012 to 403 per

1,000 in 2016 (PMI, 2019; WHO, 2021). Thus, researchers like Murindahabi et al., (2018) argue that there is an increased number of malaria cases due to several factors despite a number of interventions.

The understanding of how climatic patterns impact malaria is notably underdeveloped. Rwanda is not among the countries that have significant prospects for malaria elimination, and in order to achieve this, there is a need of new researches that may inform the decision making processes on the effective malaria interventions (WHO, 2016). It would be useful at this stage to consider, on the other hand in spite of recent findings about the implementation and availability of interventions that address malaria burden, it still is one of the deadly diseases and with highest morbidity rate in Rwanda, especially among vulnerable population including pregnant women (Habimana et al., 2020).

There are existing malaria interventions countrywide and in Bugesera District which include the provision of mosquito nets to pregnant women, and indoor residual spraying (IRS) which are ineffective and lack the understanding of the influence of the climate variability (Baeza et al., 2014). Other interventions that focus on malaria in pregnancy include the encouraging early detection and treatment of malaria in pregnant women through providing ITNs and distribution to pregnant women during ANC visits, as well as support from the community health workers in charge of maternal health (ASMs). However, Bugesera is still among the priority malaria prone areas when it comes to enhancement of malaria elimination path.

The significance of the climate variability on malaria morbidity showcases that the malaria transmission peaks occur after the rain seasons (USAID, 2018). The existing research has not shown how malaria morbidity relates to changes in climate change factors on the most vulnerable groups including pregnant women and, in the malaria prone areas such as Bugesera

District in Rwanda. This research will provide an answer on how a changes in temperature, rainfall, and humidity affect malaria morbidity among pregnant women in Bugesera District.

## 2. LITERATURE REVIEW

### 2.1 Malaria morbidity among pregnant women

Half of the global population is at risk of malaria even though it can be prevented and treated. This disease is prevalent in almost 100 countries in Americas, Southeast Asia and Africa (Gutierrez et al., 2015). Considering the burden of Malaria in Pregnancy (MIP); there are 45 million pregnancies in malaria endemic regions with 23 million in high transmission areas of Sub-Saharan Africa. MIP is particularly harmful and pregnant women are among the population that is highly vulnerable to malaria, without showing the symptoms. Furthermore, malaria pose a fatal threat to pregnant women.

The consequences are even more dangerous as malaria sets up the negative health impacts for both mothers ( 3-15% of severe anemia, and up to 10,000 anemia related deaths per year), and new born (8-14% of all birth weight with 30 % of preventable low birth weight (LBW), 8-36 % of prematurity, 3-8 % of infant mortality) (Harmer, 2015), hence early detection and treatment is essential (McGready, 2016). Pregnancy Associated Malaria (PAM) has destructive consequences to both the health of mothers and infants throughout the development stages. Those include anemia, severe malaria, cerebral malaria, intrauterine growth retardation, abortions, premature births, LBW, malnutrition, neonatal and infant mortality among others (Restrepo-Posada et al., 2020).

Overall, pregnant women are more susceptible to severe malaria due to changes in their immune system during pregnancy. According to the World Health Organization (WHO), there has been a reduction in maternal malaria globally in the last two decades. The WHO estimates that between 2000 and 2015, the rate of malaria infection among pregnant women worldwide decreased by 37%, and the number of deaths decreased by 40% (WHO, 2015). A study published in The Lancet Global Health in 2020 also found a reduction in the malaria morbidity among pregnant women in sub-Saharan Africa between 2010 and 2018. The study reported a decline in malaria infection from 30% in 2010 to 17% in 2018 (Dellicour et al., 2020). However, despite these improvements, malaria remains a significant public health problem for pregnant women in different regions globally, particularly in sub-Saharan Africa. The WHO estimates that in 2019, there were 11 million pregnant women at risk of malaria in sub-Saharan Africa (WHO, 2020).

Malaria morbidity in pregnant women still is one of the main global health interests because their immunity is reduced during pregnancy (CDC, 2021). The illiteracy and late attendance of antenatal care services are among the causes that exacerbate malaria burden in pregnant women as shown in the research conducted in Argungu, north-western Nigeria, which found that 41.6% had malaria during their pregnancy (Fana et al., 2015). In order to support national strategy for the Malaria prevention among pregnant women ; WHO recommends providing ITNs at the first antenatal care (ANC) visit and effective case management of malaria (USAID; CDC, 2020). However, malaria is still a huge concern because the pregnant women do not comply with the first ANC visit.

In Rwanda, MIP triggers negative health outcomes including abortion, preterm births, LBW, stillbirth and early pregnancy loss among others. Moreover, malaria contribute to morbidity and mortality among pregnant women (Kwizera et al., 2021).

## 2.2. Relationship between climatic patterns and malaria among pregnant women

Malaria is one of the greatest climate sensitive communicable diseases across the world, despite significant measures of elimination of the disease. In the context of pregnant women, the influence of climatic patterns on malaria is particularly important due to the physiological changes that occur during pregnancy. Pregnant women experience alterations in their immune system, hormonal balance, and body temperature regulation, which can affect their susceptibility to malaria infection and the severity of its consequences (Bauserman et al., 2019).

The study conducted in Asia-Pacific shows the strong link between VBDs-vector-borne diseases like malaria, and the impacts of climate change whereby 21 million of global cases of malaria are projected to be triggered by climate change in the year 2030 (APMEN, 2020). This would reverse the positive impacts of VBDs and malaria interventions and other investments towards achieving the SDGs. Moreover, there are significant justifications of the influence of anthropogenic activities, mostly environmental changes such as agriculture practices, human migration, deforestation on malaria transmission (Dagen, 2020).

Every year, more than 200 million of population living in the tropics are affected by malaria which results in 500 thousand deaths especially pregnant women and children under five. Furthermore, 3.2 billion of the human population is exposed to malaria infection, which creates a huge concern and a potential immense toll. Environmental, climatic and social factors are among the preconditions for malaria to occur in any population (Berglar et al., 2019). It is now well established from a variety of studies that pregnant women are among the most vulnerable to infectious diseases, even during the climate hazards. The floods in 2010 in Pakistan caused detrimental effects on human health, which pregnant women had been exposed (Baqir et al., 2012).

Over the last century, global warming has caused earth's average temperature to increase by approximately one degree centigrade, and this alters the behavior of different living organisms. This explains the extreme weather events because of global warming that hugely affects the distribution of the infectious diseases transmitted through biological vectors such as mosquitoes that are prevalent mostly in tropical areas. Malaria is among the major diseases that are studied in relation to their risk of spreading due to climate change. High temperatures make malaria carrying mosquitos more active (Kumar et al., 2022; OpenMind, 2019), which affect pregnant women among other populations vulnerable to the disease.

Overall, the average temperature and the rate of temperature variation influence the changing aspects as well as the spreading of malaria. There is solid association between the survival rate of parasite within the mosquitos, the biting capacity , development rate and the force of transmission , and the temperature changes (Blanford et al., 2013).

According to Kapwata et al., (2021), the high rates of malaria go along with the co-existence of elevated temperature and rainfall. Annual average temperature is likely to rise as the climate changes, hence the land would become warmer and there are awaited changes in the formation and range of insects and disease-causing vectors. Kumar et al., (2022) emphasized how relative humidity often benefits the vectors, clearly influence the lifecycle od mosquitos and increase the risk of malaria in pregnancy. The varying weather patterns may disturb the timing, amount and type of precipitation. Water scarcity may also increase as the rainfall becomes more irregular. There is also likelihood of increasing the regularity and severity of floods. Those changes in rainfall augment the mosquitos' ability to thrive (Kumar et al., 2022).

The issue of malaria has received considerable critical attention in different studies, however, the climate irregularity effect on morbidity among pregnant women is important but understudied, cause for concern. Climatic patterns can affect malaria spread, but population density, socioeconomic status, healthcare access, and people's actions also change the risk for pregnant women. We must also think about local climate changes and regional issues to truly understand how climatic patterns correlate with malaria among pregnant women.

# 3. RESEARCH METHODS

## 3.1 Research Design

A retrospective quantitative study was conducted to assess the relationship between the climate patterns and malaria morbidity among the pregnant women in Bugesera District. This study was based secondary data including monthly malaria morbidity among pregnant women in Bugesera District as well as monthly data on three climate variables (temperature, humidity, and rainfall) from January 2015 to December 2021.

## 3.2 Target Population

This study focused on women who were pregnant from January 2015 to December 2021 in Bugesera district, in Eastern province, which is one of the highest malaria prone areas in Rwanda.

## 3.3 Data Collection Procedures

Rwanda Meteorological Agency (RMA) oversees climate monitoring and forecasting and is responsible for the collection and storage of climate data in Rwanda. Likewise, the Nyamata Level II Teaching Hospital collected historical data on malaria cases among pregnant women in Bugesera District. Retrospective health records of clinically diagnosed and treated malaria cases among pregnant women in Bugesera District between January 2015 and December 2021 were requested from Nyamata Level II Teaching Hospital's registers. Additionally, monthly aggregated climate data of Bugesera District collected by RMA were requested to obtain data used for this study. The data abstraction was used to obtain relevant data from the data sets, which were provided by RMA and Nyamata Level II Teaching Hospital. The climatic datasets routinely kept by RMA and were requested via an online platform available on RMA website. The datasets obtained for climatic patterns include minimum and maximum temperature, humidity, and rainfall data. The supporting letter for data collection from Mount Kenya University was submitted, with an official letter requesting data.

### 3.4 Data Analysis

This study used a time series monthly data. The quantitative data were analyzed using STATA, and Excel Spreadsheet was used from importing, cleaning, and organizing time series data. The dependent variable was the monthly malaria morbidity among pregnant women in Bugesera, whereas the independent variables were the three climate variables (the average monthly minimum temperature, the average monthly maximum temperature, the monthly total rainfall, and the monthly mean humidity).

Descriptive analysis was applied focusing on measuring the malaria morbidity by month to assess which month pregnant women are vulnerable to malaria. In addition to that, a line graph was utilized to analyze the change of malaria morbidity during the period of January 2015 to December 2021. Moreover, the trends of changes in malaria morbidity, temperature, humidity, and rainfall were plotted to analyze their relationship. Pearson correlation analysis was conducted to study the significance of the relationship between the climate three variables and malaria morbidity among pregnant women in Bugesera district.

The results of the correlation test provided the Pearson's correlation coefficient, which indicates the direction (positive or negative) and strength (weak, moderate, strong) of the relationship between the variables under investigation. To analyze if the relationship is significant the calculated p value was compared to the critical significant level (0.05 at 95% of confidence level). Multiple linear regression was used to show the relationship between climate variables and MIP. The following is the multiple linear regression model that was used in the study, according to (Hyndman & Athanasopoulos, 2018):

$$Yt= \beta0+\beta1x1t\ \beta1x2t +\beta2x3t+\beta3x4t+€t$$

Where:

Y is the outcome variable (malaria morbidity among pregnant women)

X is the independent variable (predictor variable, x1: minimum temperature, x2: maximum temperature, x3: humidity, x4: rainfall)

The model can be simplified as follow:

$MPt=\beta0+\beta1MinTt+\beta2MaxTt+\beta3Ht+\beta4Rt+€t$

MinTt= Minimum temperature at a given time

MaxTt= Maximum temperature at a given time

Ht=humidity at a given time

Rt=rainfall at a given time

€t= error terms

β0 is a constant β1, β2, β3 and β4 are coefficients of minimum temperature, maximum temperature, humidity, and rainfall respectively. Those coefficients measured how each independent variable relates to the dependent variable as they measure the marginal effects of predictor variables. Their signs (positive or negative) show the direction of the impact. Multiple linear regression analysis was employed to each independent variable (minimum temperature, maximum temperature, humidity, and rainfall) with the dependent variable (malaria morbidity among pregnant women) to understand the magnitude of dependency of malaria morbidity among the pregnant women of the study area on the variation of the climatic patterns. STATA-statistical software was used to analyze data.

# 4. RESEARCH FINDINGS AND DISCUSSION

## 4.1 Presentation of Findings

### 4.1.0 Descriptive Statistics of Study Variables

In this study, the variables of interest were malaria morbidity, temperature, rainfall, and humidity.

| Variable | N | Mean | Std. Dev. | CV(%) |
|---|---|---|---|---|
| Malaria (N) | 84 | 116 | 118.06 | 102.21 |
| Min Temp (°C) | 84 | 16.53 | 0.87 | 5.26 |
| Max Temp (°C) | 84 | 27.86 | 27.86 | 3.32 |
| Humidity (%) | 84 | 69.05 | 7.85 | 11.36 |
| Rainfall (mm) | 84 | 72.45 | 51.74 | 71.42 |

**Table 1.** Descriptive Statistics of malaria in pregnancy and climatic patterns in Bugesera District.

Table 1 shows that even though there is a high variability of malaria cases throughout the 12 months of the year, the average monthly malaria cases among pregnant women is 116 (SD=118.06). Regarding the climatic patterns, the average monthly mean temperature was 16.53 (SD=0.87), the mean maximum temperature is 27.86 (SD=27.86), the mean humidity is 69.05 (SD=7.85), and the mean total rainfall is 72.45 (SD=51.74). Among all the studied variables, the temperature seems to be stagnant through the seven years.



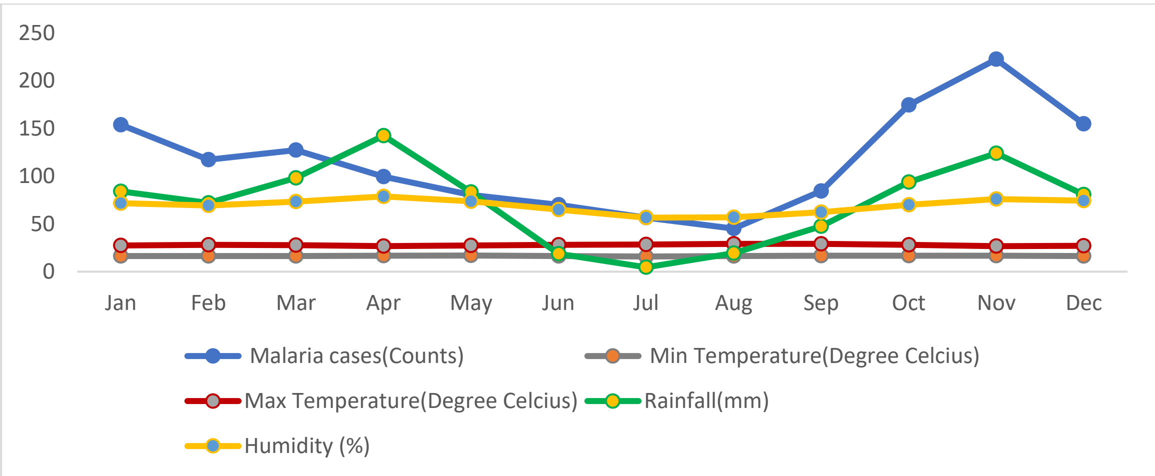


**Figure 1.** Trend of mean monthly malaria cases among pregnant women against monthly climatic patterns' variation, 2015-2021

This study uses secondary data to analyze how climatic patterns interact with malaria in pregnancy. It provides useful information for public health approaches for malaria eradication and for further research.

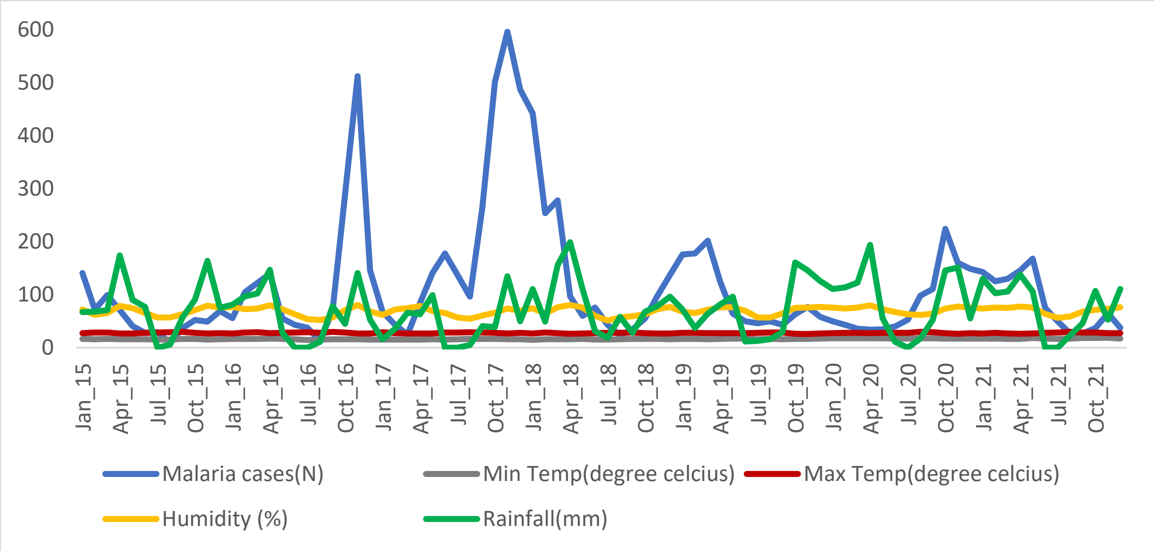


**Figure 2.** Seasonal climatic patterns' variation and malaria among pregnant women- Bugesera District, 2015-2021



September through December is the period of higher cases of malaria cases among pregnant women in Bugesera District as well as a rise in rainfall, and increased humidity. This means that malaria morbidity occurs mostly in the long rainy season in the study area (Figure 1 and 2), which aligns with USAID findings for malaria operational plan for national malaria control programs (USAID, 2018).

#### 4.1.1 Trend for Malaria Morbidity among Pregnant Women in Bugesera District

With respect to the first research question, the results from Figure 3 below show that in Bugesera District, from 2015 malaria cases among pregnant women were increasing until its peak in 2017. However, there was a continuous decrease from 2,622 cases in 2017 to 1031 cases in 2021. Although there is a decrease of malaria morbidity, there is still a high number of malaria cases among pregnant women in Bugesera District.

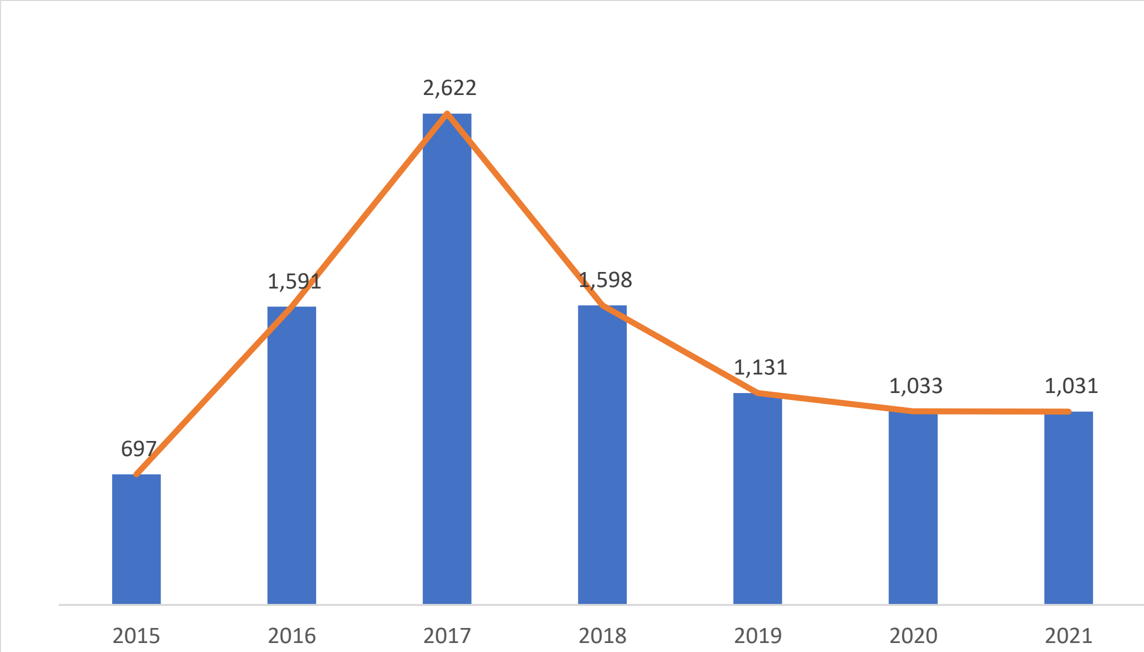


**Figure 3.** Annual trend of total malaria cases in Pregnancy- Bugesera District, 2015-2021.

### 4.1.2 Relationship between climatic patterns and malaria morbidity among pregnant women in Bugesera District

This study also aimed at analyzing the existence of relationship between malaria morbidity and maximum temperature, minimum temperature, humidity, and rainfall among other climatic patterns.

| Variables | (1) Malaria | (2) MinTemp | (3) MaxTemp | (4) Humidity | (5) Rainfall |
|---|---|---|---|---|---|
| (1) Malaria | 1 | | | | |
| (2) MinTemp | -0.149 | 1 | | | |
| (3) MaxTemp | -0.16 | 0.038 | 1 | | |
| (4) Humidity | 0.218** | 0.282*** | -0.718*** | 1 | |
| (5) Rainfall | 0.194* | 0.195* | -0.669*** | 0.792*** | 1 |

*** *p<0.01*, ** *p<0.05*, * *p<0.1*

**Table 2.** Correlation between malaria morbidity and climatic patterns- Pearson correlation coefficients.

The findings show that there is a negative, weak, and non-significant correlation between malaria morbidity and minimum temperature (r=-.15, p=.178), as well as maximum temperature, (r=-.16, p=.145). However, the humidity is positively, strongly, and significantly correlated with malaria morbidity among pregnant women in Bugesera District at 5%

significance level, (r=.22, p=.046), whereas the rainfall has a positive, weak, and significant correlation at 10% significance level r=.19, p=.077. These results suggest that increased humidity increases the number of malaria cases. This effect can be explained not only by the amount of swamp water in Bugesera District but also how different climatic factors including temperature and rainfall intersect to increase humidity.

| **Variable** | **β** | **95% CI** | **t** | **ρ** |
|---|---|---|---|---|
| MinTemp | -0.184 | [-0.408; 0.040] | -1.63 | 0.106 |
| MaxTemp | 0.087 | [-0.211; 0.384] | 0.58 | 0.563 |
| Humidity | 0.046** | [ 0.003; 0.088] | 2.14 | 0.036 |
| Rainfall | 0.000357 | [-0.005; 0.006] | 0.12 | 0.901 |

**** p<0.01, ** p<0.05, * p<0.1*

**Table 3.** Multivariable Linear Regression model for the climatic patterns that corelate with malaria among pregnant women

Table 3 show that, overall, the regression model was found significant(p<.05). This regression analysis shows that minimum temperature has a negative and non-significant effect on malaria morbidity (β= -0.18407, t=-1.63, p= 0.106), while maximum temperature and rainfall have positive but non-significant effect on malaria morbidity (β= 0.086893, t=0.58, p=0.563; β= 0.000357, t=0.12, p=0.901 respectively). On the side, malaria morbidity is affected positively and significantly by humidity (β= 0.045785, t=2.14, p=0.036).

### 4.2 Discussion

This study investigated the climatic patterns and their relationships with malaria morbidity among pregnant women in Bugesera District, Rwanda. Insightful information on the long-term patterns of malaria morbidity among pregnant women in the research area from January 2015 to December 2021 was supplied by the quantitative analysis of the secondary data. A critical year in the analysis was 2017, when 2,622 cases of malaria among pregnant women were documented, making it an important year. A possible explanation of that might be that the spread of malaria is dynamic, and infection rates may experience abrupt changes as justified by (Alonso et al., 2019; He & Pascual, 2021).

In general, the changes of temperature alone in Bugesera District tend to be constant and justify the weak relationship between malaria and temperature- this outcome suggests that temperature does not have potential use for malaria prediction in Bugesera District. This finding agrees with previous researchers that temperature and rainfall alone cannot predict malaria transmission dynamics(Pascual et al., 2006);Baqir et al., 2012) while this outcome is contrary to that of Blanford et al., (2013) who suggested that temperature is an important determinant of malaria transmission.

The findings of this study emphasize a significant association between humidity and malaria in pregnancy during the study period. It was observed that an increase in humidity levels correlated with a notable increase of malaria cases among pregnant women in Bugesera District. This aligns with existing literature that has emphasized the influence of humidity in creating favorable conditions of the breeding and proliferation of the female anopheles' mosquito, which is the vector transmitting malaria (ALMA, 2021; NISR, 2015; Rodó et al., 2013). Similar studies have shown how the adult anopheles' mosquitoes have the conducive environment for better survival due to higher humidity(Chowdhury et al., 2018; Kumar et al., 2022; Nath & Mwchahary, 2013), which is confirmed in this research due to the increased transmission of malaria among pregnant women in Bugesera District especially during the month of November.

# 5. CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

This study demonstrated that humidity provides the best predictor of malaria transmission in Bugesera District. Among the three climatic patterns studied, humidity is strongly and positively correlated with malaria in pregnancy, while temperature doesn't change a lot and should not be solely relied upon to predict malaria risk in Bugesera District. Therefore, the findings of this study underline the importance of targeted interventions that focus on controlling mosquito breeding sites and enhancing awareness among pregnant women in Bugesera to mitigate the elevated risk posed by higher humidity, especially before and during November, which is identified as the peak month for malaria among pregnant women in Bugesera District. Moreover, I'd like to suggest that the relationship between the three studied climatic factors and malaria among pregnant women in Bugesera District can be complex and dynamic, emphasizing the need to consider the impacts of changing climatic patterns on malaria from a local context rather than a general one.

## 5.2 Recommendations

The following recommendations can be drawn from this study:

- To improve the effectiveness of existing interventions and achieve better results towards eliminating malaria.
- To design specific malaria interventions targeting vulnerable populations including pregnant women, and place-based approaches and necessary timely interventions considering November as the peak month for malaria among pregnant women in Bugesera District
- To invest in more effective protective technologies and climate-based strategies that would provide early warning systems regarding the changes in climatic patterns as well as integrated approach for malaria control.



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