TEMPORAL AND DEMOGRAPHIC PATTERNS OF MALARIA PREVALENCE IN ADIYAN, OGUN STATE, NIGERIA (2019–2022): A RETROSPECTIVE STUDY USING ANTIMALARIAL DRUG SALES AS AN INDICATOR OF DISEASE BURDEN

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ABSTRACT

Background: Malaria remains a major epidemic in Nigeria, continuing to impact lives negatively through-out the country and especially in semi-urban settlements such as Adiyan Ogun state. In spite of efforts to educate and promote awareness of malaria to the people and to help them control it, there continues to be a slow increase in cases during certain seasonal periods and an uneven distribution based on age (teenagers vs. adults). A thorough examination of local pharmacy sales will offer more accurate insight into the actual burden of malarial disease because medical professionals may be unable to properly capture all cases in traditional surveillance methods.

Objective: Provide insight into the seasonal and age-related distribution of malaria cases in Adiyan for the time frame of 2019-2022 by providing management of the medications that are being issued for treatment of malaria. **Methods**: The study examined the effect of weather and seasonality on malaria incidence. Data sources included historical sales data from Kotz Pharmacy in Ogun State, categorized into three groups based on age: Adults, teenagers, and Children. Seasonal trend analysis was performed to identify any seasonal patterns in malaria cases within each age group. ANOVA and Tukey's post-hoc tests were performed to determine if there were differences between the age groups regarding the number of malaria cases. Pearson correlations were performed to determine how closely the number of malaria cases tracked across all three(age) groups. **Result**: Adult (Ages 18-64) Anti-Malarial Purchases were over 78% of total 'over-the-counter' sales of Anti-Malarial during the rainy season (between June and August) of each year, and peaked (142) in July 2021. The burden of disease was significantly greater among adults, than either Children, or Teenagers (ANOVA statistic $F(2, 107) = 109.28$, $p < .001$). The result reveals that there was strong relationship between the teen and child ($r = +0.72$, $p < 0.001$), but the pattern did not hold between adults and children ($r = +0.25$, $p = 0.090$). **Conclusion**: The findings make it clear: malaria in Adiyan follows a seasonal rhythm and hits adults hardest. Using pharmacy sales data alongside environmental information paints a more detailed picture and can help tailor malaria prevention efforts by age group.

INTRODUCTION

Malaria remains a major public health problem in sub-Saharan Africa, with Nigeria having the largest number of malaria cases and deaths globally in 2022. Nigeria accounted for 27% of malaria cases and 31% of malaria-related deaths in 2022[1]. In Ogun State in south western Nigeria where climate conditions are ideal for malaria with lots of rainfall and temperatures that are always optimal for malaria vector breeding[2], malaria remains hyper-endemic. Semi-urban communities such as Adiyan in Ogun State face numerous problems in controlling malaria infection with available preventive methods such as ITNs and

ACTs. A proxy measure for malaria endemics using antimalarial drug sales has proven effective in a setting where malaria diagnosis may be incomplete[3]. This measure indicates drug-seeking behavior but may lead to an incorrect estimate of malaria cases where malaria treatment in Nigeria often occurs[3]. This retrospective study examines temporal and demographic trends of malaria incidence in Adiyan for 2019 to 2022 based on sales data for antimalarial drugs.

The seasonal changes in malaria infection rates are also climate-related and follow a pattern where rainfall and temperatures increase mosquito breeding and development. Studies have shown that Nigeria experiences a peak in malaria cases during the raining season (April to October) due to a surge in the number of malaria-carrying mosquitoes[5]. In Ogun State, a similar pattern has also been observed where more malaria cases are recorded during the raining season[2]. This study will evaluate the annual and monthly variations in Adiyan for a period of four years in a manner that looks for any seasonal variations that might be associated with changes in environmental conditions such as the COVID-19 pandemic[6].

Demographics, particularly age, also remain a major driver of malaria prevalence because of differing levels of immunity and healthcare access. Children below five years of age bear the largest risk of malaria with a larger parasite density and prevalence levels identified in studies as 23% in 2018 compared to 42% in 2010[7]. But teens and adults in those communities also bear a similar risk because of a decline in levels of immunity among older individuals with additional risk because of occupation[8]. Also in south-western Nigeria, a large number of malaria cases among teens have been identified because of more time spent outdoors[9]. This research aims to determine whether the average number of malaria cases in Adiyan each month is similar for children, teens, and adults.

The association between malaria prevalence among different age groups remains vital for comprehension of community malaria transmission dynamics. Evidence indicates that community transmission of malaria may exist due to a potential association among cases in a particular age group via inherent environmental and behavioral factors[10]. In particular, in Adiyan communities where various socioeconomic factors of risk exist, investigating such associations may be vital for potential reservoirs of malaria transmission. The application of antimalarial drug sales data may be effective for such an assessment.

This work aims to: explore the trends of malaria prevalence in Adiyan between 2019 and 2022, examine whether there are any statistically significant differences in average monthly malaria cases represented by age groups, and evaluates statistical relationships for malaria prevalence among teens, children, and adults. This study uses malaria treatment using the drug sale data which offer another dimension to malaria prevalence which is another technique to the trend of malaria[11]. This data would be used to develop fitting preventive measures for malaria in Adiyan, aligned with Nigeria's National Malaria Strategic Plan to ensure malaria prevalence remains below 10% in 2026[1]. Despite national and regional studies on malaria prevalence, there is limited research focusing on fine-scale temporal and demographic patterns in specific communities like Adiyan, Ogun State. Additionally, using antimalarial drug sales as a proxy for disease burden remains underexplored, especially in relation to demographic subgroups and seasonal trends. This gap highlights the need for localized, retrospective analyses that integrate drug sales data to better understand malaria dynamics at the community level[26].

The proxy indicator role of sales of antimalarial drugs assumes a lot of significance in the context of Adiyan, where accessibility to healthcare might be a problem and self-medication does occur. This has come out in studies where only 3.9% of those who bought antimalarial drugs had tested positive using rapid diagnostic tests[11]. This particular study looks into such problems because instead of pointing towards absolute figures for prevalence rate, this study intends to look towards trends and thereby give correct information regarding trends associated with malaria. Trends within data would help in ascertaining peak seasons of transmission and thereby help towards optimal intervention seasons for ITNs and Indoor Residual Spraying.

MATERIAL AND METHOD

Study Design: A cross-sectional study design was employed for this study to retrospectively examine secondary data regarding purchases made for antimalarial drugs each month in Kotz Pethabam Pharmacy Ltd for a period of 2019 to 2022. Guidelines such as STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) were utilized.

Setting: Kotz Pethabam Pharmacy Ltd. Adiyan, Ogun State.

Duration: 4 years. January 2019 – December 2022.

Sampling Technique: This study purposively sampled a pharmacy because this particular pharmacy serves a major population of adults and always keeps good records.

Sample Size: Every observation in this data series corresponds to one month of sales of antimalarial drugs. Because this data series is for one month each time for a total of four years, the sample size relies on the number of months. A calculation for sample size does not apply because this research relies on total population available.

inclusion criteria

i. All purchases of antimalarial drugs made by adults were recorded at Kotz Pethabam Pharmacy Ltd between January 2019 and December 2022.
ii. Sales data for a month with details about drug types sold, quantity sold, and date of transaction.

Exclusion Criteria:

i. There may be incomplete sales records.

ii. Returns/refunds for which no drug use is involved.

Data collection and management: This research uses secondary data sourced from inventory data documented at Kotz Pethabam Pharmacy Ltd. The data used comprises the number of antimalarial drugs sold to adults each month based on types and date of sale.

Ethical Approval: This study analyzed publicly available, de-identified secondary data obtained from Kaggle (https://www.kaggle.com/datasets/esperatbamgbose/prevalence-of-malaria-in-adiyan-ogun-nigeria). As the dataset contains no personally identifiable information, the research posed no risk to individuals. All analyses were conducted following established ethical standards for research using publicly accessible datasets. Formal approval from an Institutional Review Board (IRB) was not required; however, the study procedures were reviewed and deemed exempt in accordance with institutional guidelines for secondary data analysis.

Analysis

1. Analysis of Monthly and Annual Trends

For monitoring monthly and yearly malaria prevalence trends in Adiyan, Ogun State, we employed line charts and bar graphs. Line graphs and bar graphs can give a picture of how antimalarial drug purchases fluctuate from month to month and year to year.

Investigation of Seasonal Variations

To examine seasonal variations in malaria prevalence and identify peak and low-prevalence months, the following methods and models was adopted:

Seasonal Decomposition of Time Series (STL Decomposition)

The time series data will be decomposed into trend, seasonal, and residual components using the additive model:

$$y_t = T_t + S_t + R_t$$

where

y_t represents the observed value,

T_t is the trend component,

S_t is the seasonal component, and

R_t is the residual (error) component

2. Assessment of Year-to-Year Variations

To evaluate whether malaria prevalence significantly varies across the four years, inferential statistical techniques will be applied:

One-Way Analysis of Variance (ANOVA)

A one-way ANOVA model will test the null hypothesis that the means of malaria prevalence (proxy: drug purchases) are equal across the four years. The model is given by:

$$y_{ij} = \mu + \alpha_i + \epsilon_{ij}$$

where

y_{ij} is the observed malaria prevalence for year i

μ is the overall mean,

α_i is the year i, and

ϵ_{ij} is the error term which is randomly distributed.

3. Correlation Analysis

To measure the level of relationship between the prevalence of malaria across the age group, Pearson correlation coefficient will be used

RESULTS

Adults report the highest malaria cases throughout the year, peaking at about 113 in July, children have the fewest, teenagers fall in between with more variable counts especially in October with a standard deviation of 7.89, and adults show the greatest swings overall, particularly in December at 37.18 and October at 31.12. As illustrated in Figure 1, adults bear the highest malaria burden, with a pronounced increase observed during the rainy season, particularly in July and August. In contrast, malaria incidence among teenagers and children remains consistently lower throughout the year, exhibiting minimal seasonal variation. While teenagers experience slightly higher rates than children, the difference is modest. Overall, adults display a distinct seasonal pattern and are disproportionately affected by malaria compared with younger age groups. Figure 2 further highlights this trend, with adults exhibiting substantially higher malaria cases and a pronounced peak in 2021, particularly during the mid-rainy season, followed by a gradual decline toward the end of the year. In contrast, malaria incidence among teenagers and children remains relatively stable, showing only minor fluctuations throughout the same period. Malaria cases among adults consistently exceed those of other age groups, peaking above 140 during the mid-year rainy season and declining below 60 in the drier months, highlighting a clear climate-dependent pattern. In contrast, cases among teenagers and children remain substantially lower, ranging approximately from 10 to 25 per month, with minimal seasonal variation, although malaria persists across all age groups throughout the study period.

Figures 4 and 5 depict the monthly time series of malaria cases among teenagers from 2019 to 2022. The series remains relatively stable in the early years but becomes increasingly variable from 2021 onward, with monthly cases ranging between 13 and 26. Seasonal decomposition (Figure 5) reveals a gradual upward trend beginning around 2020, pronounced annual seasonal cycles, and minimal residual variation. Overall, malaria incidence among teenagers appears to be influenced by a combination of a slowly rising long-term trend and consistent seasonality, with the decomposition model effectively capturing the primary drivers of temporal variation. Figures 6 and 7 show malaria cases among children from 2019 to 2022. Early spikes occur in 2019 and 2020, peaking around 23 cases in late 2019, followed by a decline, with most months below 15 cases in 2021–2022. Seasonal decomposition (Figure 7) shows an initial decline, a brief increase, and a subsequent drop, with consistent 6- to 12-month seasonal cycles. Residuals are minimal, except for larger deviations in 2019 due to unusually high counts.

Figures 8 and 9 show adult malaria cases rising from late winter to a July peak of approximately 113, then declining to February lows near 55, with minor increases in October and December. STL decomposition indicates a trend between 75 and 85 cases, rising from 2019 to mid-2021 before declining, with pronounced seasonal fluctuations of roughly 25 cases below to 30 above the trend, and residual variation largely random except for unusual spikes in 2021.

Assessing Significant Differences in Mean Monthly Malaria Cases across Age Groups.

Hypotheses

H_{01}: There is no statistically significant difference in the average monthly malaria cases across the different age groups.

H_{11}: At least one age group shows a statistically significant difference in its mean number of malaria cases compared with the others.

Significance Level: $\alpha = 0.05$

The F statistic leaves no doubt, with 109.28 far exceeding the 3.15 threshold, showing that malaria risk is not equal across age groups and that adults should receive the majority of intervention resources.

Tukey HSD (Honestly Significant Difference)

Because ANOVA revealed significant differences in malaria cases between age groups, we conducted a Tukey Honestly Significant Difference post-hoc test to identify which specific group comparisons were responsible.

The Tukey results make it clear: children and teenagers are nearly identical with a p-value of 0.7196, while adults differ sharply from both groups with p-values below 0.001, showing that the malaria burden among adults far exceeds that of the younger age groups.

Correlation Analysis of Malaria Prevalence across Age Groups (Teenagers, Children, and Adults)

Hypothesis

H_{02}: No linear correlation exists between age groups.

H_{12}: A significant linear correlation exists.

The best correlation exists between teenagers and children: $r = +0.72$, $p < 0.001$, reflecting very similar patterns of malaria and shared seasonal peaks, probably due to similar environments or behaviors. There is a weaker but still significant correlation between teenagers and adults: $r = +0.32$, $p = 0.025$, indicating partial overlap in transmission, whereas the correlation between children and adults is the weakest: $r = +0.25$, $p = 0.090$, falling further to $r = -0.21$ by 2022.

Table 1: Monthly Averages and Standard Deviations (2019-2022)
Same month order and values.

Month	Teenagers (Mean ± SD)	Children (Mean ± SD)	Adults (Mean ± SD)
April	13.25 ± 6.60	13.00 ± 2.83	58.00 ± 9.70
August	16.50 ± 4.43	12.50 ± 5.20	89.50 ± 13.30
December	16.00 ± 6.78	11.50 ± 5.97	87.00 ± 37.18
February	12.50 ± 2.52	13.75 ± 6.60	54.75 ± 12.66
January	11.25 ± 3.20	12.25 ± 2.87	69.75 ± 26.75
July	16.00 ± 4.69	11.00 ± 5.89	112.75 ± 11.84
June	17.00 ± 6.48	11.25 ± 5.38	94.00 ± 17.17
March	11.50 ± 1.73	7.50 ± 3.87	61.50 ± 12.66
May	15.75 ± 4.57	10.00 ± 4.08	81.50 ± 25.85
November	14.50 ± 3.42	12.50 ± 7.72	63.50 ± 16.34
October	14.25 ± 7.89	10.25 ± 3.10	84.00 ± 31.12
September	17.25 ± 4.27	10.75 ± 2.06	74.50 ± 20.42

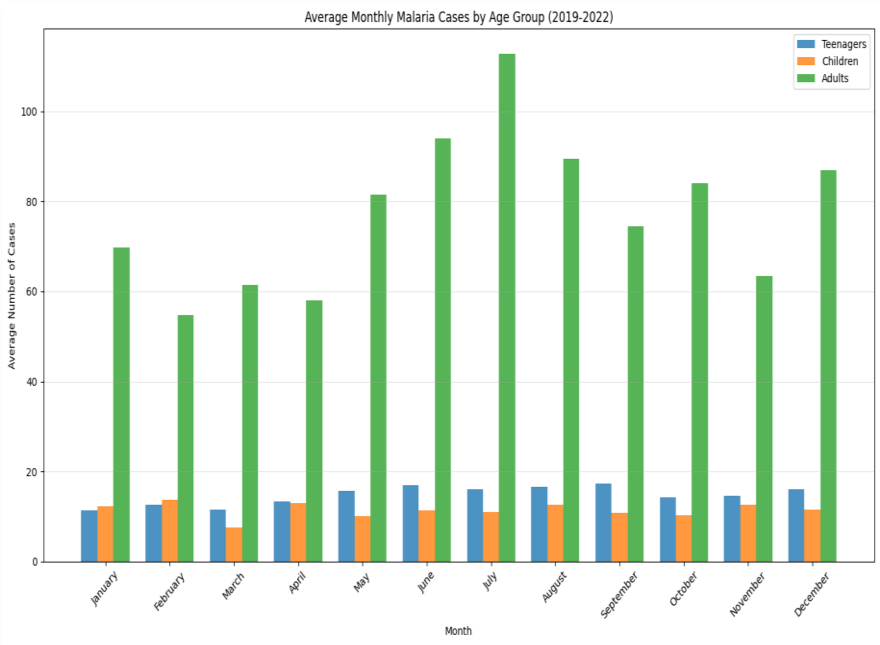

Figure 1: *Bar Chart Showing Average Monthly Malaria (2019-2022)*

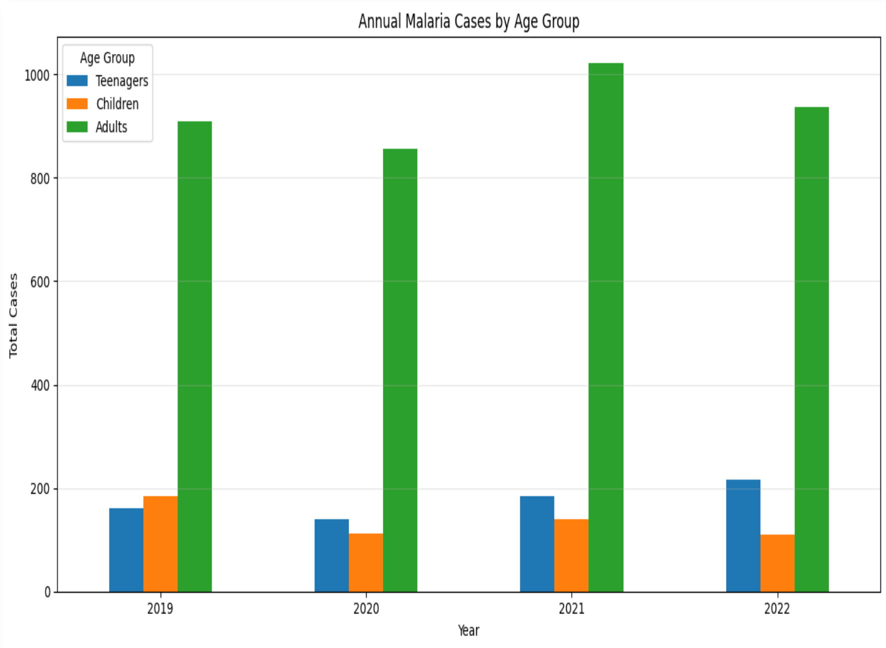

Figure 2: *Bar Chart showing Annual Malaria Cases (2019 -2022)*

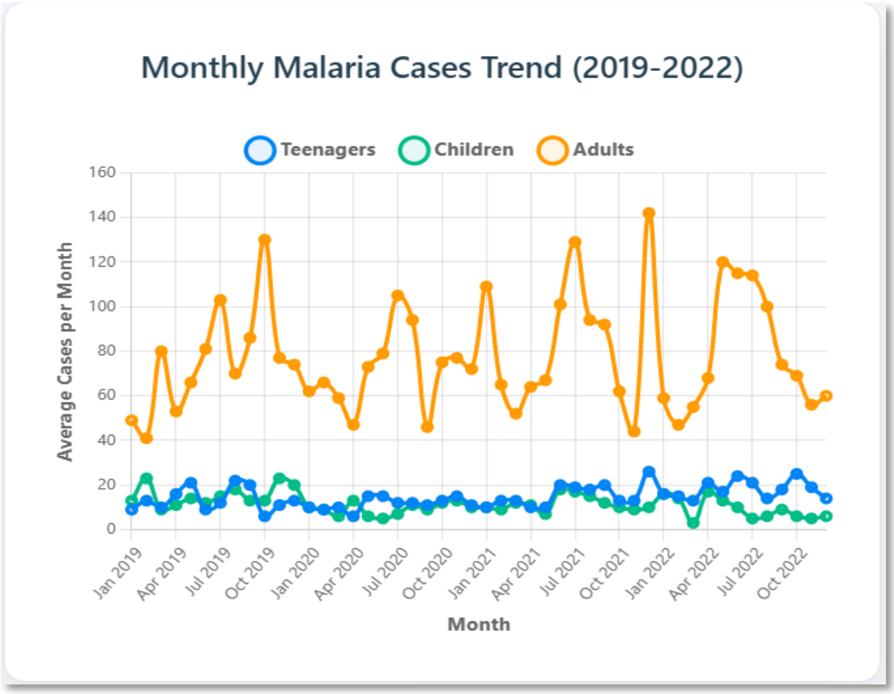

Figure 3: *Time series Plot of Monthly Malaria Cases (2019 -2022)*

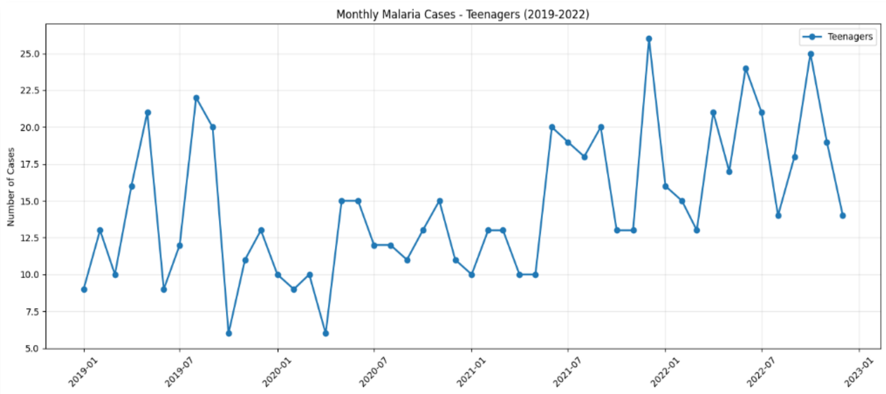

Figure 4: *Trend of Monthly Malaria Cases for Teenagers*

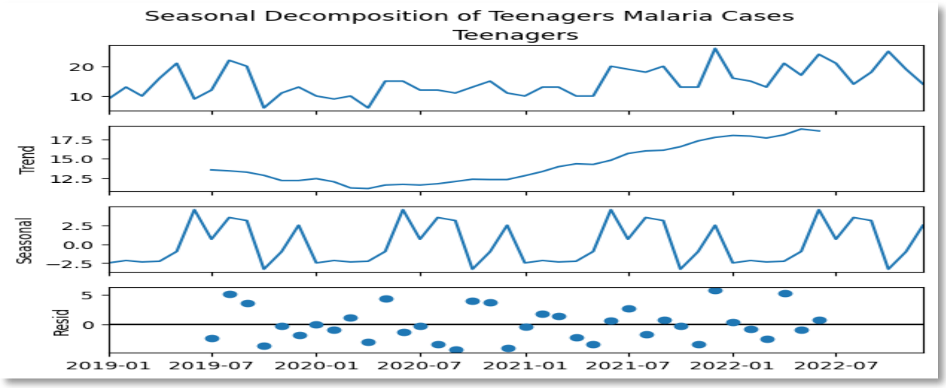

Figure 5: *Seasonal Decomposition, Trend, Seasonal and Residual of Teenager*

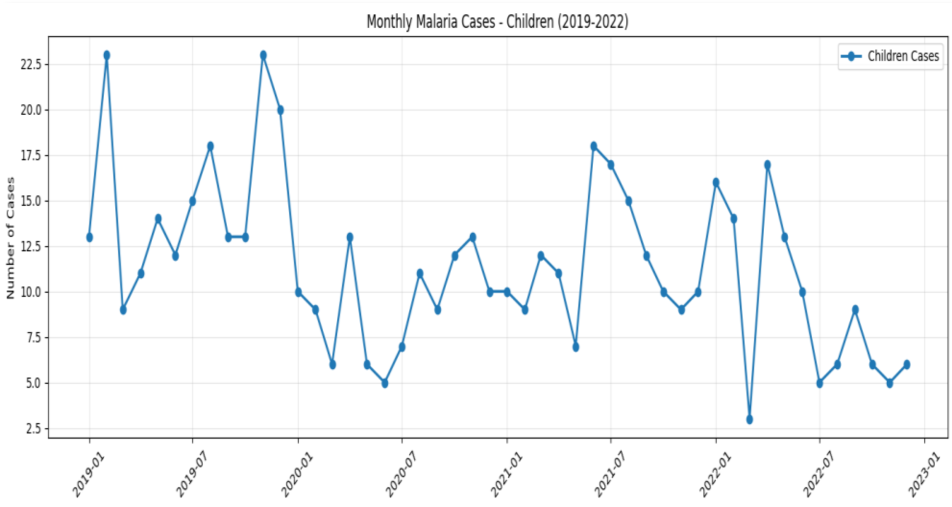

Figure 6: *Trend of Monthly Malaria Cases for Children*

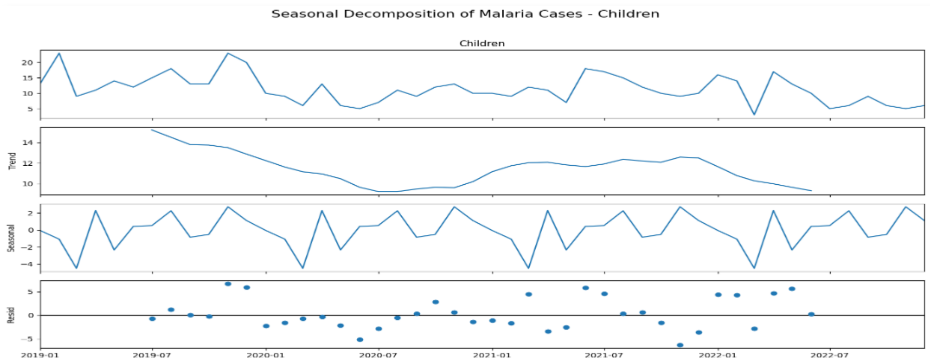

Figure 7: Seasonal Decomposition, Trend, Seasonal and Residual of Children

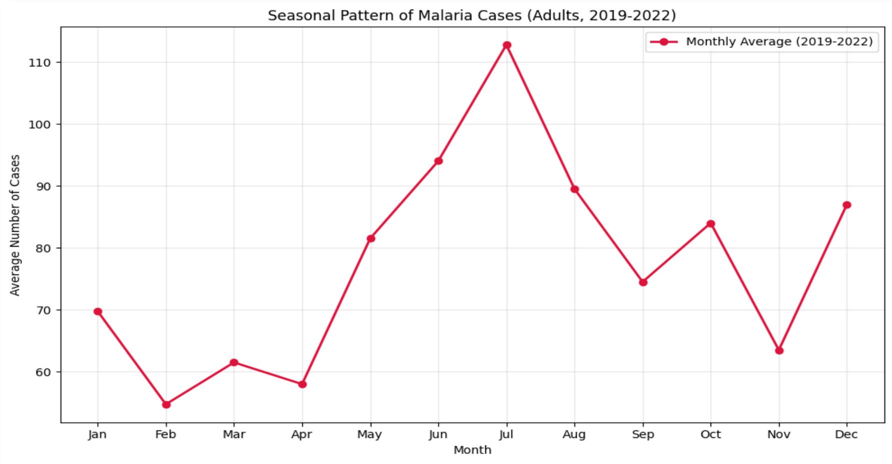

Figure 8: *Trend of Monthly Malaria Cases for Adults*

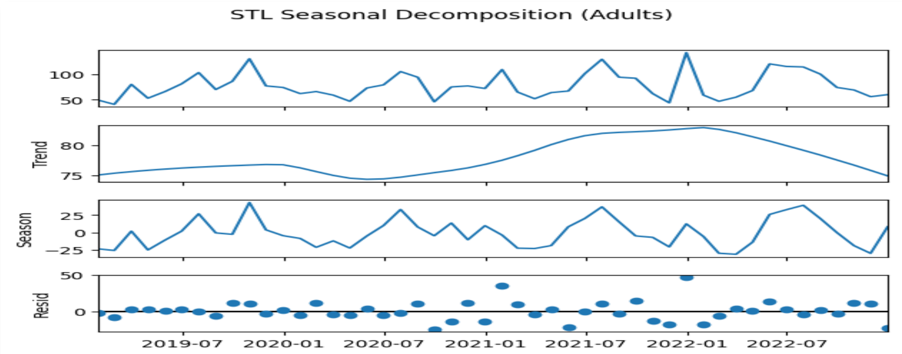

Figure 9: Seasonal Decomposition, Trend, Seasonal and Residual of Adults

Table 2: Malaria ANOVA – Comparison across Age Groups

Source of Va	Sum of Squa	Degrees of F (df)	Mean Squar	F-statisti	F-critica	P-valu
Between (Age)	54,004.47	2	27,002.24	109.28	3.15	< 0.05
Within (Error)	19,922.47	81	246.09	-	-	-
Total	**73,926.94**	**83**	-	-	-	-

Table 3: Tukey HSD Summary

Group 1	Group 2	Mean Diff	p-adj	Lower	Upper	Reject
Children	Teenagers	1.125	0.7196	-3.066	5.316	False
Children	Adults	63.521	0.001	59.330	67.712	True
Teenagers	Adults	62.396	0.001	58.205	66.587	True

Table 4: Correlation Results

Comparison	r(Correlation Coefficien	t-statistic	p-value	Conclusion (α=0.05)

Teenagers vs. Childre	+0.72	6.92	<0.001	Significant (Reject H_0)
Teenagers vs. Adults	+0.32	2.31	0.025	Significant (Reject H_0)
Children vs. Adults	+0.25	1.73	0.090	Not significant (Fail to rejec

DISCUSSION

The evident seasonality of malaria prevalence in Adiyan, Ogun State, Nigeria, with a peak in June to August when it rains and a low level in December to February when it is dry, correlates well with malaria epidemic seasons associated with environmental factors. Rainstorms aid in Anopheles larval development in pools of stagnant water, a major factor in vector development, evident in July 2021 when 142 cases of adults were recorded. This finding supports previous studies such as[12], who agreed that more malaria cases are recorded during rainy seasons because of breeding sites for malaria vectors such as puddles and drainage. Also supporting this finding was a study in Kano State[13] where there was a 60.6% prevalence of Plasmodium falciparum infection with strong seasonality associated with rainfall.

The seasonal decomposition analysis, pointing towards a prominent cyclical feature, corroborates other findings with[14], who used time series techniques to illustrate how resulting malaria cases were climate-related in urbanizing Nigerian communities. The slight positive trend in cases among adults until 2021 might be due to climatic changes, as explained in□[15], who associated prolonged rainy seasons with increased vector levels in southwestern Nigeria. Conversely, better access to diagnosis, as proposed[16], might be a contributing factor for increased cases being reported but cannot be directly validated because this study used pharmacy data.

This major variation in malaria cases among age groups, with a mean number of 78.6 for adults compared to 15.1 for teenagers and 11.4 for children ($F = 109.28$, $p < 0.001$), identifies adults as being the major disease reservoir in Adiyan. This agrees with[8], who identified increased malaria among adults in a rural southwestern region of Nigeria. This was explained by their prolonged outdoor exposure to agricultural work and construction jobs, making them more likely to come into contact with Anopheles infectious carriers. An examination of Tukey Honest Significant Differences for adults compared with teenagers and children (adults vs. teens: $p < 0.001$; adults vs. children: $p < 0.001$) also identifies this demographic as having a similar issue with[61]. Adults in countries with a high prevalence still comprise a major proportion because preventive materials such as ITNs are used less frequently than for children, who had lower and more level case numbers in Adiyan. This would be a likely effect of preventative programs such as ITNs being distributed and health programs being completed in schools, as evidenced in a study among children in Mali with[62]. Here, children under five had lower levels of malaria because of Seasonal Malarial Chemoprevention and ITN expansion.

The occupational and behavioral factors underlying vulnerability among adults in Adiyan reflect similar observations made in[19], which emphasized that adults in semi-urban Nigeria are vulnerable because of their outdoor occupation. Unlike children who are protected because of indoor-targeted intervention strategies, adults' mobility and behavior put them in vector-susceptible environments, a phenomenon similar to that reported in a Ghana-based study[20], where low use of ITNs among adults contributed to increased malaria cases. This comparison indicates that the phenomenon among Adiyan adults who bear a larger disease burden may be a norm among communities with such socioeconomic conditions.

The positive association between malaria cases in teens and children ($r = +0.72$, p-value < 0.001) indicates a strong overlap in transmission environments such as schools and public places where behavioral factors such as outdoor games prevail. This association is in line with[21], who observed a large number of malaria cases among school-age children in Kenya because of shared environmental factors where school playgrounds were identified as major malaria transmission sites. The association between teens and adults ($r = +0.32$, p-value $= 0.025$) indicates a degree of overlap that may exist in households. This observation is validated by[22], who identified malaria cases in a cluster level manner in the Democratic Republic of Congo because of inter-generational transmission. The fact that there was no association between malaria cases in children and adults ($r = +0.25$, p-value $= 0.090$); with a new negative association observed in 2022 ($r = -0.21$) indicates a clear divergence in malaria trends because of child-specific malaria intervention. This observation validates[23] who observed a decline in malaria cases among children under five years in Nigeria because of ITN & SMC distributions, making a distinct gap between children & adults.

In a similar manner, a study conducted in Ethiopia[24] observed a marked reduction in malaria prevalence among children aged five years and below who received ITN when compared with those in other age groups. This lends evidence to the observed divergence among children and adults in Adiyan. There appears to be a contrast with regard to divergence when one considers a study conducted[17] in the Congo. They observed that a household trend remained constant for a given region among all age ranges. This may indicate that intervention among children in Adiyan may be more effective than other endemic areas. The lower prevalence among children in Adiyan than in[18] in Mali may be a similar indicator of successful ITN and health campaign delivery implementations.

Unlike this study, Adiyan has the advantage of a longitudinal study design with a data span of four years. Results reiterate the importance of age-targeted and season-targeted intervention strategies for Adiyan. The disease burden among adults necessitates a workplace intervention model with mobile clinics and chemoprevention programs along the lines indicated for Nigerian agricultural communities[19]. Vector control measures prior to the rains could help reduce peak entodermic; this would be consistent with[12]. Effectiveness of childhood malaria intervention programs as indicated by a decrease in cases among children and adolescents correlates with advocacy for expansion of SMC and SB programs indicated in[18]. A model combining environmental data with data generated from pharmacies[25] would potentially improve surveillance for timely intervention. This model based on data reported for Adiyan and recommendations based on literature for this region would help in decreasing malaria disease burden in semi-urban Nigeria.

CONCLUSION

The pattern of malaria transmission in Adiyan, Ogun State, from 2019 to 2022 was seasonal and strongly associated with climatic variability. The incidence spiked during intense rainfall and decreased during the dry season. Peak transmission occurred with mid-year rain, resulting in a significant spike in July 2021. Thus, rain-induced stagnant water facilitates Anopheles mosquito breeding suspected to cause this incident. Time-series study revealed increasing humidity increased the burden while higher temperature during dry months reduced malaria transmission with the decrease in the larval habitat. Adults have the highest burden of disease, reflecting possible increased exposure from outdoor occupations like farming and construction. Age-specific patterns reveal interesting social contact patterns that affect transmission dynamics. The clustering of cases among children and adolescents reinforces the role of schools as relevant settings for the continuation of school-based interventions. So, transmission linkages between adolescents and adults may facilitate community spread. The increase in the gap in incidence of malaria between children and adults over time suggests that child-focused preventive efforts are making an impact, signifying support for the continuation of age-specific climate-resilient malaria-control efforts in quasi-urban areas.

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