



Influence Of Seasonal Variability On Malaria Incidence And Clinical Outcomes: Evidence From Madhepura District, Bihar

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Abstract

Malaria is a critical social health problem in flood-prone rural areas where the variability in climatic conditions affects the relationship of malaria transmission. This paper determined the effects of seasonal variability on malaria cases and clinical outcomes in Madhepura District, Bihar, by conducting a retrospective cohort analysis on 100 laboratory-confirmed cases of malaria reported in 2012. To study the trend of variations of disease occurrence and severity over time, it was divided into four seasons of the year. The outcomes revealed that there was clear seasonal pattern whereby the highest incidence was recorded during the monsoon season, and then the post-monsoon season and the lowest incidence occurred in winter. Patterns of cases monthly showed a slow increasing trend in the pre-monsoon months, which reached its maximum during peak rainfall. The most vulnerable group was adults between the ages of 15 and 49 years and children were also susceptible to a great extent. The severity of the clinical conditions, such as severe anemia, high parasitemia, and an extended stay in the hospital, were more intense in high seasons of transmission. The results emphasize the fact that malaria incidence and clinical results are highly dependent on such climatic conditions as rainfall, humidity, and temperature. The study highlights the importance of season-sensitive, climate-sensitive malaria control measures to help to minimise disease burden in flood-prone endemic districts.

Keywords: Malaria, Seasonal Variability, Clinical Outcomes, Climate Factors, Bihar

1.INTRODUCTION

Malaria is a infectious disease that is transmitted by vectors and is caused by protozoan parasites of the genus *Plasmodium* and is transferred to humans by bites of infected female *Anopheles* mosquitos. Although tremendous efforts in the control of malaria have been made globally, it is still evident that the malaria disease is still a great health and socioeconomic indicator in most developing regions. Malaria epidemiology is complicated and highly dependant on the environmental, climatic, and socio-demographic factors that govern the distribution of vectors and transmission of the parasite. Climatic variations that come with seasons in tropical and subtropical regions such as India generate dynamic transmission patterns and malaria is an illness with a close relation to ecological and weather changes.

1.1 Burden of Malaria in India and Bihar

Malaria remains one of the greatest social health issues in various sections of India particularly in rural and flood-prone areas where climatic and environmental factors conducive to breeding of mosquitos are observed. One such state is Bihar where malaria transmission has a strong seasonal expression mostly due to rainfall, temperature, and humidity in addition to stagnant water during the monsoon season. Madhepura District is situated in the river basin of the Kosi river thus is always prone to flooding and waterlogging which provide anopheles mosquitoes, the main vectors of malaria, good ecological niches.

1.2 Role of Seasonal and Climatic Variability in Malaria Transmission

Malaria transmission changes greatly with seasonal fluctuation. The stagnant water bodies formed during monsoon and post monsoon seasons by the increased rainfall provide the breeding grounds of the mosquitoes. The temperature and humidity also influence the survival and breeding ability of the mosquito vectors in addition to the developmental cycle of *Plasmodium* parasites in the mosquito. This means that an epidemic of malaria is commonly high during such seasons and the winter and extreme summer seasons are usually low in terms of transmission.

1.3 Seasonal Variability and Clinical Outcomes: Study Rationale

In addition to its impact on the occurrence of diseases, seasonal variation has an impact on the clinical outcomes. The periods of high transmission levels are usually associated with an increased parasite load, a more significant intensity of such symptoms as anemia and lengthened fever, and an increased level of hospitalization. Knowing these seasonal

trends is fundamental in formulating specific prevention, surveillance and treatment measures. Thus, the purpose of the study is to evaluate how seasonal changes affect the incidence of malaria and the related clinical outcomes of the disease in Madhepura District, Bihar.

1.4 Research Objectives

The current research was aimed at examining influence of seasonal climatic variation on developing malaria and its clinical consequences in Madhepura District, Bihar. In accordance with the purpose, specific objectives were developed as follows:

1. To test the seasonal variation in the malaria case in Madhepura District, Bihar, on monthly and seasonal basis.
2. To determine the impact of climatic variables of rainfall, temperature, and humidity on malaria transmission in various seasons.
3. To determine the seasonal difference in the clinical outcomes such as severe anemia, high parasitemia, and long hospital stay among the malaria patients in the study area.

2. REVIEW OF LITERATURE

In a study that was done by Kumar et al. (2012) in Bihar, it was found that climatic conditions including rain fall, temperature and seasonal weather patterns had a major impact on the transmission of malaria. The researchers noted that malaria prevalence was high during the monsoons and post-monsoons seasons because stagnant water bodies were formed and this provided the ideal breeding grounds to the Anopheles mosquitoes. They found that precipitation and humidity were major causes of seasonal malaria trends and pointed to the significance of climate-based surveillance in order to achieve good control.

Bhattacharya, Sharma and Dhiman (2011) explored the links of climate variability and the dynamics of malaria transmission in India. Their results reflected that changes in temperature and humidity had a direct influence on the mosquito survival, reproduction and parasite life cycle. The paper has emphasized that average temperatures together with high humidity in the rainy season enhanced the pace of transmission and helped in the occurrence of regional variations in the incidence of malaria.

Singh, Singh, and Sharma (2010) examined the seasonal environmental factors that make malaria disease transmitted in rural India and found out that the highest number of cases occurred during and just after the monsoon season. They pointed out that the presence of stagnant water, high humidity and the presence of favorable temperatures were favorable to the growth of the vectors and the growth of parasites that eventually led to the establishment of more severe clinical features of the outcomes among the at-risk populations.

Sharma (2009) appraised the reoccurrence of malaria in India and highlighted the contribution of the climatic and environmental changes, including fluctuation in rainfall, deforestation, increase in irrigation, and ecological alterations. This research postulated that these conditions resulted in creating good breeding conditions by the vectors, which led to seasonal malaria epidemics and reaffirmed the relationship between environmental variability and disease reemergence.

Hay et al. (2010) explored the connection between climate change and malaria resurgence in the East African highlands and revealed that increased temperatures and a change in rain patterns increased the time frame of malaria transmission. They analyzed and found that even slight temperature increases stimulated parasite development in mosquito vectors and extended the life of the vectors, making them more dangerous vectors. Even though it was based on Africa, the study was very useful in offering insights that could be applied in malaria-infested areas such as India, where these climatic variations affect the trends of seasonal cases and severity.

3. METHODOLOGY

This Section explains the research design, study setting, sample size, data sources, seasonal classification, variables, and other statistical methods employed to identify the effect of seasonal variability on malaria cases and clinical outcomes in Madhepura District, Bihar. The research methodology was designed to record the changes in the cases of malaria in various climate seasons as well as to obtain the correlation between those changes and the severity and outcome of the disease among the patients.

3.1 Study Design and Study Area

The research design was a retrospective observational one based on the analysis of hospital records. It was done in Madhepura District, Bihar, a rural and flood prone area in the Kosi river basin under heavy rainfall, frequent floods and waterlogging during the monsoon season, which provides conducive breeding to the Anopheles mosquitoes and transmit malaria. The case data on malaria were accessed through regular surveillance and diagnostic reports of the district hospitals and the primary health centers (PHCs).

3.2 Study Population and Sample Size

A sample of study population was comprised of individuals with laboratory proven cases of malaria in selected PHCs and district hospitals in Madhepura District in 2012. The analytical sample consisted of 100 cases (N = 100) having full clinical and diagnostic data. Microscopy and/or rapid diagnostic test (RDTs) confirmed the case, and the patients were of all ages and either gender. Incomplete information in the records or unestablished diagnosis records were excluded so as to have a reliable data.

3.3 Seasonal Classification

In order to determine seasonal variability, the 2012 year was further subdivided into four climatic seasons as pre-monsoon (March- May), monsoon (June-September), post-monsoon (October-November) and winter (December-February) seasons. This classification was used to represent differences in rain, temperature and humidity that influence the breeding and transmission of mosquitoes. The cases of malaria were allocated to each season according to the month of diagnosis in order to establish the season peaks and periods of minimum transmission.

3.4 Variables Studied

The research looked at epidemiological and clinical variables in order to assess how seasonal variability affects the occurrence and outcomes of malaria. Monthly and seasonal distribution of cases of malaria was the main variable. The clinical indicators were the severity of symptoms and the anemia, the duration of hospitalization, and the demographic data like age and gender were obtained to determine the susceptibility. Climatic factors such as rainfall, temperature and relative humidity were also taken as contextual factors that influence seasonal dynamics of transmission.

3.5 Statistical Analysis

Descriptive statistics like frequencies and percentages were used to analyze data and identify the seasonal trends and associations. The chi-square test was used to evaluate the relationship between seasonal variability and such clinical outcomes as anemia and symptom severity. Simple regression analysis was also done to determine the relationship between climatic factors (rainfall, temperature, and humidity) and malaria incidence to establish the impact of seasonal variability on the occurrence and severity of the disease.

4. RESULTS AND DISCUSSION

This section shows the results of the study conducted on the analysis of 100 laboratory-confirmed malaria cases reported in the Madhepura District in the year 2012. The findings are arranged in a way that brings out the seasonal distribution, and the trends per month, demographic trends, and clinical outcomes. The results are understood against the background of seasonal climatic variation and its effect on the prevalence and intensity of malaria.

4.1 Seasonal Distribution of Malaria Cases

Table 1 shows the seasonal distribution of the cases of malaria to be reported in Madhepura District in the season of reference with the number and percentage of cases as per the four climatic seasons. The table brings out the seasonal environmental factors including rainfall, temperature and humidity which have an effect on the incidence of malaria as they breed and transmit vectors.

Table 1: Seasonal Distribution of Malaria Cases (N = 100)

Season	Number of Cases	Percentage (%)
Winter (Dec–Feb)	10	10%
Pre-monsoon (Mar–May)	20	20%
Monsoon (Jun–Sep)	45	45%
Post-monsoon (Oct–Nov)	25	25%
Total	100	100%

A strong seasonal difference in the occurrence of malaria is observed as shown in the table with malaria cases registered most during the monsoons (45%), then the post-monsoons (25%). Pre-monsoon season contributed 20 percent of the cases and the lowest incidence was during the winter (10 percent). This pattern shows that the Malaria transmission in Madhepura is closely linked to the ecological alterations which are of monsoon nature, especially the increased rainfall and water stagnation which facilitates the breeding of Anopheles mosquito. The fact that cases were still present even in the post-monsoon period can be attributed to the presence of a persistent and continued activity of the vectors because of the presence of residual stagnant water and good humidity conditions despite the fact that the rainfalls had reduced.

To show the seasonal distribution of the malaria cases (N = 100) in Madhepura District graphically, the percentage of the cases/malaria that are carried by winter, pre-monsoon, monsoon, and post-monsoon seasons are shown in Figure 1 to facilitate a visual representation of the seasonal distribution of the cases.

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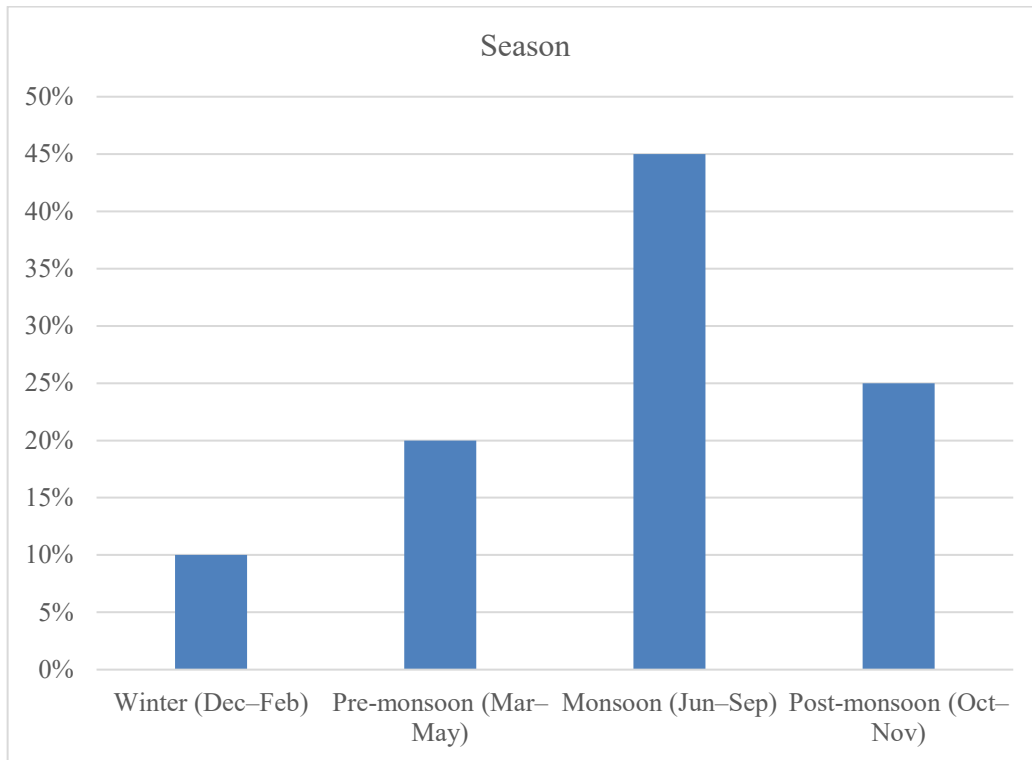


Figure 1: Graphical Representation of Seasonal Distribution of Malaria Cases (N = 100)

The graphical analysis indicates the presence of a distinct seasonal pattern, i.e., cases of malaria increase very fast during the monsoon and decrease leading to winter. The peak of the monsoons underlines the ardent contribution of the rainfall and humidity to breeding and propagation of mosquitoes, whereas moderate ratios after the monsoon appear to reveal that the breeding and propagation of mosquitoes continue since there are areas of second-best breeding.

4.2 Monthly Trend of Malaria Incidence

Table 2 shows the distribution of the cases of malaria recorded in Madhepura District in the year 2012 on a monthly basis. The table shows the temporal change in malaria morbidity during the whole twelve months allowing one to closely monitor the seasonal development and changes in the transmission patterns under climatic variations during the year.

Table 2: Month-wise Distribution of Malaria Cases in 2012

Month	Cases
Jan	3
Feb	2
Mar	5
Apr	6
May	9
Jun	12
Jul	15
Aug	10
Sep	8
Oct	7
Nov	6
Dec	7

The month-wise distribution shows a clear temporal pattern, with low cases in winter (January–February) and a gradual rise from March, peaking in July during intense monsoon rainfall. Cases declined after September but remained moderately high until November, indicating continued post-monsoon transmission. The pattern highlights the close link between rainfall, humidity, and malaria incidence across the year.

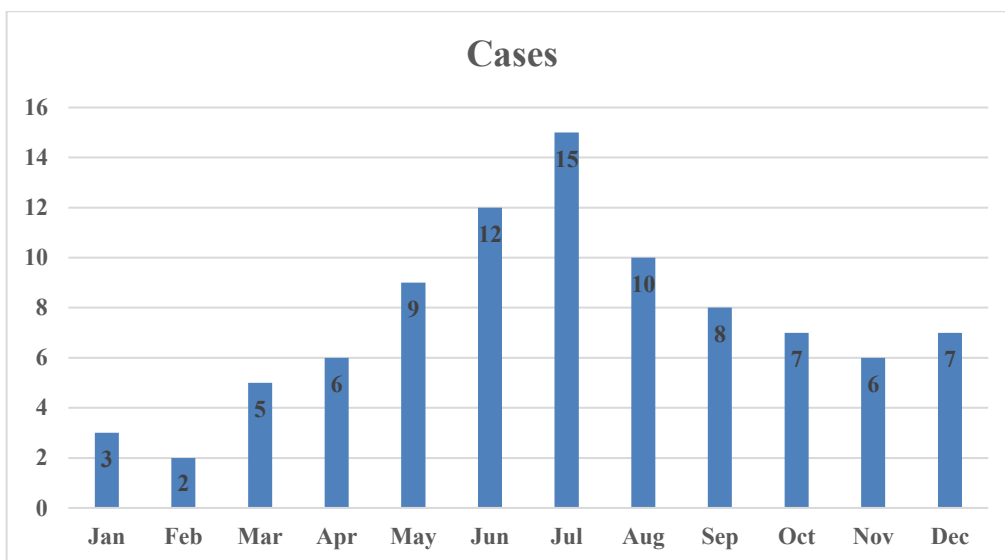


Figure 2: Graphical Representation of Month-wise Distribution of Malaria Cases in 2012

The trend as depicted in the graph indicates that the malaria cases gradually increase after the beginning of the summer season and reaches its peak in July as the monsoon precipitation is the highest and then a consistent decrease after September. The cases are generally maintained at moderate levels until October and November, which means that there is continuous post-monsoon transmission, with the lowest rates in January and February indicating the less active use of vectors in the colder seasons.

4.3 Demographic Distribution of Malaria Cases

Table 3 gives distribution of the malaria cases by age in the Madhepura District, indicating the number and percent distribution of malaria cases by three distinct demographic groups, including: children, adults, and older adults. The table gives a review of the population level vulnerability and shows the difference in malaria incidence with respect to the different age groups based on the exposure and immunity patterns.

Table 3: Age-wise Distribution of Malaria Cases

Age Group	Number of Cases	Percentage (%)
Children (<15 years)	35	35%
Adults (15–49 years)	45	45%
Older Adults (50+ years)	20	20%
Total	100	100%

The age-based distribution indicates that the highest number of cases of malaria was among the adults (15 years to 49 years old) (45%), followed by children (35%), and older adults (20%). This increased burden in adults would be as a result of having more exposure to occupational and outdoor activities during peak breeding times of the mosquitoes, and children are susceptible to further infections because of a poor immunity. These demographic disparities in malaria are demonstrated graphically in figure 3.

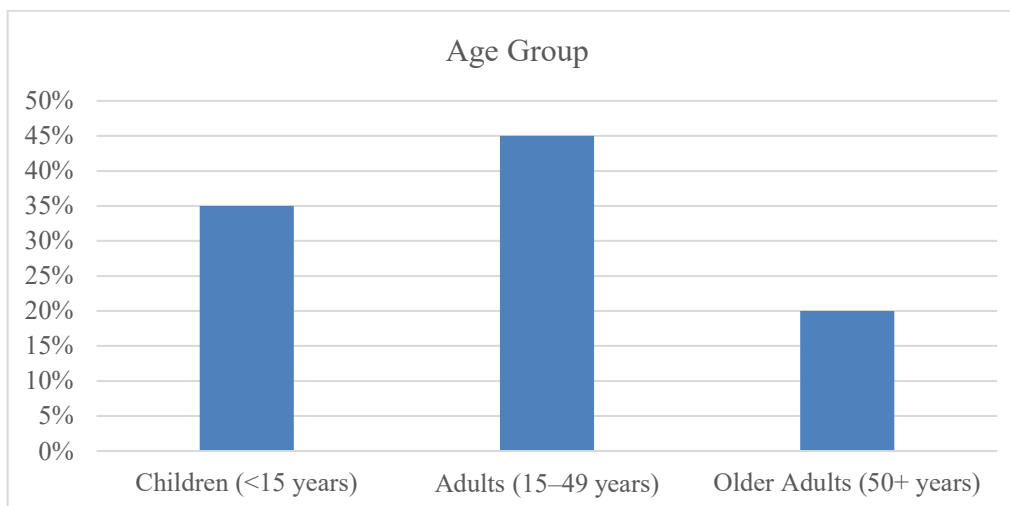


Figure 3: Graphical Representation of Age-wise Distribution of Malaria Cases

The graphical demonstration indicates that adults (15-49 years) carry the greatest burden of malaria cases, then children, and the older adults have the least. The trend is a manifestation of the fact that adult people are more exposed to the diseases at work, and children are less immune, thus the differences in the risks of malaria among age groups are demographic.

4.4 Seasonal Variation in Clinical Outcomes

Table 4 is a table that shows the seasonal distribution of the major clinical outcomes among the malaria patients in Madhepura District of the four climatic seasons in terms of severe anemia, prolonged hospitalization, and high parasitemia. The table offers a summary of the effect of seasonal levels of transmission and related environmental factors on the severity of a disease.

Table 4: Season-wise Distribution of Clinical Outcomes

Season	Severe Anemia	Prolonged Hospitalization	High Parasitemia
Winter (Dec–Feb)	1	1	1
Pre-monsoon (Mar–May)	3	2	3
Monsoon (Jun–Sep)	12	10	11
Post-monsoon (Oct–Nov)	6	5	5

The seasonal distribution indicates that the severity of the disease was the most intense during the monsoon season, accompanied by more severe cases of anemia, a greater number of cases of prolonged hospitalization, and high parasitemia. The post monsoon also registered moderate levels of high severity, and the lowest complications were recorded in winter. These seasonal differences in clinical outcomes in various climatic periods are depicted in figure 4.

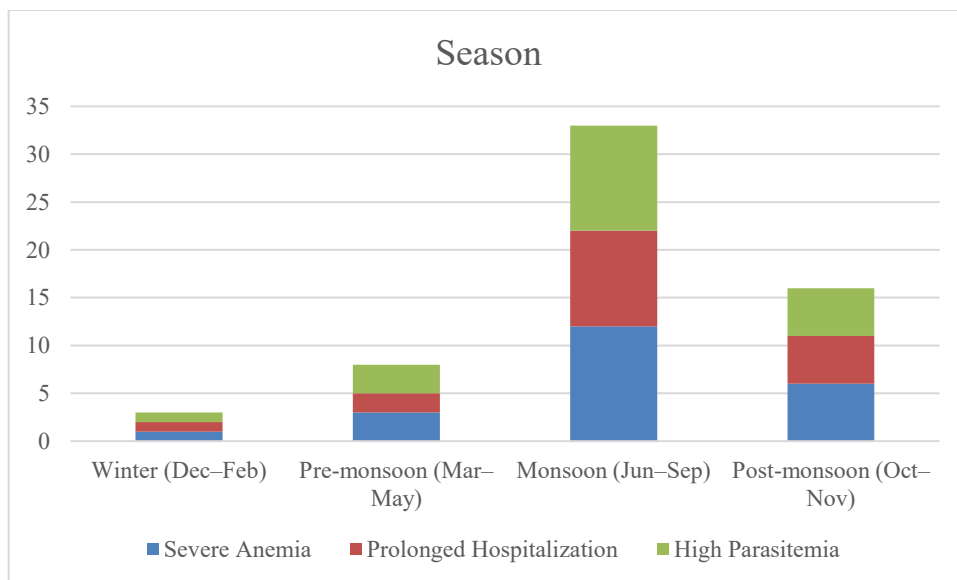


Figure 4: Graphical Representation of Season-wise Distribution of Clinical Outcomes

The graphical depiction indicates that the highest clinical severity is in the monsoon season and moderately high in the post-monsoon season and the lowest in winter. This tendency denotes that the increase in rain and humidity promotes the growth and spread of mosquitoes and the transmission of parasites, which results in more significant clinical outcomes and treatment delays within the period of floods.

4.5 Overall Interpretation and Discussion

The findings prove that malaria cases and clinical outcome have a great seasonal impact on the Madhepura District. The height in the monsoon and post-monsoon seasons coincides with the ecological conditions that support the breeding of the mosquitoes such as stagnant water, averagely low temperature, and high humidity. The gradual increase of cases between March and July also highlights the predictive position of climatic changes in the transmission of malaria.

Clinical severity was also influenced by seasonal variation where anemia, parasitemia, and hospitalization were higher in high transmission months. This shows that climatic factors do not just affect how malaria occurs, but also complications and clinical progression of the disease.

In general, the results indicate that malaria in Madhepura is epidemiologically regular, which is motivated by environmental changes related to the monsoon season. These findings emphasize the necessity to employ specific seasonal control strategies such as the increase of the intensity of the control measures against vectors, the use of diagnostic screening at the time of the major months, and the enhancement of clinical preparedness to handle the severe cases within the periods of the high transmission rates.

5.CONCLUSION

The research obtained a conclusion that incidence and clinical outcomes of malaria in Madhepura District had a clear seasonal distribution, the highest rate was found in the monsoon season and the lowest in the winter season. The climate (rainfall, humidity and temperature) contributed, to a great extent, to the change in the breeding and spreading of the mosquito. The result also showed that the most impacted group was the adult population since they were exposed more while children were also susceptible since their immunity was lower. Further, the severity of the clinical condition, such as anemia, high parasitemia, and long-term hospitalization, was the highest during peak months of transmission. In general, the paper highlighted the importance of implementing season- and climate-sensitive malaria control measures to ensure the reduction of incidence and better clinical outcomes in endemic areas that are likely to experience floods.

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