Epidemiology of Malaria in a Desert Area, Case of the Taoudenni Region in Mali from 2017 to 2020

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ABSTRACT

Malaria is an acute febrile human illness caused by the *Plasmodium* parasite that is transmitted by the bites of infected female Anopheles mosquitoes. The Taoudenni region, located in the Sahel-Saharan zone, is vulnerable to a malaria outbreak due to its very low transmission levels zone. The objective was to study the epidemiology of malaria in the Taoudenni region, with the aim of optimizing control measures. We conducted a cross-sectional study from August 2021 to July 2022. We analyzed malaria data from 2017 to 2020 from this region and carried out a census of all malaria cases. The data were analyzed with SPSS version 18. Proportions were compared with Pearson's Chi2 test or Fisher's Exact test or the Z test of the centered normal distribution reduced to the significance threshold p=0.05. In total, 10,084 patients were identified, including 4,202 confirmed cases of malaria. The sex ratio was 1.07 in favor of the female sex. The overall proportion of malaria was 41.67% (4,202/10,084) among suspected cases. Those aged over 15 had the highest proportion of confirmation with 47.65% followed by those aged 5-14 with 41.08%. Malaria was simple in 91.2% of cases and serious in 8.8% of cases. Peak incidences were mainly observed between September and October. The trend was upward; the highest annual incidence was observed in 2020 and the lowest in 2017 with respectively 82 cases per 10,000 inhabitants compared to 21 cases per 10,000 inhabitants. From 2017 to 2020, an upward trend in malaria cases was observed in the Taoudenni region. A study integrating rainfall data could be considered to better explain the observed trends.

Keywords: Malaria, Desert, Taoudenni, Mali

INTRODUCTION

According to the Word Health Organization (WHO), epidemiology is the study of the distribution (frequency, pattern) of diseases and health conditions in human populations, as well as the factors (determinants) that influence this distribution. Malaria is an acute febrile human illness caused by the *Plasmodium* parasite that is transmitted by the bites of infected female Anopheles mosquitoes (1). Two of the five species of plasmodia that cause human malaria are especially dangerous: *P. falciparum*, the parasite responsible for the most deaths and the most widespread in Africa, and *P. vivax*, the dominant species in most countries outside sub-Saharan Africa (1).

In 2020, approximately 241 million cases of malaria were estimated worldwide (2). The estimated number of deaths attributable to malaria rose to 610,000 in 2024 (2). The WHO African Region continues to bear the

greatest burden, with 11 countries accounting for about two thirds of global cases and deaths (2). Children under the age of 5 accounted for approximately 80% of all malaria-related deaths in the Region (1). Just over half of all malaria-related deaths worldwide were recorded in four African countries: Nigeria (31.9%), the Democratic Republic of the Congo (13.2%), the United Republic of Tanzania (4.1%), and Mozambique (3.8%) (1).

In Mali, the prevalence of malaria is 19% (3). The estimated cases is 8,475,000 (2). The prevalence among children under 5 was 19% in 2018 (4). Mali is divided into four malaria transmission zones. The Sahara is located in the sporadic transmission zone (4), where the population has no immunity to malaria, and people of all ages are at risk of severe and complicated malaria (4).

The Taoudenni region is part of the Sahel-Saharan zone at risk of malaria epidemics, with an annual incidence of fewer than 100 cases per 1,000 person-years. It is characterized by areas of very low transmission (5).

Since 1993, Mali has had a national malaria control program based on the National Malaria Control Policy Statement (4). This program is administered by the National Malaria Control Directorate and enjoys a degree of managerial autonomy. A strategic plan for malaria control has been developed for the period 2018–2022, with the primary objective of reducing malaria-related mortality and morbidity by 50% compared to 2016 levels (5).

All of these policy documents emphasize the monitoring of areas at risk of epidemics, such as the Taoudenni region; this is what motivated the present study, which aims to describe the epidemiology of malaria in a desert area, specifically the Taoudenni region.

Objective

The objective of this study was to describe the epidemiology of malaria in the Taoudenni region from 2017 to 2020.

MATERIALS AND METHODS

Study site

The Taoudenni region is Mali's ninth administrative region, comprising six districts. It covers an area of more than 323,326 km² (approximately 25% of the country's total land area) and had a total population estimated at 186,704 in 2019 (6). In this region, monthly high temperatures exceed 40°C from April through September, peaking at 48°C in July. Average annual rainfall ranges from 14 mm to 125 mm, with a high concentration of mosquitoes from July through September; most of the rain falls between July and October (6). The population is largely nomadic. The region comprises six health districts (Araouane, Bou-djebeha, Al-Ourche, Achouratt, Foum-Elba, Taoudenni) and a regional health directorate. The ratio of health professionals (doctors, nurses, and midwives) per 10,000 inhabitants was 5.3 (7). The rate of acute malnutrition among children aged 0 to 59 months is 10.1%. Insecurity along major roads hinders people's access to healthcare.

Study type and study period

This was a descriptive study conducted from August 1 to July 31, 2022. The study analyzed data from 2017 to 2020. As part of the epidemiological surveillance of malaria, data are collected monthly in an Excel file at the health district level and entered into the District Health Information System version 2 (DHIS2) data management software. These data are sent to and archived at the regional health directorate. We selected the data corresponding to our study variables from this dataset.

Study population

The population of the Taoudenni region was included in this study.

Inclusion Criteria

Any patient who received care in one of the health districts of the Taoudenni region between January 2017 and December 2020 and underwent a rapid diagnostic test (RDT) or thick smear for the diagnosis of malaria.

Non-inclusion criteria

Any patient who received care in one of the health districts of the Taoudenni region between January 2017 and December 2020 but for whom no records were kept.

Sampling and sample size

This was a comprehensive survey covering all suspected malaria cases reported at the health district level for which a thick smear or a rapid diagnostic test (RDT) had been performed for confirmatory purposes, in accordance with national guidelines. A total of 10,084 suspected malaria cases were identified during the period.

Measured variables

Dependent variables

Malaria

Independent variables

Age, sex, district, year, month, RBC count, thick smear, uncomplicated malaria, severe malaria, population.

Data collection methods

We obtained data for the Taoudenni region from 2017 to 2020. These data, presented in reports, included all the variables we used.

Data entry and analysis

Based on the data obtained, we created a database in Microsoft Excel 2010 and analyzed it using SPSS version 18. We presented the results in the form of tables and graphs and performed cross-tabulations, from which we calculated Pearson's chi-square statistic or Fisher's exact test depending on the conditions of validity, with a significance level of $p = 0.05$. We also used the Z-test for the reduced centered normal distribution to compare proportions without cross-tabulation.

Ethical and professional considerations

We obtained the data from the health information system coordinator for the Taoudenni region with the authorization of the Regional Director of Health. This data was used solely for the purposes of this study and did not include any patient names.

RESULTS

Socio-demographic characteristics of malaria cases in Taoudenni from 2017 to 2020

From 2017 to 2020, we recorded 4,202 confirmed cases of malaria among 10,084 patients tested, representing an overall prevalence of 41.67%.

People aged 15 and older had the highest confirmation rate at 47.65%, followed by those aged 5–14 at 41.08%. We found that the confirmation rate differed significantly by age group ($p=2\times10^{-6}$) **(Table 1)**.

Table 1: Distribution of suspected and confirmed malaria cases in the Taoudenni region from 2017 to 2020 by age group

Age group	Malaria cases		
	Suspected	Confirmed	% confirmed
< 1 year	22	0	0.00
1 to 4 years	1057	154	14.57
5 to 14 years	3695	1518	41.08
15 years and older	5310	2530	47.65
Total	**10084**	**4202**	**41.67**

Females accounted for 52% of confirmed cases (2,173 out of 4,202). The sex ratio was 1.07, favoring females.

Of all confirmed malaria cases, uncomplicated malaria accounted for 91.2%. There was no association between the type of malaria and age groups (p=0.07) **(Table 2)**.

Table 2: Distribution of confirmed malaria cases in the Taoudenni region from 2017 to 2020 by type of malaria and age group

Age group	Confirmed malaria		
	Simple case n (%)	Severe case n (%)	Total N (%)
< 1 year	0 (0.00)	0 (0.00)	0 (0.00)
1 to 4 years	148 (3.52)	6 (0.14)	154 (3.66)
5 to 14 years	1383 (32.91)	135 (3.21)	1518 (36.13)
15 years and older	2301 (54.76)	229 (5.45)	2530 (60.21)
Total	3832 (91.19)	370 (8.81)	4202 (100.00)

Trends in malaria cases in the Taoudenni region from 2017 to 2020

In 2017, incidence peaks were observed in August and September, with a monthly incidence of 5 cases per 10,000 people. In 2018, the incidence peak occurred in September, with 19 cases per 10,000 people per month. In 2019, the peak incidence occurred in October, with 15 cases per 10,000 people. For 2020, peak incidence rates were observed in September and October, with a rate of 19 cases per 10,000 people **(Figure 1)**.

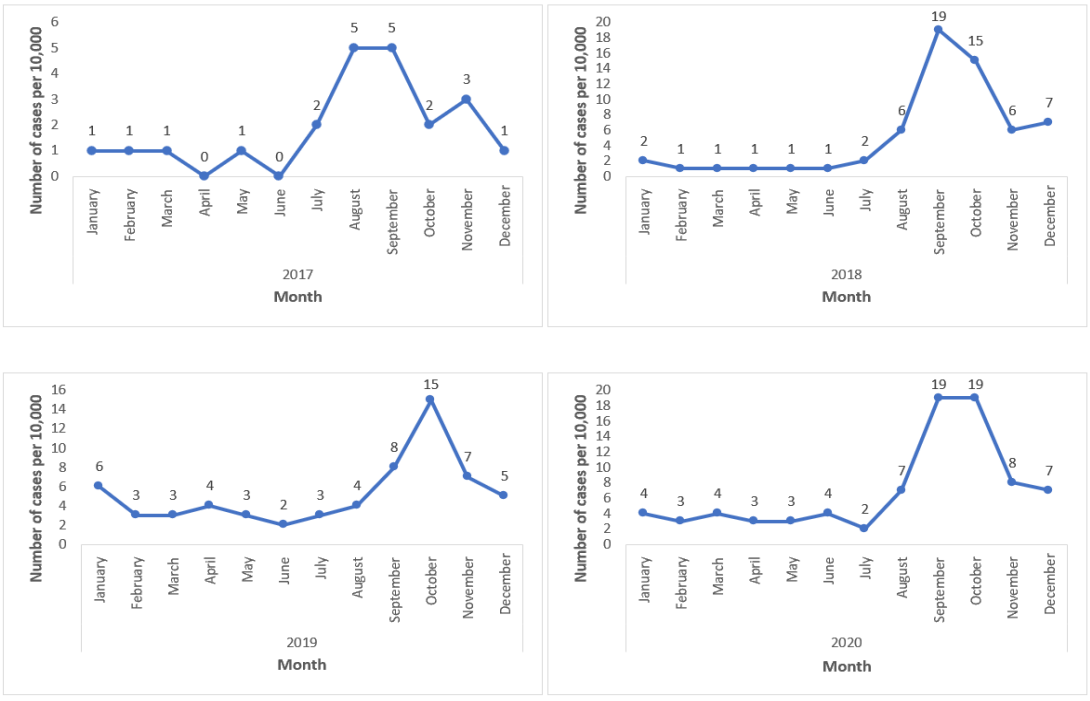

Figure 1: Incidence of malaria in the Taoudenni region from 2017 to 2020

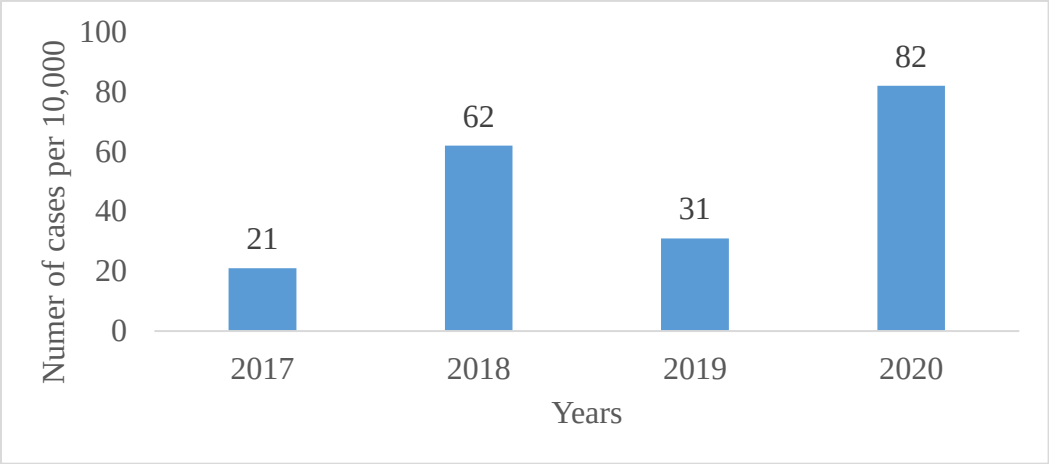

Figure 2: Trends in the annual incidence of malaria from 2017 to 2020 in the Taoudenni region

Between 2017 and 2020, the annual incidence of malaria increased gradually in the Taoudenni region.

DISCUSSION

Socio-demographic characteristics of malaria cases in Taoudenni from 2017 to 2020

Our study included all age groups, and we found that the proportion of confirmed cases differed significantly by age group ($p=2\times10^{-6}$). The most represented age group was those aged 15 and older, accounting for 60.21% of confirmed malaria cases. Our results are similar to those of Sogoba LF (8) in 2008 in Douentza, where the most affected age group was 14 years and older (42%). Two observations may explain this: first, the implementation of NMCP guidelines, including Seasonal Malaria Chemoprevention (SMC), in all health districts of the Taoudenni region, aimed at reducing the incidence of malaria among children aged 3 to 59 months (9) second, the lack of immunity in the older age group increases susceptibility to malaria (10). Malaria cases were diagnosed in 52% of female patients compared to 48% of male patients. The female-to-male sex ratio was 1.07. Our results are similar to those reported by Coulibaly and Samake (11,12). This predominance of females in our study is likely due to men's mobility in this region, which results in a higher proportion of women in the villages. In our study, there were no cases of malaria in the < 1 year of age group; we have not found an explanation for this.

Malaria was uncomplicated in 91.2% of cases and severe in 8.8% of cases; the proportion of uncomplicated and severe malaria varies across studies. In fact, in their study, Sidibé reported that 60.3% of cases were uncomplicated malaria, compared with 39.97% of cases as severe malaria in 2019 in Sirakorola (13).

Thus, we observe a lower proportion of severe malaria in our study compared to that reported by Sidibé M. This could be explained by the location of our study, where the population tends to seek care for major health problems at the referral health centers in the Timbuktu region, which are considered to be better equipped. This low proportion of severe malaria in our study could also be explained by the presence of other *Plasmodium* species in the Malian Sahara. Some studies described the presence of other *Plasmodium* species in the north notably *Plasmodium malariae* and *Plasmodium ovale*, two species responsible for malaria with relatively mild clinical manifestations (14,15). These two species can also be detected by RDTs, which would imply that *P. falciparum* malaria is not the only type of malaria in the Taoudenni region.

Among the cases of severe malaria that were identified, the most common age group was 15 years and older. There was no association between malaria type and age groups (p=0.07). This could be explained by the epidemiological profile of our study site, which is located in an area of sporadic or even epidemic transmission where there is no immunity, and adults are also at risk of developing severe and complicated malaria (16).

Trends in Malaria Cases in the Taoudenni Region from 2017 to 2020

During our study, peaks in incidence were mainly observed between September and October. The trend was upward, with the highest annual incidence observed in 2020 and the lowest in 2017, at 82 cases per 10,000

inhabitants and 21 cases per 10,000 inhabitants, respectively. This upward trend could be explained by several factors:

Starting in 2017, with the semblance of peace in the northern regions and improved living conditions in the Taoudenni region (17), an increase in the population of the Taoudenni region was observed; this influx of people came from regions further south (18), where malaria is much more prevalent, which could be the source of malaria outbreaks through imported cases.

From 2018 to 2020, the Taoudenni region experienced heavy rains that caused flooding and led to the formation of stagnant pools of water, which serve as ideal breeding grounds for mosquitoes (18). Given the limited use of insecticide-treated bed nets is very limited in the Taoudenni region (18), this may have increased the population's exposure to mosquito bites. In 2020, the spread of COVID-19 in the northern regions had a significant impact on malaria control activities in the Taoudenni region, according to the International Committee of the Red Cross (ICRC), The fight against COVID-19 diverted some of the funds allocated to malaria prevention in northern Mali, a region that has been weakened for years by terrorist violence (19).

Other factors must also be taken into account, such as the improvements to the health information management system resulting from the introduction of DHIS2 in 2017 (20).

CONCLUSION

Of the 4,202 malaria cases reported during the period, 91.2% were uncomplicated. Women and people aged 15 and older were the most affected. From 2017 to 2020, a rise in malaria cases was observed. It would be important to increase public awareness of preventive measures. Furthermore, a study incorporating rainfall data could be considered to better explain the observed trends.

Conflicts of Interest

We declare that we have no conflicts of interest

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