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Assessment of the burden of malaria in the dry season in the savannah of Northern Côte d'Ivoire

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Abstract
Malaria vector control efforts in the tropic settings are in most cases deployed during the rainy season, which is often mistakenly considered as the only period of transmission. This study aimed to gain insight into the burden of malaria during the dry season in the savannah area. To achieve this, a retrospective parasito-clinical survey based on the collection of parasito-clinical data in health facilities was conducted. This survey consisted of consulting curative care registers and recording all cases notified of malaria (simple or severe) in the population by health facility managers over a period of 5 years from 2012 to 2016. Data on other major pathologies were also consulted. Thus, malaria was the most frequent disease with 71.88% and 62.11% of cases of pathologies followed by respiratory infections in health districts, respectively. During the dry season, the prevalence was 7.13% (05.30%-09.34%) in the village of Longo (Niakaramandougou health district) and 3.08% (02.10-04.33) in the village of Bémavogo (Korhogo district). Malaria transmission in both sites during the dry season remains a concern. Vector control should also be applied during long dry periods for greater effectiveness.

Keywords: Survey, parasito-clinical, malaria, dry season, north, Côte d'Ivoire

1. Introduction
Malaria is a parasitosis caused by a haematozoan of the genus Plasmodium and transmitted to humans by the bite of a female mosquito of the genus Anopheles. This disease remains undoubtedly one of the most serious and complex public health problems facing humanity at the beginning of the 21st century. As of 2019, the number of malaria cases was estimated at 229 million and the number of deaths at around 409,000. Approximately 3.2 billion people, almost half of the world's population, are at risk from malaria. Fifteen countries, mainly in sub-Saharan Africa, account for 90% of malaria cases and 92% of deaths worldwide. In children under five [5] years of age, 61% of malaria-related deaths were recorded [1]. In Côte d'Ivoire, malaria is the leading cause of consultations (33%), morbidity (43%), school absenteeism (40%), and loss of agricultural income (50%), hospitalisation (62%) and mortality (11.8%) in health centres (NMCP, 2017). Across the country, about 3.5 million children under five and 1 million pregnant women are exposed to malaria [2]. The distribution of the endemic malaria in the world is closely linked to climatic conditions. The natural transmission of malaria by Anopheles vectors of Plasmodium can only take place among a human population in regions where three climatic elements combine their effects: sufficient rainfall, temperature and hygrometry, and the multiplication of parasites in their organism [3]. In sub-Saharan Africa, the climate is favourable all year with a strong pullulation of Anopheles vectors in forest areas [4]. This permanence of adequate climatic conditions disappears in the savannah zone, where a rainy season is clearly distinct, and its duration shortens towards the north to become very short. However, it is clear that the pathological consequences of malaria are more important in the savannah than in the forest [5]. In the north of Côte d'Ivoire, where the dry season lasts 8 months (October to May), many cases of malaria are diagnosed during the dry season during consultations in health facilities [6]. A study conducted in Korhogo in northern Côte d'Ivoire observed a close relationship between the strong seasonality of climatic variables and the seasonality of clinical malaria [7].

The persistence of malaria cases could be linked to the presence of asymptomatic carriers, as observed in Korhogo (Côte d'Ivoire) and Kaedi in southern Mauritania [7]. Indeed, malaria vectors would become infected during blood sampling of asymptomatic carriers, thus contributing to the malaria epidemic [7]. Face to the current and predicted environmental and climatic changes, malaria epidemiology in savannah zone requires particular attention, especially in dry season where populations neglect individual protection measures against mosquito vectors. During this season, respiratory diseases due to the harmattan (a cold, dry and dusty wind from the north) may predominate over malaria. Vector control programmes have always marginalised this season due to the rarity of vectors. However, despite this rarity, transmission does occur. There is little recent data on the burden of malaria compared to other diseases in the dry season in the savannah zone of northern Côte d'Ivoire. This lack of data is an obstacle to vector control and consequently to the control of malaria transmission. To fill this gap, this study aims to provide a better knowledge of the epidemiology of malaria in the dry season, which will enable health authorities to optimise malaria control strategies. The objective of this work is to evaluate the burden of malaria in relation to major diseases in the dry season in savannah.

2. Materials and Methods

2.1. Study site

The collection of data on malaria was carried out in the rural savannah zone in the north of Côte d'Ivoire in the health districts of Korhogo and Niakaramandougou. Four villages were selected taking into account their accessibility, their location in a long dry season zone, their proximity or not to a watercourse. These are Longo in the commune of Niakaramandougou and Gossonkaha, Bémavogo and Nalourgokaha in the commune of Kiémou (Figure 1). These villages were classified into two sites based on their proximity: -The Longo/Gossonkaha site: Longo (Niakaramandougou district) and Gossonkaha (Korhogo district); - The Bémavogo/Nalourgokaha site: Bémavogo and Nalourgokaha (Korhogo district) the villages of Longo and Gossonkaha are located 1 km and 0.5 km respectively from the Bandama River. The village of Bémavogo and Nalourgokaha are located 10 km and 12 km respectively from the Bandama River (Fig.1). To estimate the malaria prevalence, data were collected in two (2) villages in the study area: Longo (Health district of Niakaramandougou) located near the Bandama River and Bémavogo (Health district of Korhogo). In fact, Niakaramandougou is both a commune and the capital of the department. The relief is dominated by very uneven plateaus. The selection criterion was based on the location of the site in a long dry season area, accessibility by road, and above all the availability of information on malaria cases in the health centres. The hydrography is dominated by the white Bandama river and the presence of numerous lowland rice fields. The climate is Sudanian with two seasons: the rainy season (4 months), from June to September and the dry season (8 months), from October to May, dominated by the harmattan, a hot and dry wind. The average annual rainfall varies from 1,200 mm to 1,400 mm. The average temperature is 26 °C. The vegetation is dominated by the tree savannah. It is shrubby and grassy in its northern part. The average monthly relative humidity varies between 35% and 79%.

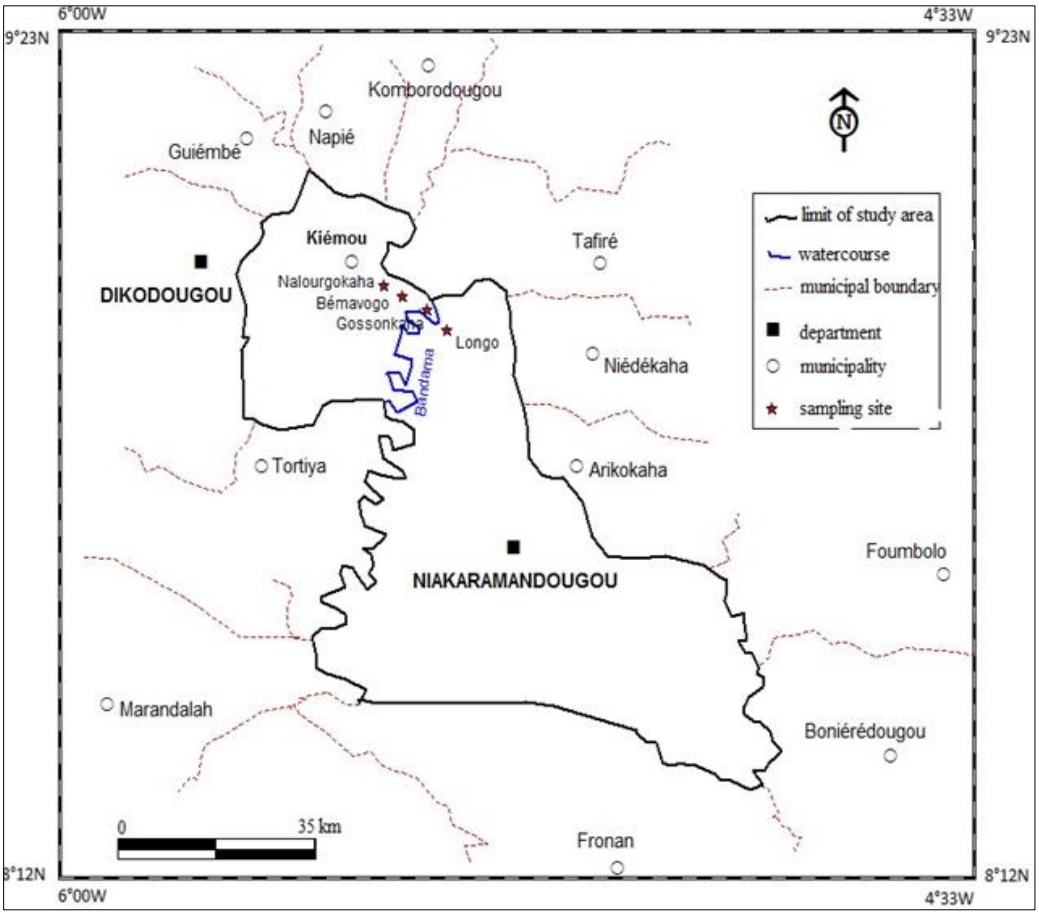

Fig. 1: Location map of study sites (Source: Administrative map of Côte d'Ivoire updated by Touré, 2017)

2.2. Collection of retrospective parasito-clinical data on malaria from 2012 to 2016 in the study sites

In order to provide to the malaria prevalence data, a retrospective survey based on health data collection was conducted in the study areas during the dry season. This survey consisted of consulting curative care registers and recording all reported cases of malaria (simple or severe) in the population and other diseases in the area, by health facility managers for 5 years from 2012 to 2016. This allowed us to compare the prevalence of malaria during the rainy and dry seasons. It is important to stress that our approach was not based on the implementation of a study on clinical cases of malaria. We only consulted health facility registers and recorded cases diagnosed as malaria. The following parameters were determined from the registers (number of consultations, number of sick cases, number of malaria cases diagnosed by RDT) of these health facilities: - malaria burden in relation to other diseases; - absolute frequency (headcount) of malaria cases in different localities from 2013 to 2016; - Relative prevalence of malaria during long dry seasons. Cumulative data over 5 years (2012 to 2016) provided a better appreciation of the level of malaria transmission. Insufficient data on malaria cases diagnosed by Rapid Diagnostic Test (RDT) in health facilities during 2012 did not allow the calculation of the absolute frequency of malaria cases for that year. It is important to note that only malaria cases diagnosed by RDT were used to calculate the frequency of malaria cases. The relative frequency was calculated as the quotient of the number of malaria cases diagnosed by RDT multiplied by 100 over the total number of patients diagnosed by RDT.

2.3. Study of malaria prevalence during long dry seasons

2.3.1. Administrative process

First, requests for authorisation to collect data from the regional health departments of the various study sites were sent to the Direction Générale de la Santé (DGS) and the Programme National de Lutte contre le Paludisme (PNLP), which responded favourably. Next, visits were made to village authorities to obtain their consent for data collection. Finally, a request for retrospective data on malaria was also sent to the Coordinating Director of the National Malaria Control Programme (NMCP) who, after having given his favourable opinion, sent a note to the regional health directors of the departments in the study area.

2.3.2. Prevalence assessment

The survey aims to compare data on the prevalence of malaria in the dry season and to investigate the factors that may influence it. More specifically, the percentage of RDT-positive individuals in an area without a permanent watercourse was compared with that in an area near a permanent watercourse. This prevalence was determined by the following formula:

$$\text{Prevalence (\%)} = \frac{\text{(Number of TDR+ individuals)}}{\text{Number of individuals diagnosed by RDT}} X100$$

As data on RDT-diagnosed malaria cases in the villages of Longo and Bémavogo were not available for the other years, the prevalence of confirmed malaria was calculated only for the year 2016.

2.4. Data analysis

All data were entered using Excel version 2013. STATA 14.0 software (Stata Corporation; College Station, TX, USA) was used for statistical analyses. The $\chi 2$ test was used to compare relative malaria case frequencies and abundances between sites and seasons.

3. Results

3.1. Most frequent diseases in the health districts of Niakaramandougou and Korhogo in the dry season

In the Niakaramandougou and Korhogo health districts (HDs), malaria is the most frequent disease with 71.88% (Fig. 2) and 62.11% (Fig. 3) of cases of pathologies respectively, followed by respiratory infections, diarrhoeal diseases, anaemia, dermatoses, etc.

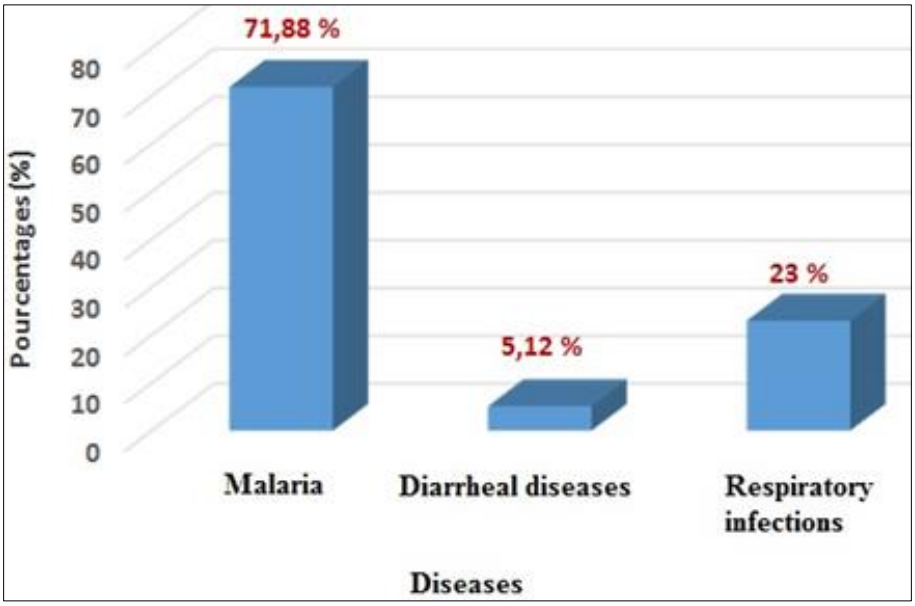

Fig 2: Situation of the most frequent pathologies in the health district of Niakaramandougou (Côte d'Ivoire) from 2012 to 2016

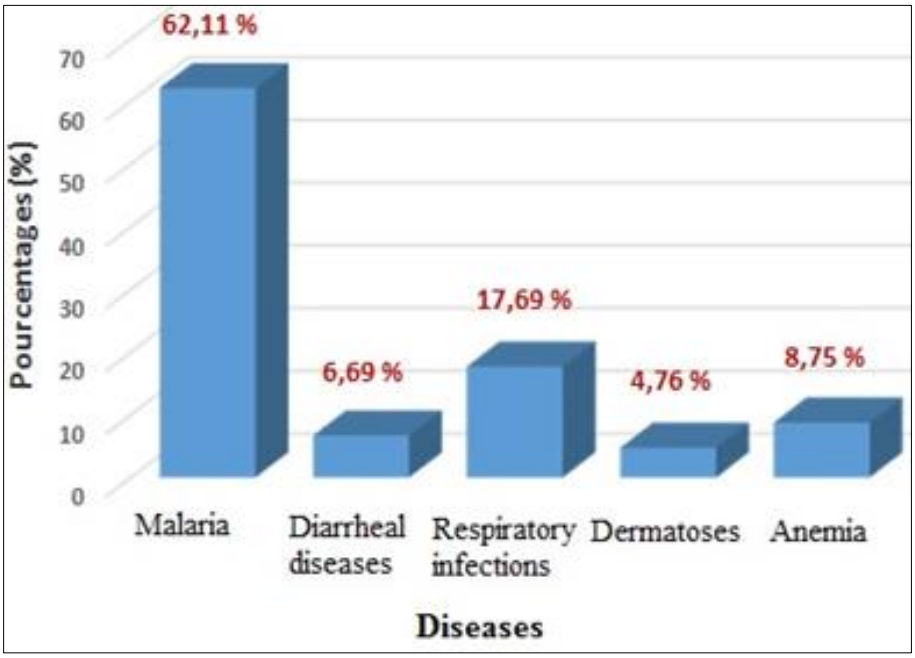

Fig 3: Situation of the most frequent pathologies in the dry season in the health district of Korhogo (Côte d'Ivoire) from 2012 to 2016

3.2 Seasonal prevalence of clinical malaria in the study sites from 2013 to 2016

Malaria cases were recorded in both rainy and dry seasons in both sites. The prevalence of clinical malaria was higher in the rainy season than in the dry season in both sites with larger fluctuations for the Longo/Gossonkaha site from 2013 to 2016. In the Longo/Gossonkaha and Bémavogo/Nalourgokaha sites, this prevalence was 25.27% and 12.63% in the rainy season respectively whereas in the dry season the frequency was 8.69% and 3.53% (Table I). Respectively in the Longo/Gossonkaha and Bémavogo/Nalourgokaha sites from 2013 to 2016, the annual prevalence's of malaria by season are globally higher in the Longo/Gossonkaha site than in the Bémavogo/Nalourgokaha site.

3.3. Prevalence of malaria cases in Longo and Bémavogo

The prevalence of confirmed malaria in the largest village in each of the study sites was determined on the basis of data collected on Rapid Diagnostic Tests (RDTs) at health centres in 2016. These are the villages of Longo (Longo/Gossonkaha site) and Bémavogo (Bémavogo/Nalourgokaha site). It is higher in the rainy season than in the dry season in both villages, with a greater fluctuation in the village of Longo. In the dry season the prevalence was 7.13% (05.30-09.34) in Longo village and 3.08% (02.10-04.33) in Bémavogo (Table II).

Table 1: Seasonal prevalence of clinical malaria from 2013 to 2016 in Longo/Gossonkaha and Bémavogo/Nalourgokaha sites

	Years	Seasons	Num of cases	Total patients	prevalence (%)	IC-95%	P
	2013	Rainy season	296	1052	28.143[a]	[22.81-33.08]	—
		Dry season	88	640	13.75[b]	[06.75-21.25]	0.0038
	2014	Rainy season	225	1123	20.03[a]	[14.77-25.22]	—
		Dry season	72	667	10.79[b]	[03.77-18.23]	0.0412
Longo/Gossonkaha	2015	Rainy season	247	1077	22.93[a]	[17.75-28.24]	—
		Dry season	30	640	04.68[a]	[04.32-16.28]	0.0298
	2016	Rainy season	339	1129	30.02[a]	[25.12-34.87]	—
		Dry season	44	777	11.07[b]	[01.70-20.24]	0.0041
	Total	Rainy season	1107	4381	25.27[a]	[22.45-27.55]	—
		Dry season	234	2724	08.59[b]	[04.52-11.47]	<0.001
	2013	Rainy season	138	1130	12.21[a]	[06.58-17.42]	—
		Dry season	42	1041	04.03[a]	[01.92-09.92]	0.0662
	2014	Rainy season	148	1101	13.44[a]	[07.58-18.41]	—
		Dry season	58	1425	04.07[b]	[01.04-09.04]	0.0289
Bémavogo/Nalourgokaha	2015	Rainy season	128	1176	10.88[a]	[05.58-16.42]	—
		Dry season	51	1603	03.18[b]	[01.68-07.68]	0.0434
	2016	Rainy season	146	1028	14.2[a]	[08.37-19.62]	—
		Dry season	35	1058	03.31[b]	[02.65-08.65]	0.0354
	Total	Rainy season	560	4435	12.63[a]	[10.21-15.75]	—
		Dry season	186	5127	03.63[b]	[01.18-06.81]	<0.001

IC-95%: interval to 95% Mean values followed by the same letter are statistically equal at the 5% level according to the Fisher test and p: probability associated with the ANOVA test

Table 2: Seasonal prevalence of confirmed malaria in Longo and Bémavogo in northern Côte d'Ivoire during 2016

		Seasons	Num of RDT Performed	Num of RDT+	Prevalence (%)	IC-95%
		RS	932	291	31,22	[28.26-34.31]
	Longo	DS	673	48	7,13	[05.30-09.34]
Villages		RS	837	126	15,05	[12.70-17.66]
	Bémavogo	DS	1036	32	3,08	[02.10-04.33]

RDT: Rapid Diagnostic Test; **+**: Positif; **RS**: Rainy season; **SS**: Dry season

4. Discussion

The longevity of Anopheles gambiae and its ability to adapt to unfavourable conditions for survival are parameters that play an important role in the maintenance of malaria transmission during the long dry season and in the endemicity of this parasitosis. Parasitological and clinical surveys have been carried out on malaria through the long dry season when transmission of the disease is assumed to be low or nil.

At the level of the health districts, malaria is the leading cause of consultation, followed by respiratory infections and diarrhoeal diseases in both health districts. The majority of suspected malaria cases are submitted to rapid diagnostic tests. This primacy of malaria over other diseases is due to the existence in these two districts of numerous watercourses and developed lowlands used for rice cultivation, as is the case in Kafiné (Niakaramandougou department) and Sékongokaha (Korhogo department). This strong implication of rice cultivation in the pullulation of malaria vectors was observed in Kafiné by Doannio *et al.* [8] who showed that rice fields were evolutionary environments where different types of biotopes more or less favourable to Anopheles, and particularly to An. gambiae, follow each other. Rice fields offer potential breeding grounds for Culicidae, which favours the emergence of malaria [9; 10; 11]. Higher frequencies of malaria cases in the rainy season than in the dry season at both sites were recorded with significant fluctuations at the Longo/Gossonkaha site. The frequency of malaria cases in the dry season is thought to be due to water from domestic activities of the population (household activities, cultivation practices and livestock activities) which serve as breeding grounds for mosquitoes waiting to lay their eggs. Our results are consistent with those of a study conducted in Côte d'Ivoire by Tia and colleagues in 2016 [12]. This study showed that domestic water tanks during the dry season would constitute relay sites for Anopheles and would participate in malaria transmission at this period. The important fluctuation of the prevalence in the Longo/Gossonkaha site compared to the Bémavogo/Nalourgokaha site would be due to the fact that the first site has different hydro geographical characteristics than the second. Indeed, the Longo/Gossonkaha site is bordered by the Bandama River which is a permanent watercourse.

Thus, while the classical breeding sites disappear during the dry season, the river that borders this site would retreat from its bed, leaving room for the formation of relay breeding sites for mosquitoes in general and Anopheles in particular. The results of malaria case frequencies and prevalence obtained from retrospective data showed that malaria transmission does not stop during the long dry seasons in the study area. A previous study conducted in Korhogo health district was recorded a high prevalence of malaria (7.7%) During the dry season (13). This explains why elsewhere in Côte d'Ivoire malaria transmission is permanent in all seasons.

5. Conclusion

The collection of parasito-clinical data in the health facilities shows that during the dry season, malaria is the first cause of consultation, followed by respiratory infections and diarrhoeal diseases in the two health districts. A relatively high frequency of malaria cases associated with a non-negligible prevalence was noted in the dry season. Malaria transmission in both sites during the long dry seasons remains a concern. Control efforts should not only be deployed during the rainy season. They must also cover the dry season for greater effectiveness.

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