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Eco-Epidemiological Characteristics of Human Rabies in Côte d'Ivoire, 2012-2017

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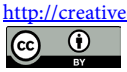


Abstract

Introduction: Human rabies is a major public health problem in many African countries, including Côte d'Ivoire. The present work aims at describing the eco-epidemiological characteristics of human rabies cases recorded in Côte d'Ivoire. **Methods:** This was a retrospective and prospective cross-sectional descriptive study based on epidemiological surveillance data that ran from september 2014 to december 2017. The clinical data were extracted from the database of the human rabies epidemiological surveillance management service of the National Institute of Public Hygiene's rabies centre. These data cover the period from 1 January 2012 to 31 December 2017. **Results:** Human rabies is endemic in Côte d'Ivoire, with most people exposed in the south and especially in the west of the country. There was no association between any of the climatological parameters (temperature, humidity, rainfall) and the occurrence of human rabies during the months of exposure to rabies infection. **Conclusion:** Ultimately, effective prevention and control of human rabies requires a thorough understanding of the links between climatological parameters and rabies. Health authorities must take ownership of these results if we are to achieve our goal of eliminating rabies by 2030.

Keywords

Human Rabies, Season, Climate, Abidjan, Ivory Coast

1. Introduction

Rabies is enzootic in developing countries, which are considered high-risk regions due to the existence of canine rabies [1]. In Vietnam, Hanh found that the

occurrence of rabies in humans was not linked to climatological parameters [2], while Rifakis in India found that the incidence of different cases of animal rabies varied according to the season [3]. In Canada, on the other hand, researchers have noted that climate change can lead to changes in the habitat, hibernation period and reproductive capacity of reservoir animals, thereby affecting the distribution of this disease [4].

A number of studies carried out throughout the world have examined the epidemiological and clinical characteristics of human rabies cases [5]-[11]. In addition, some authors have indicated that rabies occurs during certain seasons without investigating the links between the season and rabies [12] [13] [14] [15] [16]. Few authors have studied the links between climatological parameters and human rabies [2] or animal rabies [3]. In Côte d'Ivoire, no study has been carried out on the links between climatic factors and rabies. The general objective of this study was therefore to describe the eco-epidemiological characteristics of cases of human rabies recorded in Côte d'Ivoire. The specific aim was to describe the seasonality of exposure to human rabies in Côte d'Ivoire and to determine a link between the period of exposure to rabies infection and climatological parameters.

2. Methods

2.1. Setting of the Study

The study took place in the Antirabies Centre of the Institut National d'Hygiène Publique.

2.2. Type and Period of Study

This was a retrospective and prospective cross-sectional descriptive study based on epidemiological surveillance data that ran from September 2014 to December 2017.

2.3. Study Population

All suspected, probable and confirmed cases of human rabies were notified to the Rabies Centre of the Institut National de l'Hygiène Publique. Also, cases of animal rabies were recorded by the Direction des Services Vétérinaires.

Inclusion and Non-Inclusion Criteria

We included in this study all cases notified to the Abidjan-Treichville rabies centre. Cases from other countries were not included in this study. included in this study.

2.4. Sampling

We used all the rabies cases contained in the Epi Info 3 database and the linear list of the National Institute's rabies centre. We also used the animal rabies cases on the linear list of the Office Vetenary Services.

2.5. Data Collection

Clinical data were extracted from the database of the human rabies epidemiological surveillance management service of the National Institute of Public Hygiene's rabies centre. These data cover the period from 1 January 2012 to 31 December 2017.

The historical meteorological data collected were rainfall, air temperature and relative humidity. The monthly meteorological data were taken from the website "Historical weather: weather archives for the whole world" [17]. This site is hosted by the French company BEWEST.

2.6. Data Entry and Analysis

The clinical data from January 2012 to August 2014 had already been entered into EpiInfo version 3.5.3 and we completed the data for September 2015 to December 2017. These data were analysed using the same Epi Info 3 software and Excel.

Meteorological data were entered using Excel. Statistical analysis of the data was performed using XLSTAT 2018 software, which was used to link the clinical and meteorological data.

The univariate analysis consisted of:

- Describing the epidemiological and clinical characteristics of human rabies cases in Côte d'Ivoire from 2012 to 2017;
- Determining the seasonality of rabies;
- Calculating the inter-annual and intra-annual values of meteorological parameters;
- Calculating the inter-annual and intra-annual correlation between human rabies and the meteorological parameters or climatic factors studied (rainfall, temperature and relative humidity).

2.7. Production of the Umbrothermal Diagram

We produced a diagram showing the temperature and rainfall curves for the twelve months. The ordinate should be graduated so that P = 2T. This makes it possible to represent the annual pattern of precipitation and temperature and to appreciate the relationship between precipitation and temperature, since drought occurs when the temperature curve rises above the precipitation curve [18].

2.8. Ethical Considerations

We have respected the confidentiality of the data collected and anonymity has been respected.

3. Results

3.1. General Results

3.1.1. Data on the Number and Incidence of Cases of Human Rabies

During the period 2012-2017 (**Table 1**), a total of 111 cases of human rabies

Table 1. Distribution of human rabies cases, Côte d'Ivoire, 2012-2017 (N = 111).

Year	Cases of human rabies	Annual incidence of human rabies cases per 100,000 population
2012	21	0.09
2013	21	0.09
2014	15	0.07
2015	17	0.08
2016	18	0.08
2017	19	0.08
Total	111	0.08

were notified, representing an average of 15.5 cases per year. The number of annual human rabies cases decreased from 21 in 2012 to 19 in 2017 with a minimum of 15 cases in 2014. As a result, the estimated annual incidence rates are between 0.07 and 0.09 cases of human rabies per 100,000 inhabitants.

3.1.2. Spatial Distribution of Human and Canine Rabies in Côte d'Ivoire

From 2012 to 2017 (Figure 1), the Institut National d'Hygiène Publique counted 107 cases of human rabies throughout the country, with the majority in the suouth-west.

3.2. Seasonality of Exposure to Human Rabies in Côte d'Ivoire

3.2.1. Comparison of Seasonal Proportions of Human Rabies Cases in Côte d'Ivoire at the Time of Exposure

During the period 2012-2017 in Côte d'Ivoire, 72% of people who died were exposed to rabies during the rainy season. However, there was no significant difference between the seasonal proportions of months of exposure to human rabies and years.

3.2.2. Seasonal Distribution of Probable Human Rabies Cases by Month of Exposure

Overall, Figure 2 shows a fluctuating increase in rabies exposure data from 2012 to 2017 with 24 exposure cases in the first quarter (January, February and March) with a seasonal peak in February (11 cases), 28 cases in the second quarter (April, May and June) with a seasonal peak in June (11 cases), 26 cases in the third quarter (July, August and September) with a seasonal peak in August (10 cases) and 29 cases in the fourth quarter (October, November and December) with a high seasonal plateau in November and December (10 cases).

The coefficient of determination R^2 was 0.092, which shows that 9.2% of the variation in the incidence of human rabies is explained by the monthly variation in exposure over the 6 years. However, the variation in human rabies was not significantly associated with the month of rabies infection ($p > 0.05$).

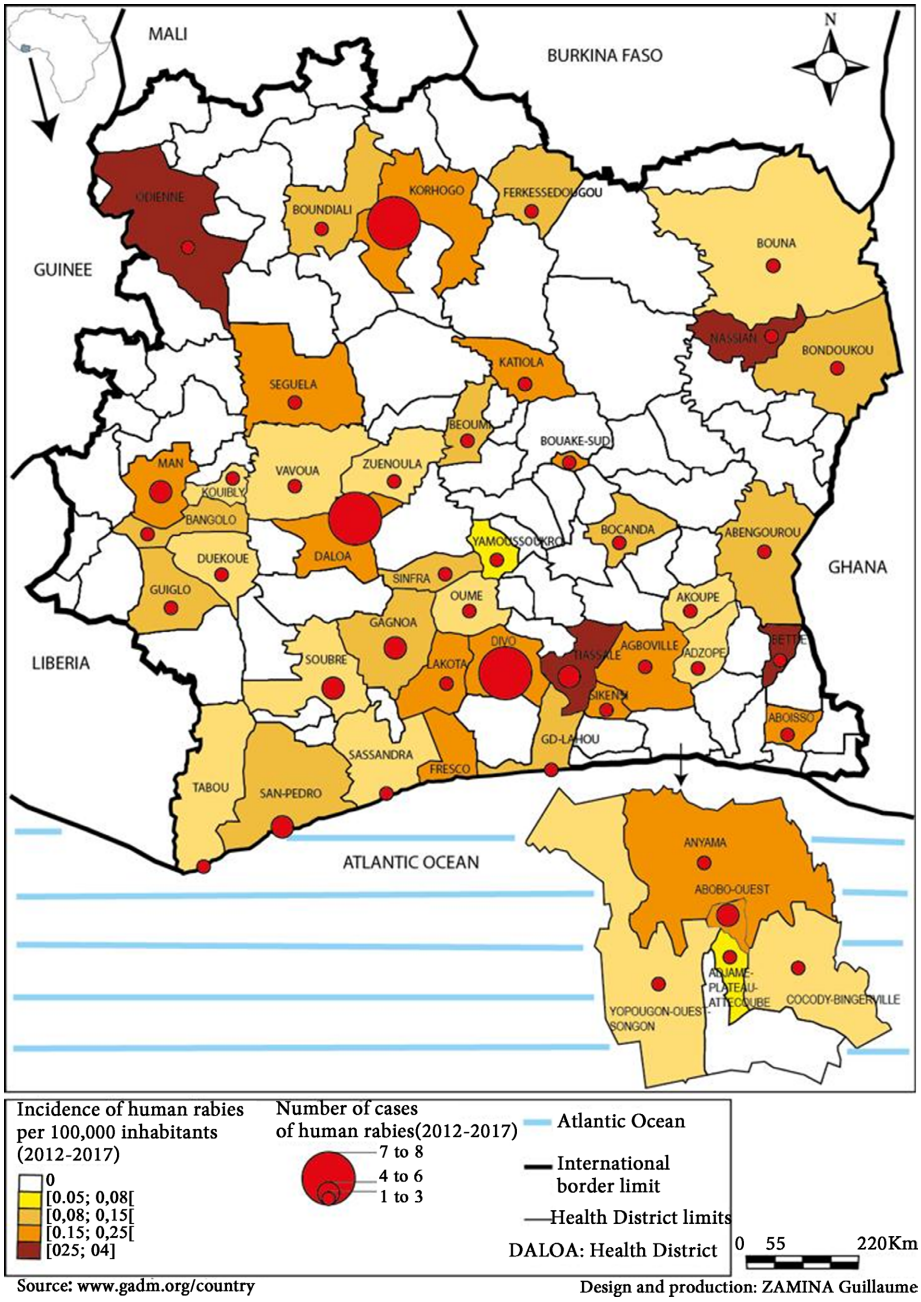


Figure 1. Spatial distribution of human rabies cases in Côte d'Ivoire, 2012-2017 (N = 111).

Table 2. Distribution of seasonal proportions of human rabies cases in Côte d'Ivoire at the time of exposure, 2012-2017 (n = 107).

Season (exhibition month)	Years of exposure to rabies infection							Total[a] (%)	p-value
	2011 n (%)	2012 n (%)	2013 n (%)	2014 n (%)	2015 n (%)	2016 n (%)	2017 n (%)		
rainy	2 (2.6)	14 (18.2)	18 (23.4)	7 (9.1)	11 (14.3)	13 (16.9)	12 (15.6)	77 (72)	0.222
dry	1 (3.3)	3 (10.0)	5 (16.7)	8 (14)	6 (20.0)	2 (6.7)	5 (16.7)	30 (28)	
Total[a]	3 (2.8)	17 (15.9)	23 (21.5)	15 (14)	17 (15.9)	15 (14)	17 (15.9)	107 (100)	

a: 4 people had no specified months of exposure.

3.3. Correlation between Probable Cases of Exposure to Rabies Infection and Climatological Factors during the Month of Exposure

3.3.1. Period of Exposure to Rabies Infection and Temperature Cases of Human Rabies

Figure 3(a) shows that the average temperature was lower from June to October (below 27˚C), while the number of cases of rabies infection fluctuated from January to December. There was a negative correlation (Figure 3(b)) between

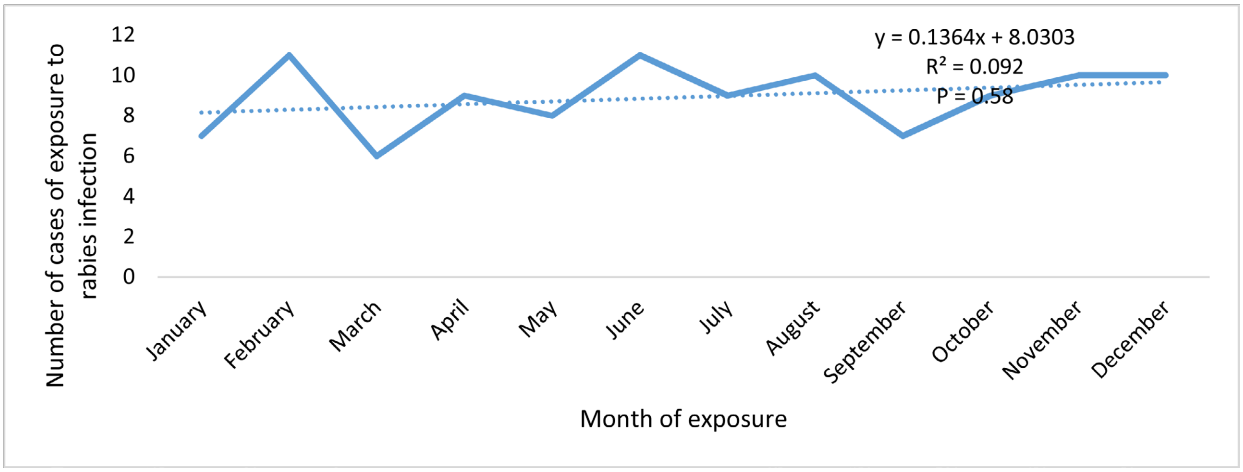
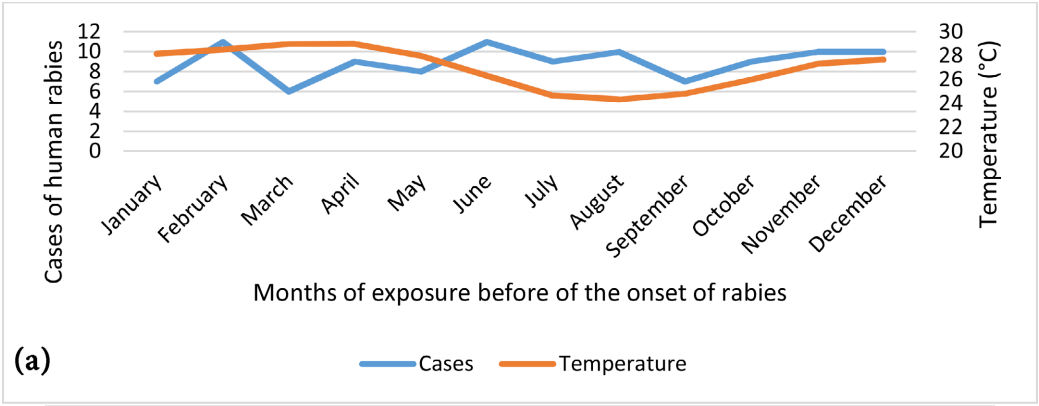
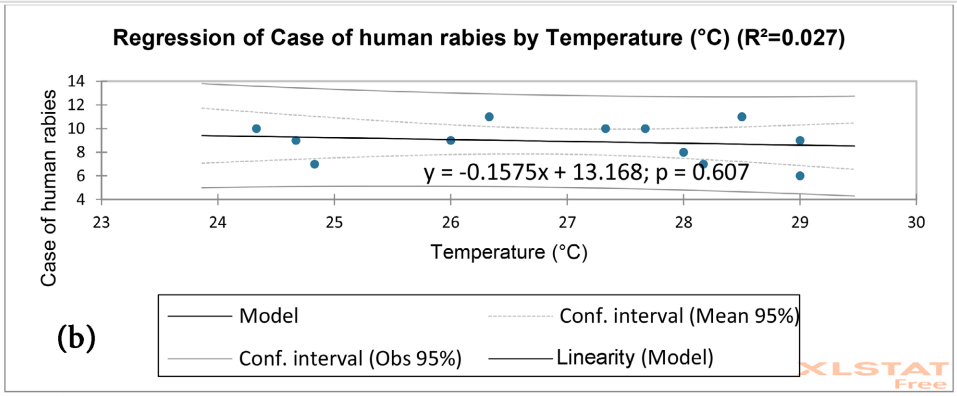


Figure 2. Seasonal distribution of exposure cases, Côte d'Ivoire, 2012-2017 (N = 107)





(n = 12 ; r = -0.16 ; p > 0.05)

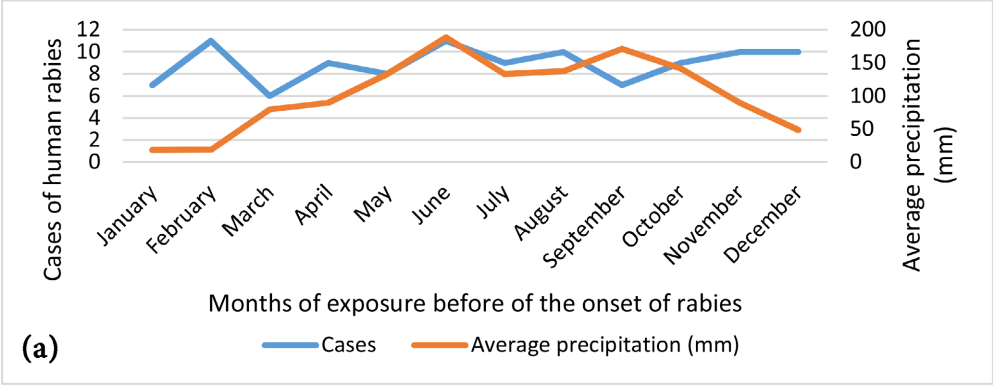
Figure 3. Monthly distribution of human rabies cases according to temperature, 2012-2017.

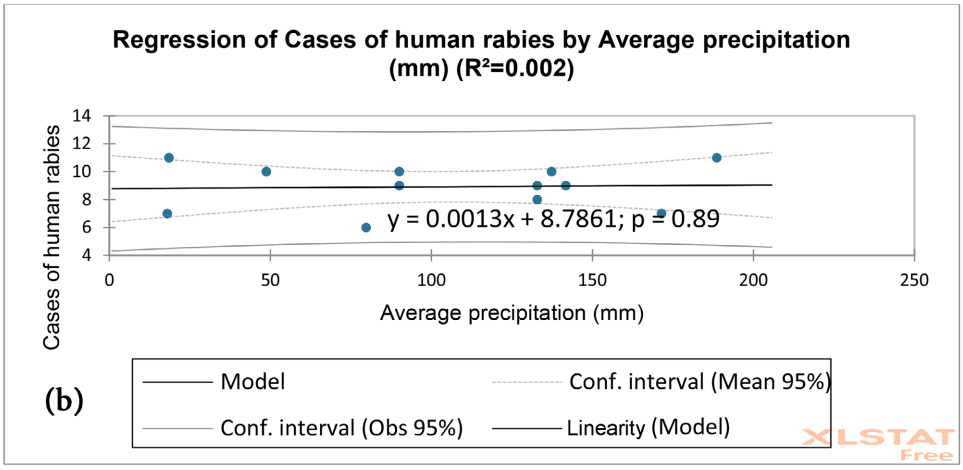
human rabies and temperature, with r = −0.16, reflecting the fact that an increase in temperature led to a decrease in the number of cases of human rabies. The coefficient of determination was 0.027, showing that 2.7% of the variation in the incidence of human rabies was explained by the variation in temperature. However, there was no significant correlation between the inter-annual (monthly) mean temperature and cases of rabies infection ($p > 0.05$).

3.3.2. Period of Exposure to Rabies Infection and Precipitation

Figure 4(a) shows that average rainfall increased considerably from January to June, reaching 188.57 mm, while the number of cases of exposure to rabies infection fluctuated with a maximum in February and June (11 cases). From June to December, average rainfall fluctuated downwards to 48.71 mm, while the number of cases of exposure to rabies infection increased, also fluctuating, with minima in July (9 cases) and September (7 cases).

There was a positive correlation Figure 4(b) between human rabies and rainfall, with r = 0.0013, reflecting the fact that an increase in rainfall led to an increase in the number of cases of human rabies. The coefficient of determination was 0.002, showing that 0.2% of the variation in the incidence of human rabies was explained by the variation in rainfall. However, there was no significant correlation between average inter-annual (monthly) rainfall and cases of exposure to





(n = 12; r = 0.0013; p > 0.05)

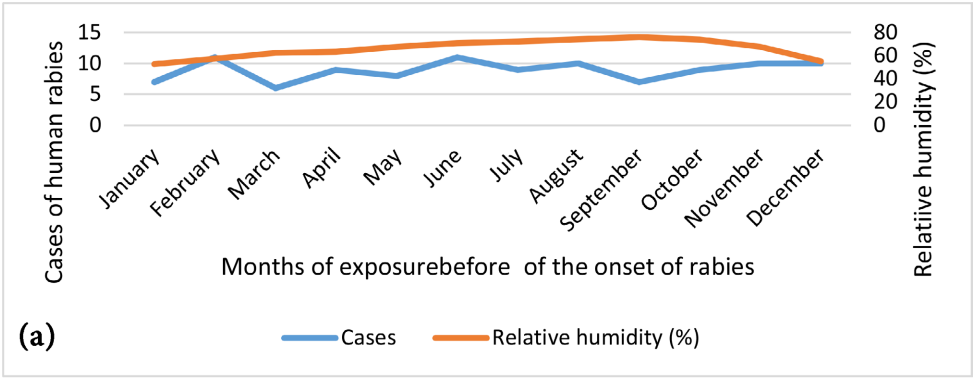
Figure 4. Monthly distribution of human rabies cases as a function of precipitation.

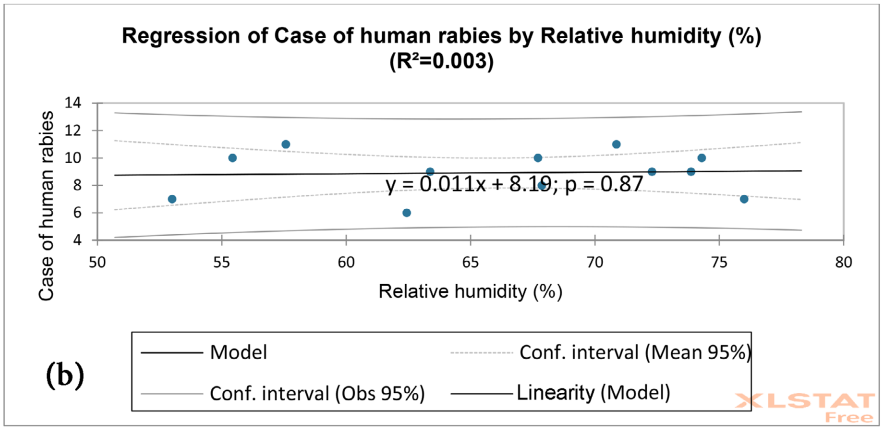
rabies infection ($p > 0.05$).

3.3.3. Period of Exposure to Rabies Infection and Humidity

Figure 5(a) shows that relative humidity increased from January to December, peaking in September (76%), while the number of cases of exposure to rabies infection fluctuated from January to December.

There was a positive correlation Figure 5(b) between human rabies and relative humidity, with $r = 0.011$, reflecting the fact that an increase in relative humidity led to an increase in the number of cases of human rabies. The coefficient of determination was 0.003, showing that 5.5% of the variation in the incidence of human rabies was explained by the variation in relative humidity. However, there was no significant correlation between inter-annual (monthly) average relative humidity and cases of exposure to rabies infection ($n = 12$: $r = 0.11$; $p > 0.05$).





($n = 12$; $r = 0.011$; $p > 0.05$)

Figure 5. Monthly distribution of human rabies cases according to relative humidity, 2012-2017.

4. Discussion

1) Spatial distribution of human and animal rabies cases in Côte d'Ivoire from 2014 to 2017

Dog rabies and human rabies were not present at the same time in some health districts. As a result, more cases of human rabies were notified than cases

of animal rabies. This finding could be explained by the fact that there was no real collaboration between human and animal health workers. However, Tiembré [19] has estimated that the evolution of human rabies is synchronous with that of canine rabies in time and place.

Canine rabies is the main cause of human rabies and is endemic in Côte d'Ivoire [20]. The main vector is the stray dog, which is responsible for infecting humans and domestic animals. Some animals, notably cats, can transmit rabies. Most of these animals roam freely, and the recrudescence of canine vectors is thought to increase during the rutting season.

2) Seasonal proportions of human rabies cases according to period of exposure

In Côte d'Ivoire, the majority of people who died were exposed to rabies infection during the rainy season. This season is thought to be favourable for hunting. During this period, human contact with dogs in rural areas could increase cases of exposure to rabies infection. In Bhutan, a South Asian country, Tenzin [15] found that most exposures to dog bites occurred in spring (40%) and winter (28%); respectively periods of snowmelt, milder weather and colder temperatures.

However, in our study, there was no significant difference between the seasonal proportions of months of exposure before the onset of rabies and the years. There were therefore just as many people exposed during the different seasons over the years. In animals, Kim [21] in Alaska in 2014 found seasonality in foxes. This characteristic is probably associated with reproductive cycles and winter feeding habits [22].

In our study, the majority of people died of rabies during the rainy season. In Henan province, China, Li [12] found that patients tested positive in all seasons, but most tested positive in the hot summer months. However, in our study, the seasonal proportions of months of human rabies deaths were not statistically associated with years. There were therefore just as many people who died in different seasons over the years.

3) Seasonal distribution of probable cases of rabies infection by month of exposure

For six years, there has been a fluctuating increase in data on cases of exposure to the rabies virus. Relatively high incidences of exposure are observed in the second and fourth quarters. The second quarter is the rainy season. The fourth quarter is the start of the dry season for the country as a whole. However, the variation in human rabies was not significantly associated with the months of exposure. Also, each of the climatological parameters (mean temperature, rainfall and relative humidity) was not significantly correlated with the occurrence of monthly cases of human rabies exposure. Furthermore, the very low probabilities of significance (coefficient of determination $R^2 < 10\%$) obtained show that climatic conditions were not responsible for temporal exposure to rabies infection and that socio-environmental factors should be able to explain exposure to this disease.

5. Conclusion

Exposure to rabies infection does not occur during a particular season. Human rabies is endemic in Côte d'Ivoire. Moreover, it affects all geographical areas of the country, in this case the South-west. However, the study found no link between any of the climatological parameters (temperature, humidity, rainfall) and the occurrence of human rabies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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