Journal: Texila International Journal of Public Health
Publisher: Texila International Journal
ISSN: 2520-3134
Volume 13 Issue 4, 2025
DOI: 10.21522/TIJPH.2013.13.04.Art026

Seasonality of COVID-19 Transmission in Tropical Countries: The Case of the Health Districts of Kati and Commune VI of Bamako in Mali

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Abstract

The existence of seasonality in COVID-19 transmission remains a major concern in the management of COVID-19 outbreaks. To answer this question, we conducted a retrospective cohort study using epidemiological surveillance data from the health districts of Kati and Commune VI of Bamako. The data was collected between January 1, 2021 and December 31, 2021. Two semi-structured questionnaires included 114 cases of COVID-19, including 43 symptomatic and 71 asymptomatic, for whom 1227 contacts were identified and followed daily for 14 days. Our results showed that 112 of the contacts followed developed the disease, i.e. an incidence rate of 9.1%. The sex ratio was 1.5 in favour of the female sex. The incidence rate was higher in the dry season with 13.2% 95% CI [10.3 - 16.7] compared to 6.7% 95% CI [4.6 - 9.4] in the cool season and 5.8% 95% CI [3.4 - 9.2] in the winter period. Also, the risk of contracting COVID-19 for exposed contacts was 2.25 times higher in the dry season compared to other seasons (RR=2.25 95% CI [1.55 - 3.28]). Incidence rates were higher for average temperatures between 28 and 34 degrees Celsius, the same is true for humidity between 19 and 37%. The dry season has been identified as favorable for the transmission of COVID-19 in our study area. As a result, response measures must be stepped up before and during the dry season.

Keywords: *COVID-19, Kati and Commune VI Health Districts, Seasonality, Transmission.*

Introduction

The COVID-19 virus, since its discovery in Wuhan in December 2019, has spread throughout the planet and was declared a pandemic by the World Health Organization (WHO) on March 11, 2020 [1]. Indeed, scientific evidence shows that COVID-19 is transmitted mainly through aerosol droplets and direct contact with soiled surfaces [2]. Despite this evidence, the level of knowledge about the COVID-19 epidemic remains low today.

According to the results of the studies carried out, the natural history of COVID-19 is not well known, the incubation time varies from 1 to 14 days with an average of 5 days as for Severe Acute Respiratory Syndrome (SARS). The reproduction number of the disease (R0 or R) lacks precision in the different estimates. At the beginning of the epidemic, the WHO announced the reproduction number of 1.4 to 2.5; A study done in China finds 2.38 [3] while the analysis of data from 11 European countries finds a value of 3.87 [3.0 to 4.7] [4].

Received: 20.02.2025 ***Accepted: 03.11.2025*** ***Published on: 24.12.2025***
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The literature accepts that patients with asymptomatic COVID-19 (healthy carriers) can transmit the disease [18]. However, the transmission of infectious diseases remains dependent on several determinants, including environmental, biological, genetic and socio-behavioural factors. Regarding the ecological aspects of COVID-19, studies have shown that transmission is lower during the summer month in temperate countries [5]. This corroborates with the seasonality of endemic respiratory viruses, including influenza and other endemic coronaviruses (CoVs) in temperate countries [5]. Also, seasonal waves have been clearly observed in the majority of temperate regions, in tropical and subtropical countries, where peaks occur sporadically throughout the year, with the discovery of new variants. The rainy season is consistently correlated with peaks, as shown in studies by Shek and Col de Viboud [6,7]. Yang [8] reported an increase in viral transmission during the rainy and wet seasons. This seasonality of COVID-19 would explain the low rates of positive cases and deaths recorded in Africa. Indeed, as of September 7, 2021, 7,926,999 confirmed cases have been recorded with 200,045 deaths in 55 African Union Member States against 220,626,513 confirmed cases with 4,566,532 deaths worldwide [9].

Indeed, Sajjad et al. concluded that epidemic areas at the global level are located within the average temperature corridors of 5 to 11 ◦C, with low humidity levels of 4 to 7 g/m3 [10]. This trend has been observed by Bukhari et al. between the northern and southern states of the United States, with many cases recorded in regions with low temperatures (4 to 10° C) and low humidity (3 to 9 g/m3) [11]. Also, James H et al. find in their study a considerable difference between the cases and deaths recorded between North Africa (a slowdown during the summer season) and South Africa (an increase in the winter period) from May [5]. Biologically, heat and humidity are known to reduce the transmission of respiratory viruses.

In Mali, the first 2 cases of COVID-19 were reported on 25/03/2020, and as of 18 June 2023, 33,151 confirmed cases, including 743 deaths, were recorded [12]. To our knowledge, there is no data in Mali on the number of secondary cases an infectious person can generate or contaminate. In addition, the climatic effects on COVID-19 transmission in the epidemic district have not been documented in this country. It has also been noted that at the global level, the impact of environmental factors on the transmission of respiratory viruses is understudied [5].

This study is situated in this context to contribute to understanding the epidemiology of COVID-19 through analysis of seasonal variation in incidence rates.

Materials and Methods

Scope of the Study

The study took place in two health districts, namely commune VI of the District of Bamako, which has a Reference Health Center (CSREF) (Figure 1, *Source: CPS-SS-DS-PF, MSDS, 2020, Health card of Mali*) for 12 health areas covering a population of 741,811 inhabitants, and the Kati health district in the Koulikoro region (Figure 2, *Source: CPS-SS-DS-PF, MSDS, 2020, Health card of Mali*), which has a CS Ref and 46 Community Health Centers (CSCom) with a population of 792,307 inhabitants in 2024 [13].

Figure 1. Health map of commune VI of the District of Bamako

Source: CPS-SS-DS-PF, MSDS, 2020, Health card of Mali

Figure 2. Health map of Kati district

Source: CPS-SS-DS-PF, MSDS, 2020, Health card of Mali

Type and Period of the Study

We conducted a retrospective cohort study with data from the epidemiological surveillance of COVID-19 cases and their contacts followed from January 01, 2021 to December 31, 2021.

Study Population

Our study population consisted of 114 cases confirmed by reference laboratories and listed in the labline of the national response coordination committee. There were 43 symptomatic cases and 71 asymptomatic cases, among whom 1227 contacts were identified and followed daily for 14 days after identification. Also, meteorological data from Bamako's monthly bulletins for 2021 were used to cross-reference with the climatic seasons.

The sample of index cases was constituted through a systematic random selection of confirmed cases on the linear list of the laboratory (labile COVID-19 of the Ministry of Health and Social Development). Index cases and contacts were included based on the criteria below:

Inclusion Criteria

1. Have a file with health facilities and be registered on the linear list or in the DHIS2 COVID Tracker instance for confirmed cases.
2. Be identified by one of the health structures and have a contact tracing sheet or be entered into the DHIS2 COVID Tracker instance for contact cases.

Exclusion Criteria

Any cases that do not have a usable/complete file, including the various forms of the DHIS2 COVID Tracker instance.

Data Collection

Two semi-structured questionnaires were used to collect data from health facilities (CS Ref Commune VI and CS Ref of Kati).

Data Processing and Analysis

Data processing and analysis were performed using SPSS version 21 and Excel. Chi2 was used for the comparison of proportions and risk ratio was used to assess the association between seasonality and COVID-19. The results were significant for a $p < 5\%$ (Figure 3 Source: *Current study)*.

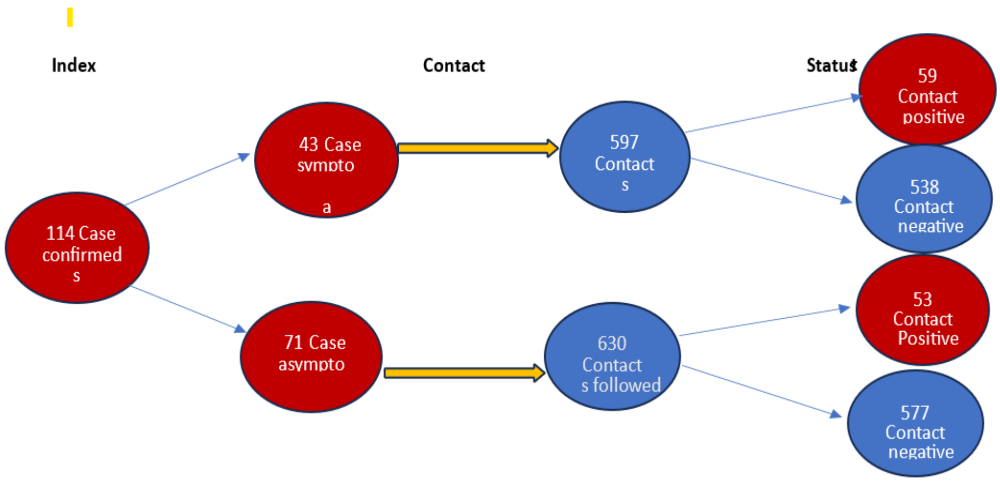

Figure 3. Design of the Study

Source: Current study

Ethical Consideration

This study used secondary data from epidemiological surveillance in the health districts of Commune VI of Bamako and Kati in the Koulikoro region. The study protocol was approved by the ethics committee of the National Institute of Public Health (INSP) of Mali (Decision No. 10/2023/CE-INSP).

Results

Socio-Demographic Characteristics

Distribution of Participants by Gender

The sex ratio was 1.2 in favor of males for index cases and 1 for followed contacts, i.e., 50% for each sex (Figures 4 and 5, Source: *Current study*).

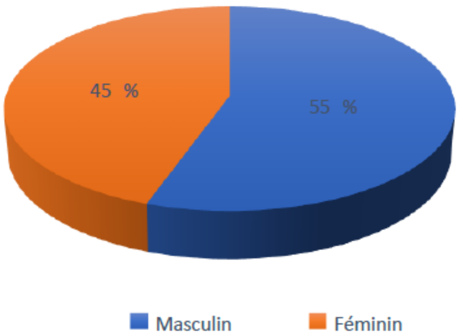

Figure 4. Distribution by sex of the 114 index cases from January 1 to December 31, 2021 in the health districts of Commune VI and Kati.

Source: Current study

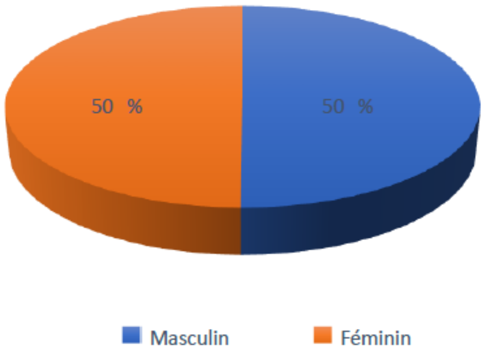

Figure 5. Distribution by sex of the 1227 contacts followed from January 1 to December 31, 2021, in the health districts of Commune VI and Kati.

Source: Current study

Distribution of Participants by Age Group

The average age was 35.9 years ± 15.6 years for index cases and 25.1 years ± 15.9 years for followed contacts. We found that 69.3% of index cases and 56.8% of contacts followed were in the 18-50 age group. Those under 18 years of age accounted for 9.7% of index cases, and the age group 51 years and over was the least represented among the contacts monitored, i.e., 8.2% (Table 1, Source: *Current study*).

Table 1. Distribution of the 114 index cases and 1227 contacts followed from January 1 to December 31, 2021, in the health districts of Commune VI and Kati by age group

Age range (years)		Index cases	Contacts followed
Less than 10	Number	2	188
	%	1,8	15,3
	95% CI	0,5 ; 6,2	13,4 ; 17,4
11 to 17	Number	9	242
	%	7,9	19,7
	95% CI	4,2 ; 14,3	17,6 ; 22,0
18 to 50	Number	79	696
	%	69,3	56,8
	95% CI	60,3 ; 77,0	53,9 ; 59,5
51 and over	Number	24	101

	%	21,1	8,2
	95% CI	14,6 ; 29,4	6,8 ; 9,9

Source: Current study

Analysis of Secondary Contamination Rates

The secondary contamination rate was 9.9% for contacts exposed to symptomatic cases compared to 8.4% for those exposed to asymptomatic cases. Contacts of symptomatic cases were at higher risk of secondary infection than those of asymptomatic cases (Table 2; Source: *Current study)*.

Table 2. Distribution of positive contacts by the presence of symptoms or not in the index case

Status Contact Tracking		**Index cases**		**Total**
		Asymptomatic	**Symptomatic**	
Negative	Number	577	538	1115
	%	91,6	90,1	90,9
Positive	Number	53	59	112
	%	8,4	9,9	9,1
Total	Number	630	597	1227

Chi-Square = 0.79, p=0.37; RR=1.19 95% CI (0.81, 1.76), Source: Current study

The table below shows that 112 contacts have become positive out of 1227 contacts followed, i.e. a positivity rate of 9.1%. The rate of secondary infection was higher in females with 11.1% (95% CI [8.7 - 13.9]) compared to 7.2% (95% CI [5.3 - 9.6]) for males, i.e. a ratio of 1.5 in favour of females (Table 3, Source: *Current study)*.

Table 3. Positivity rate of the 1227 contacts followed in the study area by sex

Status	**Sex n (%)**		**Total**
	Feminine	**Masculine**	
Negative	547 (88,9)	568 (92,8)	1115 (90,9)
Positive	68 (11,1)	44 (7,2)	112 (9,1)
95% CI	8,7 ; 13,9	5,3 ; 9,6	7,6 ; 10,9
Total	615	612	1227

Chi2= 5,5 et p=0,019, Source: Current study

Analysis of the Incidence Rate According to Seasonal Variation

The table below shows a link between seasonal variation and the level of COVID-19 contamination. The contamination rate was 13.2% (*95% CI [*10.3 - 16.7]) in the dry season compared to 6.7% (*95% CI [*4.6 - 9.4]) in the cool season and 5.8% (*95% CI [*3.4 - 9.2]) in the winter period (Table4, Source: *Current study)*.

Table 4. Determination of the secondary contamination rate by season

Status	**Season n (%)**			**Total**
	Cold	**Rainy season**	**Dry**	
Negative	421 (93,3)	260 (94,2)	434 (86,8)	1115 (90,9)
Positive	30 (6,7)	16 (5,8)	66 (13,2)	112 (9,1)
95% CI	4,6 ; 9,4	3,4 ; 9,2	10,3 ; 16,7	7,6 ; 10,9
Total	451	276	500	1227

Chi-Square =17,02; p < 0,001, Source: Current study

Regarding the relative risk, the figure below shows that the dry season was more favourable for COVID-19 transmission than other seasons, with a risk incidence of 2.25 and a 95% CI of [1.55 - 3.28]. Indeed, contacts exposed to COVID-19 cases during the dry season were 2.25 times more likely to be contaminated by COVID619 than those exposed during the winter or cold season (Figure 6, Source: *Current study)*.

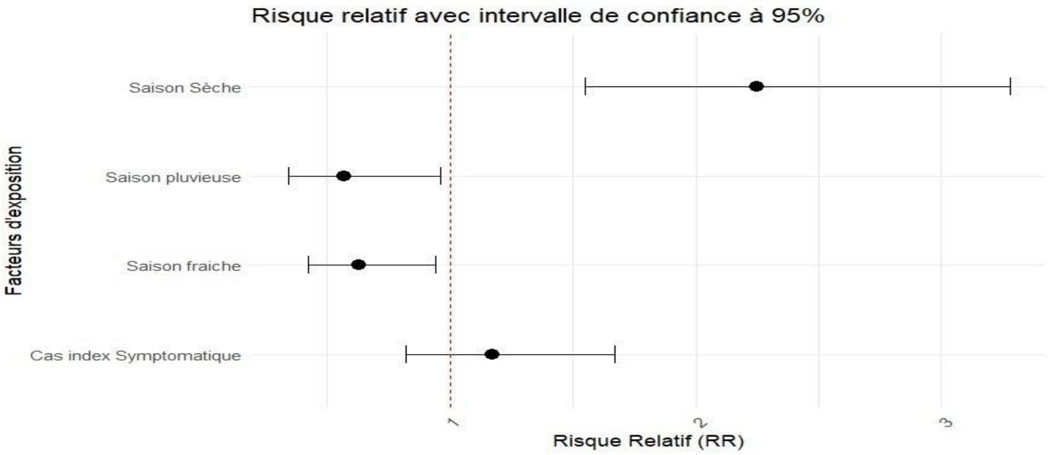

Figure 6. Relative risk of COVID-19 in the 1227 contacts followed from January 1, 2021 to December 31, 2021 by exposure factors.

Source: Current study

Analysis of the Incidence Rate According to the Monthly Change in Average Temperature

Contamination was higher in March followed by April with a monthly incidence of 16.8% and 12.9% respectively, followed by November (12.8%) and December (11.9%) and no contact identified and followed up in June became positive (0.0%) ($p < 0.001$).

In terms of the change in monthly impacts as a function of average temperature, the rate of contamination/transmission was higher for temperatures between 28 and 34 degrees Celsius. (Figure 7, Source: Current study).

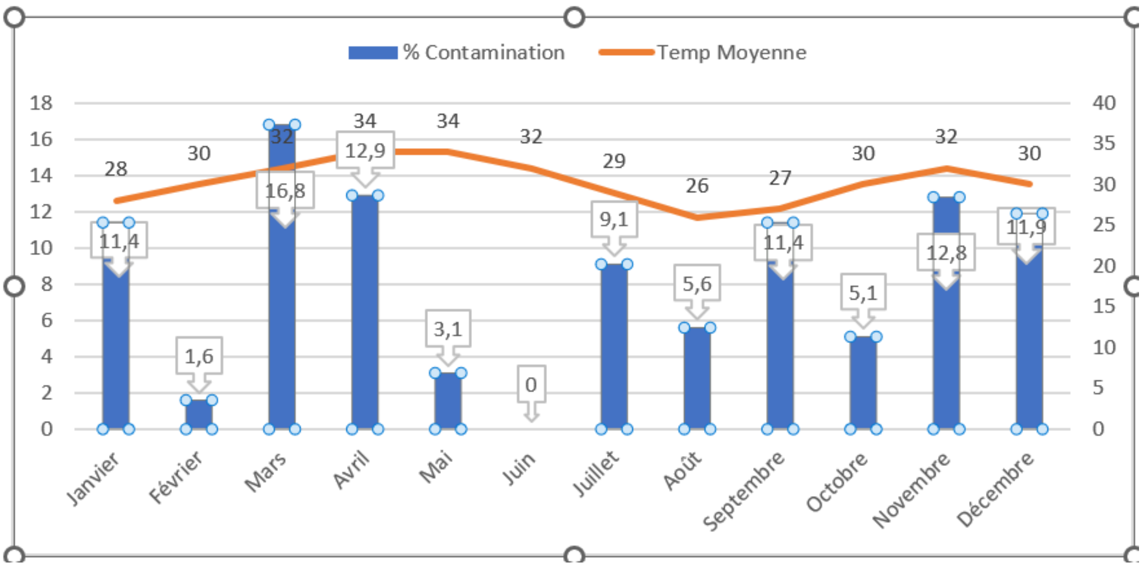

Figure 7. Monthly evolution of the Positivity rate among the 1227 contacts followed from January to December 2021 according to the average temperature in degrees Celsius

Chi-Square =44,84; p < 0,001, Source: Current study

The analysis as a function of humidity shows that transmission would be favoured by a humidity between 19 and 37%, the higher the humidity, the more confirmed cases decreased (Figure 8, Source: *Current study)*.

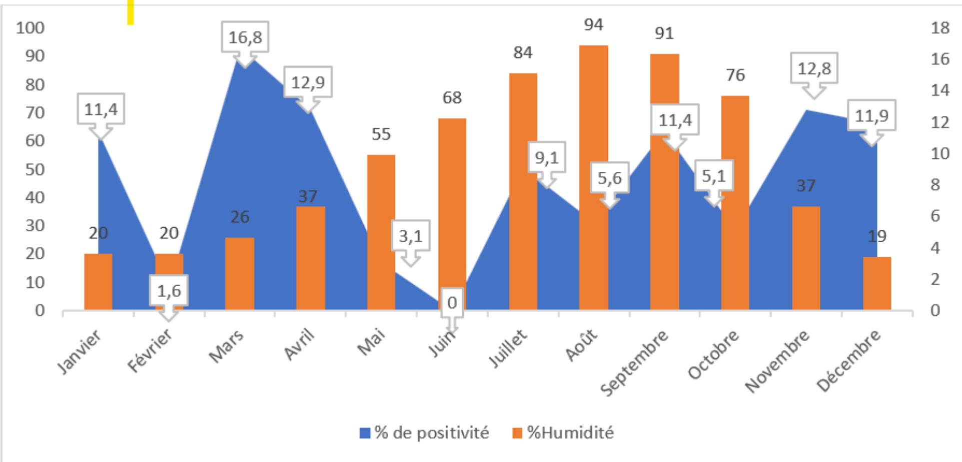

Figure 8. variation in the positivity rate as a function of humidity in the study area from January 1, 2021 to December 31, 2021

Source: Current study

Discussion

This cohort study carried out with 114 index cases and 1227 contacts followed daily for 14 days in the health districts of Kati and Commune VI of Bamako aimed to analyze the seasonality of COVID-19 transmission from January 1 to December 31, 2021. Our results confirm a link between seasonality and the risk of COVID-19 contamination. They also show that the dry season was more favourable for disease transmission in our study areas. Of the 1227 contacts followed, 112 developed COVID-19, with an incidence rate of 9.1%, 95% CI [7.6 - 10.9] (Table4). This rate was higher in females with 11.1% 95% CI [7.6 - 10.9] compared to 7.2% 95% CI [5.3 - 9.6] for males, i.e. a ratio of 1.5 in favour of females (p=0.019) (Table 3). The factors that may explain this predominance were not explored in our study. Our result is different from that of De Lusignan S et al, who in a British cohort study in primary care, found a predominance in men (OR = 1.55 95% CI [1.27 - 1.89]) [14].

For the analysis of COVID-19 incidence by season**,** the risk of COVID-19 for contacts was 2.25 times higher in the dry season compared to other seasons (RR=2.25, 95% CI [1.55 - 3.28]). We found an incidence rate of 13.2% 95% CI (10.3; 16.7) in the dry season versus 6.7% 95% CI (4.6; 9.4) in the cool season and 5.8% 95% CI (3.4; 9.2) in the winter period (Figure 6). This result is comparable to that of Sajadi et al, who found that the risk of being contaminated by COVID-19 is higher in a range of average temperatures of 5 to 11◦C with a low humidity level of 4 to 7 g/m3 [11]. Our results are inconsistent with those of Lagacé-Wiens P et al, who find that endemic coronaviruses and other common respiratory viruses cause annual seasonal outbreaks during the Canadian winter months [15].

In Mali, the dry season runs from March to May, the incidence rate found in our study was higher in March with 16.8% followed by April (12.9%) (Figure 7). This low rate in May and June coincides with the beginning of the wintering season. This result is consistent with the SitRep N°178 of the Ministry of Health of Mali where the peak of positivity occurred in the 14th and 15th epidemiological weeks with 14.7% and 11.7% respectively. These periods correspond to April 2021 [16]. This result is comparable to that of Peter J et al, who find low levels in periods of relative humidity (per 10%)

and absolute humidity (per 5g/m) with RTIs of 0.91 (0.85–0.96) and 0.92 (0.85–0.99) respectively [17].

For the analysis of monthly impacts based on average temperature, the rate of contamination/transmission is higher for temperatures between 28 and 34 degrees Celsius. In addition, transmission would be favored by a humidity between 19 and 37%. From a biological perspective, heat and humidity are known to affect the transmission of respiratory viruses negatively [18].

Conclusion

This cohort study, conducted in the health districts of Kati and Commune VI of Bamako, aimed to analyze COVID-19 transmission seasonality from January 1 to December 31, 2021.

Our results showed differences in incidence rates across seasons in Mali. The dry season from March to May has been identified as more favorable for COVID-19 transmission in our study areas than in others. This outcome needs to be taken into account in the mobilization of resources for the COVID-19 response, especially in this context of limited resources. There is a need to strengthen control measures before and during the dry season in response models for human-to-human diseases, including COVID-19.

Acknowledgement & Conflict of Interest

We want to thank in particular:

The heads of the Laboratory and the Department of Public Health Emergency Operations of the National Institute of Public Health of Mali.

The Chief Medical Officers and Surveillance Officers of the health districts of Kati and Commune VI of the District of Bamako shared their field experiences on the theme.

There is no conflict of interest. We funded the data collection and provided analysis and interpretation. We did not receive any sponsorship or funding for the production of this article.

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