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Association of Meteorological Factors With COVID-19 During Harmattan in Nigeria

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ABSTRACT: Harmattan is a season of dry, cold, dusty wind, and haze that is peculiar to West Africa. This season and COVID-19 share common conditions such as malaise and respiratory issues like as runny nose, cough and sneezing, and raise a question of a possible relationship that begs to be answered. This study investigated whether the meteorological factors of humidity and wind speed during harmattan have association with COVID-19 incidence and mortality in the 2 major COVID-19 epicenters of Lagos state and the Federal Capital Territory (FCT) in southern and northern geopolitical regions of Nigeria respectively. Data used were from March, 2020 to February, 2022, which corresponded to the period of 2 years after the first case of COVID-19 was detected in Nigeria. Correlation analysis was performed using incidence or mortality data on COVID-19 over the duration of 2 years and during the harmattan periods, as well as the humidity and wind speed data for the corresponding periods. Our results showed that there was no significant correlation between the humidity or wind speed and COVID-19 daily incidence or mortality during the harmattan and non-harmattan periods in Lagos state. In the FCT however, there was a significant positive correlation between humidity and COVID-19 incidence, as well as a negative correlation between wind speed and COVID-19 incidence. No significant correlation existed between humidity or wind speed and daily mortality. Taken together, the findings of this study show that weather components of the harmattan season have association with COVID-19 incidence but not mortality, and the association could vary depending on location.

KEYWORDS: COVID-19, harmattan, seasons, West Africa, Nigeria

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Introduction

Harmattan is a season that is peculiar to West Africa and usually occurs from the months of November to March.[1,2] This season is characterized by dusty winds, cold, low humidity, and haze. This is particularly so because of the north-east trade wind that moves south-westwards across the Sahara Desert to the West African region becomes lower in humidity, picking up fine dust particles and gets colder upon crossing the expanse of the desert.[2] The harmattan season falls within the wider dry season that alongside the rainy season constitute the 2 major seasons in west Africa. Cold temperatures are usually common during the harmattan period, but the dry dusty wind and temperature that could get warmer during the afternoon differentiate it from the winter experienced in other parts of the world.[3] The harmattan has been linked to exacerbation of health issues such as allergies, dehydration, asthma, hypertension, skin problems and respiratory infections, and environmental problems like air pollution and fire outbreaks.[1,4]

One of the most researched topics from the beginning of the Corona Virus Disease 2019 (COVID-19) pandemic till date is the association of weather and seasons with the spread of this disease. Interestingly, COVID-19 has symptoms similar to those manifested by people during the harmattan season like coughs, cold, catarrh, runny nose, and general feelings of malaise. Oftentimes during the harmattan season, it could be confusing to differentiate if symptoms are due to weather or COVID-19 infection or both. Questions also arise on the possibility of a relationship between harmattan and COVID-19. Some other infectious respiratory diseases, such as influenza and the severe acute respiratory syndrome (SARS) have been shown to be seasonal,[5-7] but there have also been conflicting reports on the association of seasons and weather elements with COVID-19 transmission and mortality.[8-15] While there is paucity of information amidst different reports from West Africa to address the question on harmattan and COVID-19,[16-19] at least one study conducted in some Nigerian cities has shown that some atmospheric parameters during harmattan can have correlation with COVID-19.[20]

Here in this study, we investigated the association between the weather components of humidity and wind speed during the harmattan season and COVID-19 incidence and mortality in Lagos state and the Federal Capital Territory (FCT) of Nigeria respectively. FCT is in the northern geopolitical region of Nigeria and suffers harsh harmattan conditions, whereas Lagos is in the southern geopolitical region of the country and only experiences mild harmattan conditions. Both locations have high COVID-19 burden, with Lagos having the highest number of cases in Nigeria and FCT having the highest number of cases for the northern part of Nigeria.[21]

Methods

FCT is a federal territory that contains the city of Abuja which is the administrative and political capital of Nigeria. It is located at the center of Nigeria in the North Central

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geopolitical zone and lies within latitude 8°50′N and longitude 7°10′E.[22] The territory has a recent projected population of about 3.56 million and a total land area of 7315 km^2.[22,23] On the other hand, Lagos state is the most populous state and the economic capital of Nigeria. It is in south western geopolitical zone of Nigeria and lies within latitude 6°35′N and longitude 3°45′E.[24] It is bordered by the Atlantic Ocean borders to the south. The state has a total land area of 3577 km^2 and a recent projected population of between 21and 35 million.[23-25]

Incidence and mortality data on Covid-19 from 1st March 2020 to 28th February 2022 were collected from the official website of Nigeria Centre for disease Control (NCDC) (www.ncdc.gov.ng) while the meteorological data, namely relative humidity and wind speed (between 6am and 12pm when normal human activities occur) that corresponds to periods of COVID-19 data were obtained from the weather unit of Time and Date AS (https://www.timeanddate.com/weather/) as previously described.[16] Humidity and wind speed were considered because they are key meteorological factors that change during harmattan periods. Harmattan periods in FCT were marked by average relative humidity values below 40%, but relative humidity below 60% for Lagos state. These threshold relative humidity values were determined by comparison of previously reported harmattan days at study locations with humidity data from Time and Date AS.[26-29] Data collected were imported into Microsoft Excel 2017 for trend line analysis. Descriptive and inferential statistics were performed in SPSS 23.0. The relationship between the COVID-19 variables (incidence and mortality cases) and meteorological variables (humidity and wind speed) were analyzed using the Spearman rank correlation test with the formula:

$$r_s = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$$

Where r_s is the Spearman correlation, S_{xy} is the covariance of the ranked variable, while $S_{xx}S_{yy}$ are the variances of the ranked variables. Test were performed at 95% probability level and considered significant when $P < .05$.

Results

Nigeria recorded the first incidence of COVID-19 on 27th February 2020 in Lagos through an Italian man that came into the country. Since then, the disease has spread to different parts of the country. Lagos state and the FCT rank first and second in terms of COVID-19 incidence and both are the epicenters of the disease for the southern and northern parts of Nigeria respectively. As at 28th February 2022, Nigeria has reported a total of 254, 525 cumulative cases and 3142 deaths from COVID-19.[30]

For the period of this study, 1st March, 2020 to 28th February, 2022, Lagos state recorded a total of 93 925 cases and 745 deaths, with a daily maximum incidence of 3393 confirmed COVID-19 cases and 79 confirmed COVID-10 deaths (Table 1). The mean incidence rate for COVID-19 in Lagos state was 136.72 ± 217.68 persons per day, while mean mortality rate for COVID-19 was 1.08 ± 4.61 person per day. Within the same period, the average humidity was 78.03% ± 7.903% and the average wind speed was 8.86 ± 3.04 km/h. There was no significant correlation between humidity (minimum, maximum, or average humidity) and either daily COVID-19 incidence or mortality within the period of this study in Lagos state. But there was a negative significant correlation between humidity (minimum, maximum, and average) and the cumulative daily incidence ($r = -.186$, $r = -.091$ and $r = -.166$; $P < .05$), as well as between humidity (minimum, maximum, and average) and the cumulative daily mortality ($r = -.194$, $r = -.099$ and $r = -.174$; $P < .05$) (Table 2). There was no significant correlation whatsoever between wind speed (minimum, maximum, or average) and any of COVID-19 incidence, cumulative incidence, mortality or cumulative mortality within the period of this study in Lagos state.

In the FCT, there was a total of 27 918 cases and 233 deaths during the 2-year period of this study, with a daily maximum incidence of 734 confirmed COVID-19 cases and 9 confirmed COVID-10 deaths (Table 1). The mean incidence rate for COVID-19 in the FCT was 40.64 ± 67.56 persons per day, while mean mortality rate for COVID-19 was 0.34 ± 0.88 person per day. Within the same period, the average humidity was 55.34% ± 23.84% and the average wind speed was 11.69 ± 9.69 km/h. There was no significant correlation between humidity (minimum, maximum, or average humidity) and daily COVID-19 incidence or mortality within the period of this study in the FCT. But there was a negative significant correlation between humidity (minimum, maximum, and average) and the cumulative daily incidence ($r = -.261$, $r = -.262$ and $r = -.271$; $P < .05$), and also between humidity (minimum, maximum, and average) and the cumulative daily mortality ($r = -.261$, $r = -.261$ and $r = -.270$; $P < .05$) (Table 2). Also, there was a negative significant correlation between wind speed (maximum and average) and daily COVID-19 incidence ($r = -.100$ and $r = -.092$; $P < .05$) (Table 2). No significant correlation existed between wind speed (minimum, maximum, and average) and either of daily mortality or cumulative daily mortality.

During the harmattan period that lasted for a total of 17 days in the 2-year duration of this study for Lagos state (see supplementary information), there was a total of 7574 COVID-19 cases and 4 confirmed COVID-19 deaths, with a daily maximum incidence of 3393 confirmed COVID-19 cases and 3 confirmed COVID-10 deaths (Table 3). The mean incidence rate for COVID-19 in Lagos state was 445.53 ± 870.39 persons per day, while mean mortality rate for COVID-19 was 0.24 ± 0.75 person per day. The average humidity was 48.26% ± 3.87% and the average wind speed was 8.24 ± 1.69 km/h. The correlation pattern observed in

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Table 1. Summary of COVID-19 pandemic and some meteorological factors in Lagos state and FCT, Nigeria (1st March, 2020 to 28th February, 2022).

VARIABLES	MEAN		SD		MINIMUM		P25		P50		P75		MAXIMUM	
	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT
DI	136.72	40.64	217.676	67.562	0	0	24	3	69	15	170	47	3393	734
CDI	42 900	13 400	29 910	9461	0	0	17 200	4777	51 400	17 700	69 800	20 500	93 925	27 918
DM	1.08	0.34	4.61	0.875	0	0	0	0	0	0	0	0	79	9
CDM	366.37	117.01	245.169	72.528	0	0	201	48	344	123	628	164	745	233
MINHUM (%)	69.82	46.07	10.586	23.581	24	6	65	24	70	46	76	67	98	94
MAXHUM (%)	86.24	64.5	6.228	25.581	54	12	83	41	86	73	90	87	100	100
AVEHUM (%)	78.03	55.34	7.903	23.843	42	10	74.5	33	78	59	82.5	77	99	96
MINWS (km/h)	5.67	5.13	2.879	5.321	0	0	4	0	6	4	7	9	15	23
MAXWS (km/h)	12.05	18.25	3.978	16.988	0	0	10	9	12	15	15	20	24	167
AVEWS (km/h)	8.86	11.69	3.04	9.689	0	0	7	6	9	9.5	10.5	14.5	18	93

Abbreviations: AVEHUM, average humidity; AVEWS, average wind speed; CDM, cumulative daily mortality; CI, cumulative incidence; DI, daily incidence; DM, daily mortality; MAXHUM, maximum humidity; MAXWS, maximum wind speed; MINHUM, minimum humidity; MINWS, minimum wind speed.

Table 2. Spearman's correlation test between some meteorological factors and COVID-19 cases in Lagos state and FCT, Nigeria.

	DI	CDI	DM	CDM	MINHUM	MAXHUM	AVEHUM	MINWS	MAXWS	AVEWS
LAGOS										
DI	1	−0.013	0.300*	−0.024	0.033	0.065	0.042	0.055	0	0.018
CDI		1	−0.117*	0.998*	−0.186*	−0.091*	−0.166*	0.045	0.013	0.032
DM			1	−0.112*	−0.003	0.019	0.005	0.003	0.04	0.02
CDM				1	−0.194*	−0.099*	−0.174*	0.028	−0.005	0.012
FCT										
DI	1	0.038	0.308*	0.037	0.002	−0.034	−0.02	−0.044	−0.100*	−0.092*
CDI		1	−0.026	1.000*	−0.261*	−0.262*	−0.271*	0.071	−0.018	0.021
DM			1	−0.022	0.053	0.055	0.051	0.041	−0.007	0.003
CDM				1	−0.261*	−0.261*	−0.270*	0.073	−0.018	0.022

Abbreviations: AVEHUM, average humidity; AVEWS, average wind speed; CDM, cumulative daily mortality; CI, cumulative incidence; DI, daily incidence; DM, daily mortality; MAXHUM, maximum humidity; MAXWS, maximum wind speed; MINHUM, minimum humidity; MINWS, minimum wind speed.
*Correlation is significant at 95% probability level (2-tailed) and $P < .05$.

Table 3. Summary of COVID-19 pandemic and some meteorological factors during harmattan season in Lagos state and FCT, Nigeria (1st March, 2020 to 28th February, 2022).

VARIABLES	MEAN		SD		MINIMUM		P25		P50		P75		MAXIMUM	
	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT	LAGOS	FCT
DI	445.53	69.66	870.389	97.116	0	0	29	5	52	24	563	116	3393	734
CDI	5139.18	8708.53	3158	5028	167	0	1089	4500	7345	10100	7463	13800	7574	14558
DM	0.24	0.37	0.752	0.89	0	0	0	0	0	0	0	0	3	6
CDM	3.65	43.12	0.996	27.799	0	0	4	18	4	53	4	71	4	78
MINHUM (%)	34.12	18.38	5.048	6.092	24	6	31	13	34	18	36.5	22.5	46	36
MAXHUM (%)	62.41	31.21	5.646	10.872	54	12	57	22.5	62	30	67.5	39	71	60
AVEHUM (%)	48.26	24.79	3.869	7.525	42	10	45.5	18.5	47	24.5	51.25	30.75	56	40
MINWS (km/h)	5.12	6.78	1.728	5.448	2	0	4	2.5	5	6	6	9	9	22
MAXWS (km/h)	11.35	20.92	3.04	13.747	7	0	10	11	11	18	11.5	26.5	20	91
AVEWS (km/h)	8.24	13.85	1.687	8.34	6	0	7.25	8	8	12.5	8.75	17.5	14	54

Abbreviations: AVEHUM, average humidity; AVEWS, average wind speed; CDM, cumulative daily mortality; CI, cumulative incidence; DI, daily incidence; DM, daily mortality; MAXHUM, maximum humidity; MAXWS, maximum wind speed; MINHUM, minimum humidity; MINWS, minimum wind speed.

Lagos state during the harmattan season was somewhat similar to that observed over the whole 2-year period of this study as there was no significant correlation between humidity and either COVID-19 incidence or mortality. In addition, there was no significant correlation between humidity and the cumulative daily incidence or cumulative daily mortality (Table 4). Similar to the non-harmattan period, there was also no significant correlation between wind speed (minimum, maximum, or average) and any of COVID-19 incidence, cumulative incidence, mortality or cumulative mortality within the harmattan period in Lagos state (Table 4).

The harmattan period lasted for 209 days in the FCT for the 2-year duration of this study (see supplementary information). There was a total of 14558 COVID-19 cases and 78 confirmed COVID-19 deaths, with a daily maximum incidence of 734 confirmed COVID-19 cases and 6 confirmed COVID-10 deaths (Table 3). The mean incidence rate for COVID-19 in the FCT was 69.66 ± 97.12 persons per day, while mean mortality rate for COVID-19 was 0.37 ± 0.89 person per day. The average humidity was $24.79\% \pm 7.53\%$ and the average wind speed was 13.85 ± 8.34 km/h. A positive significant correlation was found to exist between humidity (minimum, maximum, and average) and the daily COVID-19 incidence in the FCT during the harmattan season ($r = .340$, $r = .180$ and $r = .241$; $P < .05$), while a negative significant correlation was found to exist between humidity and cumulative daily COVID-19 incidence ($r = -.321$, $r = -.345$ and $r = -.354$; $P < .05$) (Table 4). There was also a negative significant correlation between humidity (minimum, maximum, and average) and the cumulative daily mortality in the FCT during the harmattan season ($r = -.331$, $r = -.350$ and $r = -.361$; $P < .05$), but no significant correlation between humidity and daily COVID-19 mortality (Table 4). A negative significant correlation was observed to exist between minimum wind speed and the daily COVID-19 incidence in the FCT during the harmattan season ($r = -.203$; $P < .05$), but not for maximum or average wind speed and COVID-19 incidence. There was no significant correlation between wind speed and cumulative daily incidence, daily mortality or cumulative daily mortality.

Discussion

In this study, we have investigated the relationship between weather variables during harmattan and COVID-19 transmission and mortality. Our results show that the association between weather variables like relative humidity or wind speed and COVID-19 during harmattan can vary depending on locations. In Lagos state, harmattan is rarely experienced and the fluctuation in weather variables over time is not so wide (Figure 1). Both meteorological factors of humidity and wind speed showed no significant correlation with the daily COVID-19 incidence or mortality during the harmattan and non-harmattan periods in Lagos state. However, the case was different for the FCT where harmattan is very much experienced and the fluctuation in weather variables is wide over a given period

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Table 4. Spearman's correlation test between some meteorological factors and COVID-19 cases during harmattan season in Lagos state and FCT, Nigeria.

	DI	CDI	DM	CDM	MINHUM	MAXHUM	AVEHUM	MINWS	MAXWS	AVEWS
LAGOS										
DI	1	−0.699*	0.158	−0.282	−0.121	−0.362	−0.36	0.103	0.03	0.222
CDI		1	−0.451	0.665*	0.222	0.278	0.333	−0.062	0.048	−0.046
DM			1	−0.306	−0.167	−0.292	−0.281	0.211	0.227	0.336
CDM				1	0.252	0.163	0.306	0.195	−0.194	−0.05
FCT										
DI	1	−0.219*	0.301*	−0.234*	0.340*	0.180*	0.241*	−0.203*	−0.069	−0.136
CDI		1	−0.123	0.998*	−0.321*	−0.345*	−0.354*	−0.018	0.01	0.001
DM			1	−0.109	0.077	−0.024	0.015	0.008	0.072	0.059
CDM				1	−0.331*	−0.350*	−0.361*	−0.009	0.007	0.002

Abbreviations: AVEHUM, average humidity; AVEWS, average wind speed; CDM, cumulative daily mortality; CI, cumulative incidence; DI, daily incidence; DM, daily mortality; MAXHUM, maximum humidity; MAXWS, maximum wind speed; MINHUM, minimum humidity; MINWS, minimum wind speed.
*Correlation is significant at 95% probability level (2-tailed) and $P < .05$.

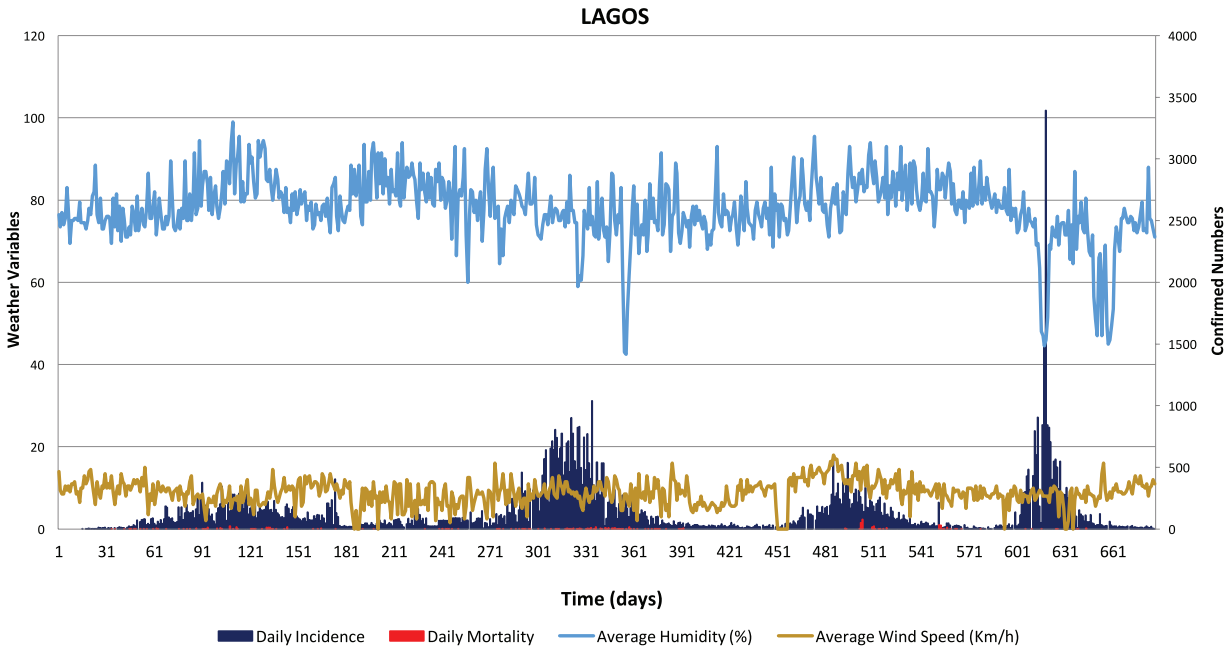

Figure 1. A time series plot showing the relationship between weather variables and incidence/mortality due to COVID-19 in Lagos, Nigeria between March 2020 and February 2022.

of time (Figure 2). Results from the FCT showed that humidity has a positive correlation with COVID-19 incidence during the harmattan period, but the correlation was not significant for mortality. Several studies support this finding of positive correlation between humidity and COVID-19 incidence,[31-33] although the results of some few studies are contrary to ours.[34,35] Although, the observed correlation does not imply causation, it does suggest that humidity might be influencing the survival of the coronavirus and indirectly contributing to COVID-19 incidence. Obviously, low humidity would adversely affect most organisms. One would then expect that there would be significant COVID-19 incidence during the rainy season with higher humidity in FCT, and also for Lagos. However, this was not the case. Different limits and thresholds exist for survival of airborne infectious agents to several environmental factors including humidity and temperature.[36] It could be that there is an upper threshold beyond which humidity has no more positive effect on the coronavirus. In addition, there could also be other factors during the harmattan that might be playing roles in the survival and spread of the virus.

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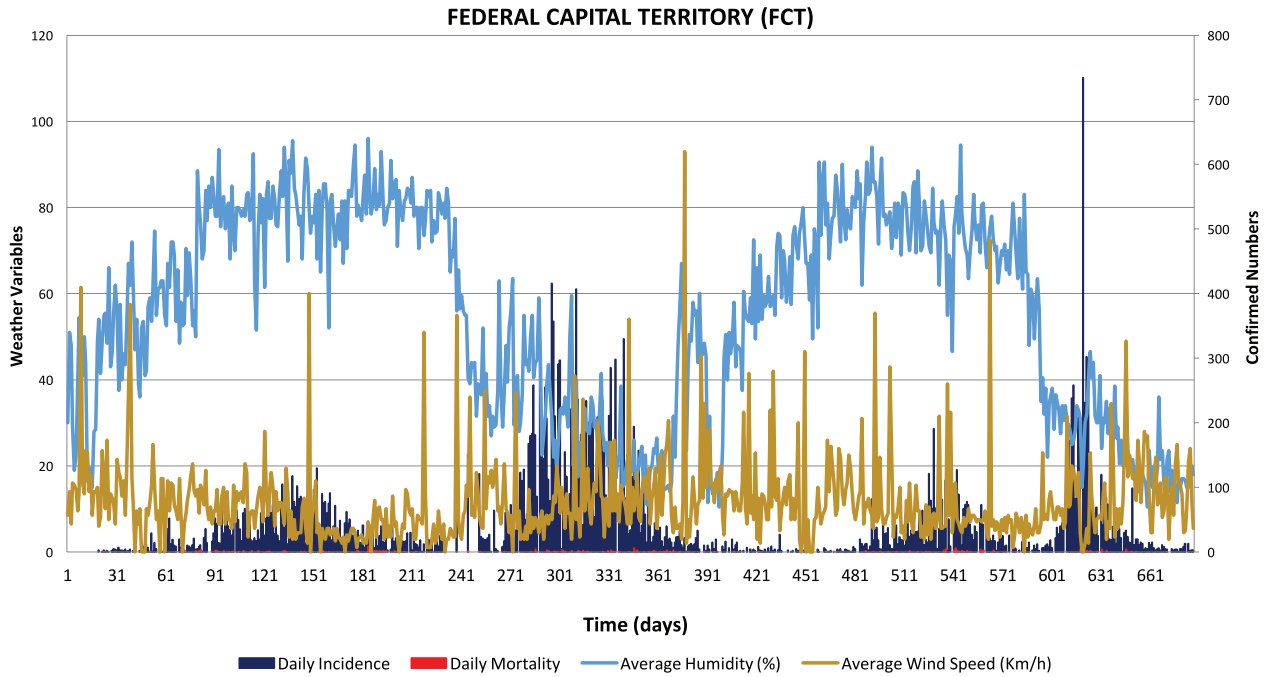

Figure 2. A time series plot showing the relationship between weather variables and incidence/mortality due to COVID-19 in the Federal Capital Territory (FCT), Nigeria between March 2020 and February 2022.

Harmattan dusts and biomass burnings have been cited as possible factors that can act as active carriers of the coronavirus and increase COVID-19 incidence during the harmattan.[20] These factors are much more prevalent in the climatic region of the FCT than in Lagos, and have been found to show significant positive correlation with COVID-19.[20,37] Another plausible explanation for the higher number of COVID-19 incidence during the harmattan could be that many locals who ordinarily would have been asymptomatic during other seasons have more respiratory issues during harmattan and are more willing to go for tests.

Wind speed showed a negative correlation with COVID-19 incidence during the harmattan and non-harmanttan seasons, implying that the spread of COVID-19 would tend to decrease as wind speed becomes higher and vice versa. Understandably, higher wind speed would mean better aeration and removal of aerosol or droplets produced by infected individuals within a given space or location, which translates to lesser disease transmission. Since the correlation between COVID-19 spread and wind speed as found in this study is weak and may be negligent, further studies will be needed to obtain a better assessment of this relationship. Similar to this study, other authors have also found a negative correlation between wind speed and COVID-19 spread in both the temperate and tropic regions.[38,39] However, our result is in contrast to Aidoo et al[17] who found that wind speed has a positive linear relationship with COVID-19 spread in Ghana. Numerous factors such as methods of analysis, solar radiation, temperature, precipitation, population density and behavior of people could be responsible for variations in the results from different studies. Availability of testing kits and government-sponsored COVID-19 testing campaigns are among some of the factors that could have also influenced the data used for this study and indirectly affect the results from this study.

Conclusion

In conclusion, weather components of the harmattan season have some association with COVID-19 in Nigeria. Humidity has a significant positive correlation with daily COVID-19 incidence during the period of harmattan, and this association could vary depending on location. Wind speed showed a negative association with COVID-19 incidence in FCT, but is not associated with COVID-19 incidence in Lagos. Overall, both meteorological factors are not associated with daily mortality due to COVID-19 irrespective of harmattan and location.

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Author Contributions

CO conceived study, OA collected and organized data, CM analyzed data, CO and CM wrote manuscript.

Supplemental Material

Supplemental material for this article is available online.

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