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CORRELATION BETWEEN CLIMATE INDICATORS AND COVID-19 PANDEMIC IN NIGERIA, GHANA, AND SOUTH AFRICA

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ABSTRACT

This study examines the relationship between climatic indicators (maximum temperature, minimum temperature, precipitation, and relative humidity) and the spread of COVID-19 using weekly data of confirmed cases and death rates from 3/25/2020 to 12/30/2020 for Nigeria, South Africa, and Ghana. Using an ex-post research design and descriptive method of analysis, the results of the study confirm evidence of correlation between climatic variables and the spread of the COVID-19 virus among the three selected countries. However, the policy recommendation that emanates from this study is that climate mitigation policies can be promoted as pandemic prevention policies, thus making a stronger case for their implementation to forestall future reoccurrence.

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Introduction

The spread of the novel COVID-19 induced COVID-19 has plunged the world into an unprecedented health and economic crisis. Early indicators showed that COVID-19 is a zoonotic disease that emanates from wildlife and transmitted to humans, perhaps through an intermediate species. There are clear links between health and the environment. In other words, environmental factors have far reaching implications on the epidemiological dynamics of many infectious diseases. Furthermore, empirical works on climate/weather conditions and disease transmission found evidence that environmental factors affect the spatial distribution and timing of infections (Lemaitre et al., 2019; Sooryanarain & Elankumaran, 2015). Based on an analysis on climatic variables, there is also evidence that temperature affects influenza epidemics in tropical regions (Tamerius et al., 2013). In addition, increasing temperatures have been associated with variations in the range of malarial mosquitoes and the spread of malaria and the Zika virus. For instance, in temperate regions of the Northern and Southern Hemispheres, evidence shows highly synchronized annual influenza epidemics during their winter months (Bedford et al., 2015; Tamerius et al., 2013).

According to Dalziel et al. (2018), climate conditions are considered top predictors of the influenza epidemic. Humidity, temperature, and wind speed are fundamental elements in the spread of infectious diseases (Bull, 1980; Yuan et al., 2006). The extent to which climatic factors are responsible for the spread of COVID-19 constitutes an important subject of ongoing research. The conclusion from current studies on the relationship between climatic indicators and the spread of COVID-19 pandemic is mixed. While studies such as Ma et al. (2020), Xie et al. (2020), Shi et al. (2020), Eslami & Jalili (2020), Bashir et al. (2020), and Prata et al. (2020) find evidence for a positive and significant relationship between environmental indicators and the spread of COVID-19. Other studies like Iqbal et al. (2020), Jüni et al. (2020), Briz-Redón & Serrano-Aroca (2020), and To et al. (2021), found no evidence on the relationship between temperature changes and the spread of COVID-19.

The present work adds to the small but emerging literature on the link between environmental indicators on the spread of COVID-19. As such, this study sought to determine the relationship between climatic factors (min-max temperature, relative humidity, and precipitation) and COVID-19 incidence in Nigeria, Ghana, and South Africa. To achieve this objective, the remaining article sections are as follows; section 2 presents a review of related studies. The methodology is discussed in section 3. Section 4 reports and discusses the results, while section 5 concludes the paper with recommendations.

Literature Review

Several factors have been ascribed to the spread of COVID-19 globally, climate-related and environmental factors are considered key to the transmission mechanism of the pandemic. For instance, previous empirical evidence has shown that air pollutants are linked to increasing incidence of COVID-19 (see Bashir et al., 2020; Fattorini & Regoli, 2020). The epidemiological dynamics of previous diseases like SARS-CoV in 2003 have made researchers to draw parallels between COVID-19 pandemic and temperature. This has led many to suggest the possibility that SARS-CoV-2 would recede as the climate becomes warmer (To et al., 2021). This analogy relates to other viral infections or COVID-19 variants like MERS-CoV and influenza (Fagbo et al., 2017; Lowen et al., 2007).

Empirical work by Ma et al. (2020), Xie & Zhu (2020), Shi et al. (2020) found evidence for the relationship between temperature, humidity, and the infection rate of COVID-19 in China. For instance, Ma et al. (2020) find that a unit surge in humidity and temperature was related to the decrease in COVID-19 death. Similarly, Xie & Zhu (2020) find that when mean temperature was below was associated with a rise in the daily of COVID-19 confirmed cases and death rate. Shi et al. (2020) found that the overall epidemic intensity of COVID-19 reduced slightly following days with higher temperatures. Also, empirical evidence from Iran, U.S, and Brazil find correlations between ambient temperature and COVID-19 infection (see Bashir et al., 2020; Eslami & Jalili, 2020; Prata et al., 2020). On the contrary, Iqbal et al. (2020), Jüni et al. (2020); Briz-Redón & Serrano-Aroca (2020), and To et al. (2021) find no association between ambient temperature and COVID-19 infection and death rate.

COVID-19 has a wide range of health implications on patients, as evidence from clinical studies has shown difficulty in breathing among patients as well as severe symptom of pneumonia. However, COVID-19 symptoms have shown similar characteristics with other variants of coronavirus like SARS and MERS which includes respiratory disorder, kidney malfunction and eventual death (Holshue et al., 2020; Wang et al., 2020). Recent empirical works have identified the bat-human relationship with yet to be identified intermediate host as the key transmission vehicle of COVID-19 (Bashir et al., 2020). It is mainly transmitted by respiratory droplets and human-human transmission (Huang et al., 2020). Wind speed, humidity, and temperature are considered to be critical climatic conditions that are in the front burner in the transmission of infectious diseases as well as predictors of coronavirus illness (Dalziel et al., 2018; Yuan et al., 2006). As such, this study seeks to add to the ongoing literature on the possible nexus between COVID-19 and climate variables in 3 African countries using Kendall Tau and Spearman rank correlation.

Methods and Data Source

This study used data from two weather stations in Nigeria, Ghana, and South Africa to study the correlation between climatic variables (maximum temperature, minimum temperature, relative humidity, and precipitation) and COVID-19 cases and death rate. Two weather stations are considered for Nigeria (Lagos, Yola), South Africa (Jansenville, Johanesburg-Rand) and Ghana (Accra, Navrongo). Weekly COVID-19 cases from last week of March to last week of December 2020 were obtained from WHO database. Monthly data for climatic variables were obtained from CLIMWAT 2.0 provided by Water Resources, Development and Management Service (AGLW) and FAO's Environment and Natural Resources Service (SDRN). The monthly data for climatic variables have been interpolated to weekly data using the Chow and Lin (1971) method. Kendall Tau and Spearman rank correlation tests were utilized to examine the correlation between COVID-19 and climatic variables due to the fact that the data is not normally distributed.

Empirical Result

The result of the descriptive statistics from Table 1 (see appendix) shows that the mean cases and death per week is 2196.34 and 21.98, the max-min for cases and death per week is (6377 and 98) and (61 and 1), respectively. The skewness value for cases, death, maximum temperature for Yola station; minimum temperature, precipitation and relative humidity for Lagos station have positive skewness (long right tail) indicating higher values above the sample average. Similarly, maximum temperature for Lagos station, minimum temperature, precipitation and relative humidity for Yola station is negative (long left tail), indicating lower values below the sample average. The kurtosis value which measure the peaked or flatness of the distribution of the series indicates that our variables are not normally distributed.

The descriptive statistics for Ghana (see Table 2 in the appendix) show that the mean, and max-min value for cases, death are 1329.29 (8.12), 5302 (33), and 22 (0.00), respectively. The standard deviation of the variables indicated that they were far away from their mean. Cases, death, maximum temperature, and precipitation of Navrongo weather station; precipitation and relative humidity of Accra weather station show that they are positively skewed (long right tail). The kurtosis value indicates that the variables are not normally distributed. Also, the probability values of the Jaque-Bera statistics indicate significance for most of the variables which shows that they are not normally distributed. Also, most of our variables' probability value is statistically significant, indicating non-normality. The descriptive statistics for South Africa (see Table 3) indicates that for both weekly caseload and death rate South Africa has the highest weekly average. The standard deviation of most of the series is high, indicating that they are far away from their mean value, which suggests the possibility of certain factors driving the climatic variables away from their trajectory. Similarly, the Jaque-Bera normality test statistics for all the variables are statistically significant, indicating that they are not normally distributed.

Due to the non-normality of our variables, we conduct a correlation test using Kendal tau and Spearman rank correlation as presented in Table 4, the result shows the correlation estimate of 6 weather indicators for six weather stations from South Africa, Ghana, and Nigeria. For South Africa, the correlation result indicates that the maximum temperature for the two weather stations is statistically significant, indicating a reduction in death rate and caseload as temperature increases. The result for the Spearman rank correlation also indicates that maximum and minimum temperatures are correlated with cases and death rates of COVID-19. The Kendal and Spearman rank correlation for relative humidity and precipitation for Jansenville and Johannesburg-Rand weather station show that they both play a significant role in the seasonal spread of COVID-19 in South Africa. The correlation result for Ghana and Nigeria also show high and significant correlation between temperature and the spread of COVID-19. The result of relative humidity and precipitation in both weather stations indicate that they play a significant role in the spread of COVID-19. The result for all countries indicates that climatic variables are highly correlated with the spread of COVID-19. The result from previous studies support our findings, for instance Shi et al. (2020), Bashir et al. (2020) find empirical support for the relationship between temperature and the spread of COVID-19 in China and US, respectively. Similarly, Chen et al. (2020), Ma et al. (2020), Poole (2020) find evidence that temperature and humidity, and other climatic indicators play an important role in the mortality rate of COVID-19.

Conclusion and Recommendation

The outbreak of COVID-19 in Africa has triggered concern about the likely impact environmental indicators on the spread of the virus. Making use of weekly data from 3/25/2020 to 12/30/2020, this study employed descriptive statistics and correlation analysis to investigate the relationship between climatic indicators (max-min temperature, relative humidity, precipitation) and the spread of COVID-19 (new cases and mortality rate). The study concludes that climatic indicators have a high and significant correlation with the spread of COVID-19 in Nigeria, Ghana and South Africa. The significance of this study is that green environment policies should be promoted as it would reduce the spread of infectious diseases such as COVID-19.

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Appendix

Table 1: Descriptive Statistics of Climatic Variables and COVID-19 Data for Nigeria

	CASES	DEATH	MAX13	MAX21	MIN13	MIN21	PRECIP13	PRECIP21	RH13	RH21
Mean	2196.34	31.98	29.74	34.07	22.59	22.03	149.84	95.85	93.50	64.30
Median	1638.00	25.00	30.30	34.28	22.39	22.52	148.73	93.78	93.74	70.72
Maximum	6377.00	98.00	32.20	39.80	24.03	26.18	329.57	205.79	101.27	82.40
Minimum	67.00	1.00	12.90	30.38	21.72	15.79	12.45	-4.20	85.10	32.55
Std. Dev.	1612.03	26.82	3.07	2.85	0.66	3.09	90.93	74.18	4.20	17.24
Skewness	0.73	0.77	-4.08	0.48	0.64	-0.80	0.26	-0.01	0.02	-0.60
Kurtosis	2.58	2.66	23.26	2.28	2.29	2.70	2.43	1.49	2.74	1.91
Jarque-Bera	3.94	4.21	814.87	2.47	3.67	4.51	1.03	3.90	0.12	4.48
Probability	0.04	0.02	0.11	0.09	0.06	0.10	0.00	0.08	0.94	0.11
bservations	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00

Table 2: Descriptive Statistics of Climatic Variables and COVID-19 Data for Ghana

	CASES	DEATH	MAX1	MAX5	MIN1	MIN5	PRECIP1	PRECIP5	RH1	RH5
Mean	1329.29	8.12	33.36	29.22	22.37	23.37	106.11	78.51	60.39	81.48
Median	740.00	4.00	33.59	29.68	22.16	23.47	92.97	69.25	66.38	81.62
Maximum	5302.00	33.00	38.38	31.17	25.59	24.48	275.15	231.04	79.32	83.85
Minimum	22.00	0.00	29.57	26.67	18.56	21.59	-0.03	14.78	30.00	78.98
Std. Dev.	1314.75	8.89	2.92	1.75	2.01	0.81	87.86	59.36	16.91	1.61
Skewness	1.47	1.54	0.11	-0.31	-0.11	-0.67	0.49	1.11	-0.46	0.00
Kurtosis	4.22	4.42	1.63	1.45	1.51	1.70	2.05	3.53	1.75	1.53
Jarque-Bera	17.27	19.73	3.28	4.75	0.50	3.25	3.19	8.95	4.14	3.71
Probability	0.00	0.00	0.19	0.09	0.08	0.10	0.05	0.01	0.13	0.00
Observations	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00

Table 3: Descriptive Statistics of Climatic Variables and COVID-19 Data for South Africa

	CASES	DEATH	MAX11	MAX26	MIN11	MIN26	PRECIP26	PREICP11	RH11	RH26
Mean	24678.54	660.27	25.54	21.64	9.39	8.93	52.73	20.17	62.13	54.83
Median	13461.00	526.00	25.00	22.24	9.49	9.08	36.03	17.31	64.17	50.82
Maximum	89949.00	2380.00	32.20	26.19	14.76	14.08	127.23	47.15	68.18	68.12
Minimum	223.00	0.00	20.00	16.08	3.85	3.29	2.85	7.39	51.79	43.08
Std. Dev.	26202.79	577.72	3.90	3.51	3.77	3.62	46.54	9.31	4.73	8.86
Skewness	1.29	1.11	0.22	-0.23	-0.05	-0.15	0.46	0.76	-0.82	0.31
Kurtosis	3.43	3.88	1.96	1.63	1.57	1.65	1.62	7.15	2.51	1.52
Jarque-Bera	11.66	9.68	2.17	3.57	3.52	3.28	4.69	4.01	4.96	4.41
Probability	0.00	0.01	0.04	0.07	0.09	0.00	0.10	0.03	0.08	0.00
Observations	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00	41.00

Table 4: Correlation Result

	South Africa			Ghana			Nigeria		
	Climatic variable/ Station	**Cases**	**Death**	**Climatic variable/ Station**	**Cases**	**Death**	**Climatic variable/ Station**	**Cases**	**Death**
Kendall's tau_b	**Max Temp11**	--0.22**	-0.11**	**Max1**	-0.43*	-0.59**	**Max13**	-0.20	-0.26**
	Max Temp26	-0.07**	-0.79**	**Max5**	-0.39**	-0.56**	**Max21**	-0.29*	-0.23*
	Min Temp11	0.22*	0.17**	**Min1**	0.05	0.08	**Min13**	0.34**	0.29**
	Min Temp26	0.13	0.04**	**Min5**	0.42*	0.58**	**Min21**	-0.15	0.16**
	Precipitation11	0.14	0.06	**Precip1**	0.39**	0.65**	**Precip13**	0.21*	0.47**
	Precipitation26	0.26*	0.16	**Precip5**	-0.03	0.08*	**Precip21**	0.15	0.31**
	Relative humidity11	0.15*	0.17**	**RH1**	0.29	0.56*	**RH21**	0.16	0.36*
	Relative humidity26	0.19	0.28*	**RH5**	0.31*	0.67*	**RH13**	0.17	0.31**
Spearman's rho	**Max Temp11**	-0.28**	-0.16**	**Max1**	-0.57**	-0.69**	**Max13**	-0.23	-0.32*
	Max Temp26	-0.12**	-0.08	**Max5**	-0.52**	-0.78**	**Max21**	-0.39*	-0.32*
	Min Temp11	0.32*	0.19**	**Min1**	0.04	0.18	**Min13**	0.48*	0.40**
	Min Temp26	0.19	0.03*	**Min5**	0.54*	0.75*	**Min21**	-0.23	0.25
	Precipitation11	0.20	0.10	**Precip1**	0.25*	0.80*	**Precip13**	0.26*	0.63**
	Precipitation26	0.29**	0.19	**Precip5**	-0.04	0.16	**Precip21**	0.20	0.46**
	Relative humidity11	0.28*	0.42**	**RH1**	0.38	0.78**	**RH21**	0.18	0.37*
	Relative humidity26	0.26	0.35*	**RH5**	0.49**	0.79*	**RH13**	0.21	0.45*

****, * stands for 5% and 10% level of significance.**

Weather Station

11 = Jansenville, **26** = Johannesburg-Rand, **13** = Lagos, **21** = Yola, **5** = Accra, **1** = Navrongo