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Impact of temperature on first-wave Covid-19 transmission in Nigeria

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Abstract

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) which caused about 80,000 Coronavirus Disease 2019 (COVID-19) incidences during its first wave in Nigeria is an enveloped virus, with infective properties that make it susceptible to inactivation, upon exposure to harsh environmental conditions. Moreover, temperature has been reported to influence the spread and viability of most known human coronaviruses. The study examines the impact of temperature variables on the transmission of COVID-19, during its first wave in Nigeria. Daily COVID-19 incidences for 300 days of the virus presence in Nigeria used in the estimation of the instantaneous reproduction number (R). In this study, R was used to measure COVID-19 transmissibility, while the daily incidences reflected the spread rate of the virus in Nigeria. Meteorological data were then matched with each of R and COVID-19 incidences, to determine the correlation between them, using Spearman's correlation coefficient (r_s) test. R estimation of 1.4 reflected the prevailing transmissibility of first wave of COVID-19 in Nigeria. Although no significant and positive relationship was observed between COVID-19 incidences and temperature variables. The strong relationship observed between R and the temperature parameters, suggests that temperature could be a driver modulating the transmission routes of COVID-19 in Nigeria.

Keywords: *SARS-CoV-2, COVID-19, First wave, Reproduction Number, Temperature, Nigeria, Transmission*

1. Introduction

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) causing the rampaging Coronavirus Disease 2019 (COVID-19), is a single-stranded, positive-sense, RNA *betacoronavirus,* with spike-like glycoprotein projections on its enveloped membranous surface (Di Nardo *et al*., 2020; and Wang *et al*., 2020). This spike protein facilitates the binding and fusion of the virus to host's membrane cells through angiotensin-converting enzyme-2 (ACE-2, as receptor in humans (Wang *et al*., 2020). Like most other enveloped viruses, the presence of a lipid bilayer envelope makes SARS-COV-2 to be susceptible to destruction upon exposure to dry heat, detergents and organic solvents (Moriyama *et al*., 2020). Although, reports from bioinformatics has it that the digestive tract may also be a route for SARS-CoV-2 infection, droplets and close contact are the most common routes for the transmission of SARS-CoV-2 amongst humans (Moriyama *et al*., 2020; and Wang *et al*., 2020).

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Earlier studies have reported that temperature influences the viability and spread of human coronaviruses 229E, SARS-CoV, and MERS-CoV (Chan *et al*., 2011; Lin *et al*., 2020; and Van Doremalen *et al*., 2013). It is assumed that temperature modulates the viability of viruses by affecting the infective properties of viral surface membrane glycoproteins (Moriyama *et al*., 2020). This may have led to its decreased stability, reduced infection potential, virus inactivation, and evaporation of respiratory droplets expelled from an infected person, and thereby, lowering the transmission rate (Moriyama *et al*., 2020; and Rosario *et al*., 2020). Furthermore, it is suggested that temperature may affect host susceptibility to viruses such as SARS-CoV-2, by modulating the effectiveness of host's respiratory defense mechanisms against infection; thus impacting viability and transmission (Moriyama *et al*., 2020; and Lin *et al*., 2020).

During the COVID-19 first wave in Nigeria, nearly 80,000 confirmed cases of the disease were officially reported by the Nigeria Centre for Disease Control (NCDC) (NCDC, 2020; and Okereke *et al*., 2021). With less than 2% of the entire population making up the infected category, several factors including the influence of weather determinants are assumed to have resulted in the impacted transmission rate of COVID-19 in the country; especially its role in modulating transmission routes of the virus. This study examines the potential significance of temperature determinants on COVID-19 transmission in Nigeria during its first wave.

2. Materials and methods

2.1. Study area

Nigeria is a country located in West Africa and consists of an area of 923,768 km^2, with a population of 206 million according to UN data projection of the 2006 population census (UND, 2020a). It lies between latitude 4°N and 14°N, and longitude 4°E and 14°E (Akande *et al*., 2017). The weather is tropical with high temperature summers and mild temperatures in winter.

2.2. Data collection

Meteorological data were collected from the National Institute of Meteorology (NIMET) in Nigeria (NIMET, 2020). Meteorological data from NIMET were limited in scope, and as such, other necessary meteorological data such as atmospheric temperature for the periods corresponding to COVID-19 incidences in Nigeria were obtained from the World Bank Climate Projection Data (WBCPD, 2020).

Data for daily incidence of the virus, for 300 days (February 27, till December 22, 2020) were obtained from the NCDC, and were analyzed for this study (NCDC, 2020).

2.3. Data analyses

For the purpose of this study, a time-dependent indicator—reproduction number (R)—that reflects the transmission of the virus in a population was estimated. R is the average number of secondary cases that are infected by the primary cases in a completely susceptible population (Zhu *et al*., 2020). R was calculated using Microsoft Excel framework of the "EpiEstim" software developed by (Cori *et al*. 2013). For the 300 daily incidences of the virus, a mean serial interval of 3.96 days (95% Credible Interval (CrI)), with a standard deviation of 4.75 days (95% CrI) derived from a previous epidemiological survey of 468 COVID-19 transmission events which reported negative serial intervals in which the infected had symptoms prior to having contacts with the infector, was applied (Du *et al*. 2020).

Spearman correlation coefficient (r_s) test was used to determine the associations between: COVID-19 incidence and temperature variables; R and temperature variables; and COVID-19 incidence and R. A Bivariate, two-tailed analysis with 95% confidence intervals was applied to each test. It is worthy of note however, that correlation does not imply causation; rather, it measures the degree of relatedness of two variables (Schober *et al*. 2018).

3. Results

As at December 22, 2020, when the pandemic was about entering another phase, the number of confirmed reported cases of COVID-19 in Nigeria was 79,789 (NCDC, 2020). This amounts to 39 infected persons, per 100,000 in Nigeria, a small ratio, compared with 1,567 infected persons per 100,000 in South Africa (SARP, 2020; and UND, 2020b). Figure 1 shows the estimated R values for COVID-19 throughout the first wave period in Nigeria. R reached a highest peak of 6.7 on March 20 (being the 23rd day since the virus was first reported in

Nigeria), with an average of 2.3 till April 26. However, the period between May 30 and August 20 (days 94-176) presented with spontaneous increase in the virus transmissibility, with R value of 1.8. This period corresponds with the rainy season in Nigeria, usually characterized by relatively low temperatures.

In spite of the varying fluctuations observed in the graph, R for Nigeria was estimated to be 1.4 (95% CrI) which was still above the threshold of 1, in which case it is assumed that the disease transmission is not being effectively controlled (Cori *et al*., 2013). Temperature variables for 11 months between February 27 and December 22, including: average temperatures, maximum temperatures and minimum temperatures were correlated with the monthly incidences of COVID-19 in Nigeria, as presented in Figure 2. Table 1 shows the Spearman's correlation coefficients (r_s) among the total confirmed cases of COVID-19 in Nigeria. As shown in Table 1, the correlation between COVID-19 incidences and each of the temperature variables were not statistically significant, with r_s tests having probability values (*p*-values) of >0.05.

Moreso, the results of r_s, between R and monthly temperature determinants shown in Table 2, were all positive; with minimum temperature showing the strongest association with R, whereas, maximum temperature appears to have the weakest correlation coefficient. In contrast, there appears to be a very weak but positive association (r_s = 0.0727; p = >0.5) between R and incidence cases.

Table 1: Relationship between COVID-19 incidences and temperature variables

Temperature variables	Spearman's correlation coefficient	*P*-value	Correlation Inference
Minimum (°C)	–0.0909	>0.5	Strongly negative
Maximum (°C)	–0.4341	0.2	Moderately negative
Average (°C)	–0.4	0.5	Moderately negative

Table 2: Relationship between R and temperature variables

Temperature variables	Spearman's correlation coefficient (r_s)	*P*-value	Correlation Inference
Minimum (°C)	0.9273	0.001	Strongly positive
Maximum (°C)	0.425	0.5	Moderately positive
Average (°C)	0.6727	0.05	Moderately positive

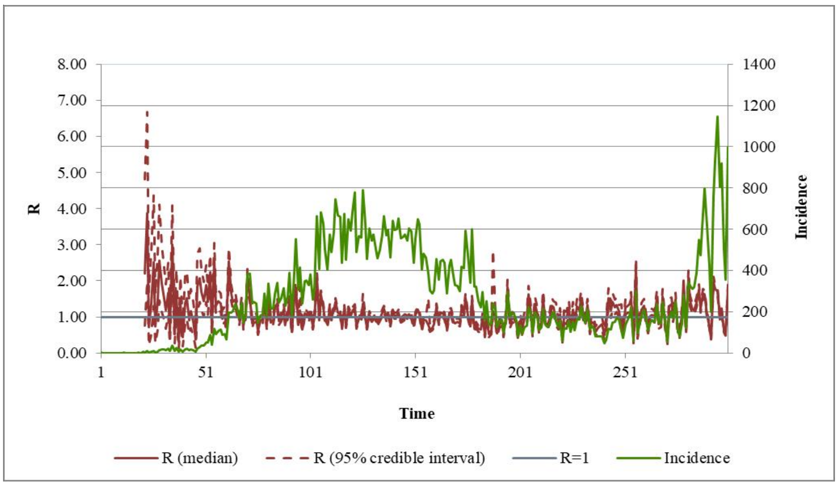

Figure 1: Daily estimated distributions of the instantaneous reproduction number R (posterior median and 95% CrI), based on NCDC epidemiological data for COVID-19 over 300 daily incidences COVID-19 in Nigeria from February 27, through December 22, 2020

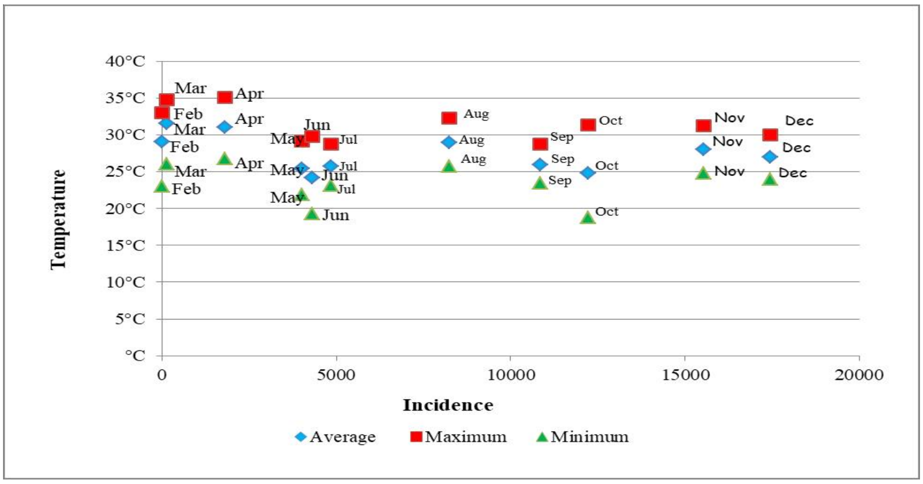

Figure 2: Average monthly temperature variables (average, minimum and maximum) from February through December, 2020

4. Discussion

In this study, the number of daily cases represents the rate of spread of the virus, whereas, R indicates the transmissibility of the virus in Nigeria. Notwithstanding the observed lack of statistical significance, the negative correlation between COVID-19 incidence and temperature variables may not imply lack of biological relevance if subjected to further experimental studies (Schober *et al*., 2018). This observation however agrees with the report of a similar study conducted on Lagos State, Nigeria, which accounted for over 60% of all reported Covid-19 cases in the country in the first wave of COVID-19. The report suggested that there was significant and negative linear relationship between temperature and COVID-19 incidence (Ogaugwu *et al*., 2020).

Nevertheless, the correlation results of R with average temperature and minimum temperatures were statistically significant; thus suggesting that the number of secondary cases that were infected by a primary case at a time t may change with the temperature variables. Contrastingly, a similar study carried out on a country with similar tropical climate, reported a statistically significant and negative correlation between temperature minimum (°C) and COVID-19 spread (Rosario *et al*., 2020). Moreover, in this study, temperature minimum (°C) appears to have the strongest association with COVID-19 transmission in Nigeria ($r_s = 0.9273$; $p = 0.001$).

Similarly, the impact of low temperature on COVID-19 transmission was also observed in the tropical cities of Brazil, where at lower temperatures, confirmed cases of the disease rose (Prata *et al*., 2020). All these reasonably suggest that minimum temperature could have impacted the low COVID-19 transmissibility observed as reflected by the R value that's above the 1 threshold, in Nigeria. Although there is little association between temperature and the reported incidence cases, we cannot imply the lack of it, as other factors including host susceptibility and viral load are also involved in who gets infected or not.

This study however, has several limitations. First, this study relied only on reported data from the NCDC and does not account for unreported cases, due to the limited laboratory testing capacity in Nigeria during this period. Thus, the actual incidence cases of the virus may have been largely underestimated and this may have created a bias in the correlation test between the number of COVID-19 incidence and temperature variables. Secondly, R is an average for a population and may hide local variation of cases, since asymptomatic case transmissions were not accounted for in this study (Adam, 2020). Thirdly, this study did not account for the effect of the various non-pharmaceutical interventions and other factors that could have heavily influenced covid-19 transmission dynamics, independently of or in prevailing temperature conditions.

5. Conclusion

Temperature may be a potentially strong driver facilitating the transmissibility of COVID-19, with minimum temperature being the most critical factor in COVID-19 impacting the transmission routes of COVID-19, especially during its first wave in Nigeria. However, future studies may take account of the corresponding effect of non-pharmaceutical interventions (such as social distancing and the use of face masks) simultaneously, with respect to the effect of temperature in the transmission of COVID-19, in Nigeria.

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