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PREDICTING COVID-19 SECOND WAVE SIGNAL IN SELECTED STATES OF SOUTHWEST NIGERIA: A COMPARISON OF CUMULATIVE SUM C2 AND CUMULATIVE SUM C1 EPIDEMIC THRESHOLDS

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ABSTRACT

Introduction: **Epidemic thresholds generated using the conventional historical data is not optimal for COVID-19 because of its short historical trajectory. This study therefore, aimed to develop and compare Cumulative sum C2 and C1 epidemic thresholds for COVID-19 in selected states in southwestern Nigeria.**

Methods: **This was a retrospective longitudinal analysis of the COVID-19 surveillance data (week 10 – 48) retrieved from the Nigerian Centre for Disease Control (NCDC) database of situation reports as at the 6th of December, 2020. Data was managed with Microsoft excel. The weekly time scale was adopted for developing the CUSUM C2 and C1 epidemic thresholds for three selected southwest states and Nigeria.**

Results: **A total of 236 situation reports were reviewed for each state. For Lagos state, the maximum C2 and C1 estimated was 2326 which was during the peak of the epidemic. From the four most recent surveillance points, the thresholds and the observed confirmed cases appeared to diverge from each other. For Ogun state, the maximum C2 and C1 estimated was 318 during the peak of the epidemic. From the four most recent surveillance points, the thresholds and the observed confirmed cases appeared to converge. For Oyo state, the maximum C2 and C1 estimated was 708 during the peak of the epidemic. From the four most recent surveillance points, the thresholds and the observed confirmed cases appeared to converge and then diverge.**

Conclusion: **A closer monitor of the surveillance data for the states is recommended for a possible public health intervention.**

BACKGROUND

Coronavirus disease (COVID-19) is a pandemic that spreads through close contact and via respiratory droplets produced when people cough or sneeze.[1] This novel strain of coronavirus, severe acute respiratory syndrome corona virus 2 (SARS-CoV-2), has not been identified in humans until January, 2020 when it was isolated, confirming the circulation of a new respiratory illness, and named coronavirus disease 2019.[2] COVID-19 has since been spreading rapidly to involve most nations of the world and the World Health Organization (WHO) declared COVID-19 a public health emergency of international concern on the 30th January, 2020.[3] Globally, over 63 million (63,691,642) people have been infected with over one million (1,476,277) death.[4] Currently, Nigeria has reported over 67, 000 cases of COVID-19 with over 1,000 deaths.[5]

The World Health Organization (WHO) has instituted public health and social measures to slow down the spread or completely stop the chains of transmission of COVID-19 outbreak at international, national and community levels.[6,7] These are individual measures such as social and physical distancing measures between people, use of facemask and reduce contact with contaminated surfaces, frequent hand washing and cough etiquette. Environmental measures to curtail this outbreak include detecting and isolating cases, contact-tracing and quarantine.[5,7]

COVID-19 is a new infectious disease with a new virus strain which requires adequate surveillance for monitoring and early detection of spikes or increase in cases. The conventional disease surveillance system involves continuous collection, analysis and interpretation of large volumes of data of diseases and health related events to enable prompt intervention for disease control.[8,9] This system is inadequate for a public health emergency like COVID–19 which requires an early warning system for immediate identification of cases meant for prompt intervention.[10]

Epidemiological data on COVID-19 globally has been collected for less than a full year. Thus, methods to

develop epidemic thresholds that require considerable historical data would not perform optimally for the development of COVID-19 epidemic thresholds for the infection. A more robust, quick, timely, efficient, sensitive and specific method of developing epidemic thresholds appears more appropriate at this time.

Variants of the cumulative sum (CUSUM) method for developing epidemic thresholds appear to be best suited for COVID-19 data because they are more sensitive and specific and best suited for a short baseline historical data compared to the historical limit's method. The cumulative sum (C-SUM) method for epidemic detection is based on computing moving averages for specified surveillance data points.[11] The objective of this study was therefore, to develop and compare epidemic thresholds for COVID-19 in selected states in southwestern Nigeria using the cumulative sum C2 and C1 methods.

METHODS

Study settings

The study was carried out in southwestern Nigeria. Southwest Nigeria is one of the six geopolitical zones in the country. It is occupied by six states including Lagos state which is the commercial hub of the country. The region also harbors the biggest and busiest international airport in the country from which hundreds of domestic and international flights take off and land. The Murtala Mohammed International airport (MMIA) operates direct and connecting flights to all regions of the world and it is a major connecting airport to the west African subregion. The first case of the COVID-19 infection in Nigeria was an Italian who boarded a direct flight from Italy to Nigeria on a business trip and came into the country through MMIA. To emphasize the importance of the airport to the control of epidemic diseases in the country, the first case of Ebola was also imported through the MMIA. Southwest Nigeria also has other land borders with Benin Republic through which several cases of COVID-19 were also imported into the country.

Study design

The study was a retrospective longitudinal analysis of COVID-19 surveillance data.

Sample size and sampling

Sample size determination and sampling were not applicable because the study was an analysis of secondary data and all relevant cases were included.

Three states were selected for this study based on specific criteria which included: 1) epi-centre for COVID-19, 2) presence of international land borders, 3) presence of international airport. Thus, Lagos, Ogun and Oyo states were selected.

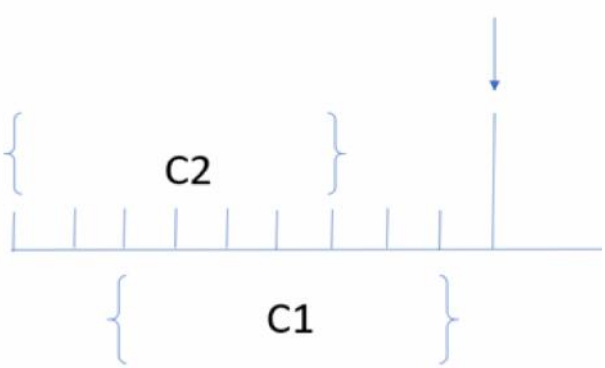
Data collection

Data were collected from all the available daily and weekly COVID-19 situation reports of the Nigerian Centre for Disease Control as at the 6th of December, 2020.[12] A piloted data extraction form was used to abstract daily and weekly COVID-19 confirmed cases depending on which was available.

Data analysis and management

Data was managed with Microsoft excel. Daily data were aggregated to weekly data based on the epidemiological week.

The time scale adopted for developing the CUSUM C2 and C1 epidemic thresholds was the weekly time scale. Figure 1 illustrates that to calculate C2 for the most recent surveillance point (as depicted by the arrow), the immediate past two surveillance points were skipped and the data for the next seven surveillance points were averaged and the standard deviation (SD) calculated.[11, 13] Thus, C2 equaled the mean (average) plus 3SD. This was done for all surveillance point that had sufficient data for the estimation.



Arrow shows the most recent surveillance point

Figure 1: Demonstration of the surveillance points for calculating Cumulative sum C2 and Cumulative sum C1

For the C1, the procedure was the same except that the seven previous surveillance points used for the estimation were derived from the immediate past seven points without skipping (Figure 1). The mean and SD were calculated using an online application (calculator.net).

Ethical approval

No ethical approval was required for the study which utilized publicly available secondary data. No ethical

issues were anticipated because only aggregate data were reported in the NCDC situation reports.

RESULTS

A total of 236 situation reports were found and downloaded from the NCDC website.

Reporting started from week 10 of the year 2020, and data was collected till week 48. The NCDC daily situation reporting stopped by week 42 (17 October, 2020). Thereafter, only weekly data was available through 28 November, 2020. Hence, for data reported prior to week 42, the daily number of cases were aggregated to weekly data.

For Lagos state, the maximum Cumulative sum C2 and Cumulative sum C1 estimated was 2326 which was during the peak of the epidemic (Figure 2). The four most recent thresholds ranged from about 800-1000 compared to the observed data which ranged from about 300-600 weekly confirmed cases. From the four most recent surveillance points, the thresholds and the observed confirmed cases appeared to diverge from each other.

For Ogun state, the maximum C2 and C1 estimated was 318 during the peak of the epidemic (Figure 3). The four most recent thresholds ranged from about

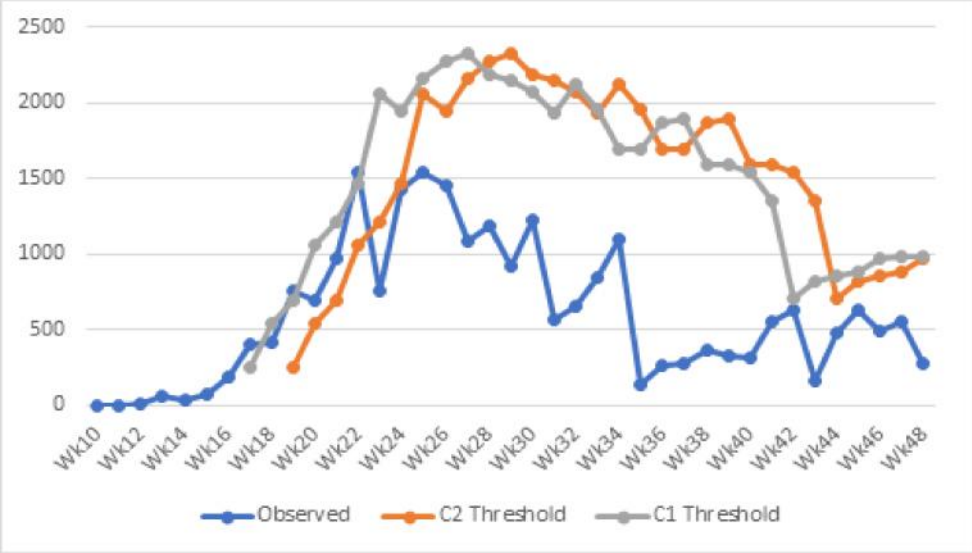


Figure 2: COVID-19 Cumulative sum C2 and Cumulative sum C1 epidemic thresholds for Lagos state

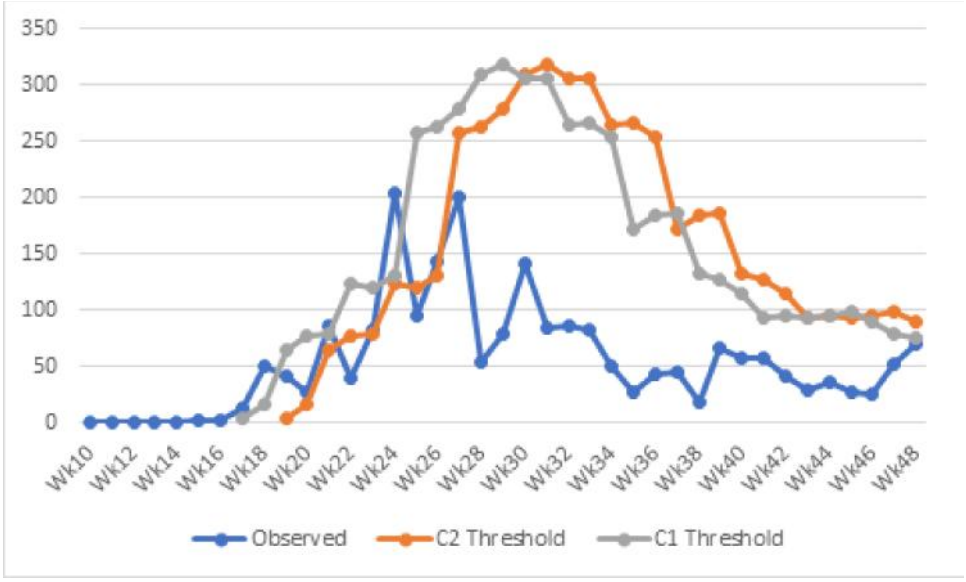


Figure 3: COVID-19 Cumulative sum C2 and Cumulative sum C1 epidemic thresholds for Ogun state Nigeria

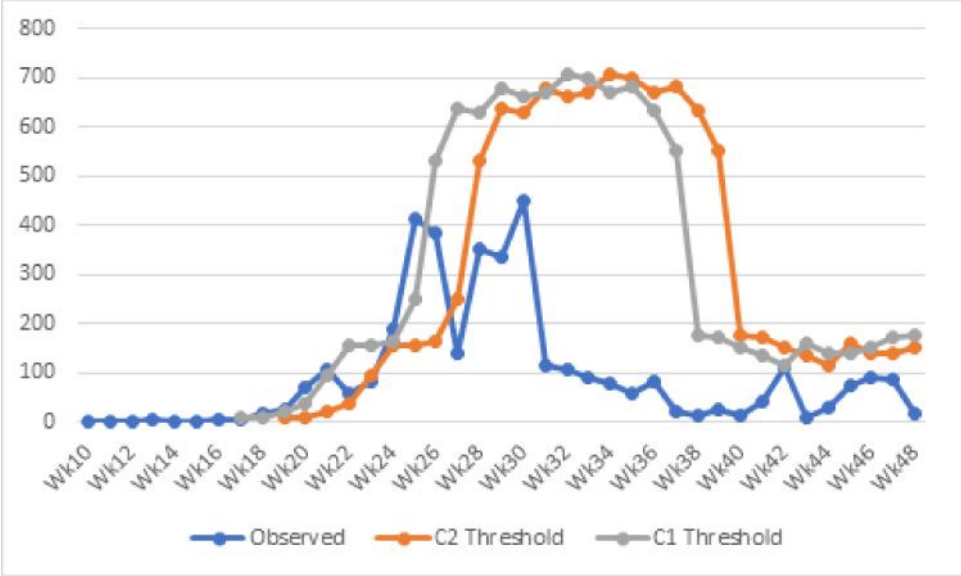


Figure 4: COVID-19 Cumulative sum C2 and Cumulative sum C1 epidemic thresholds for Oyo state

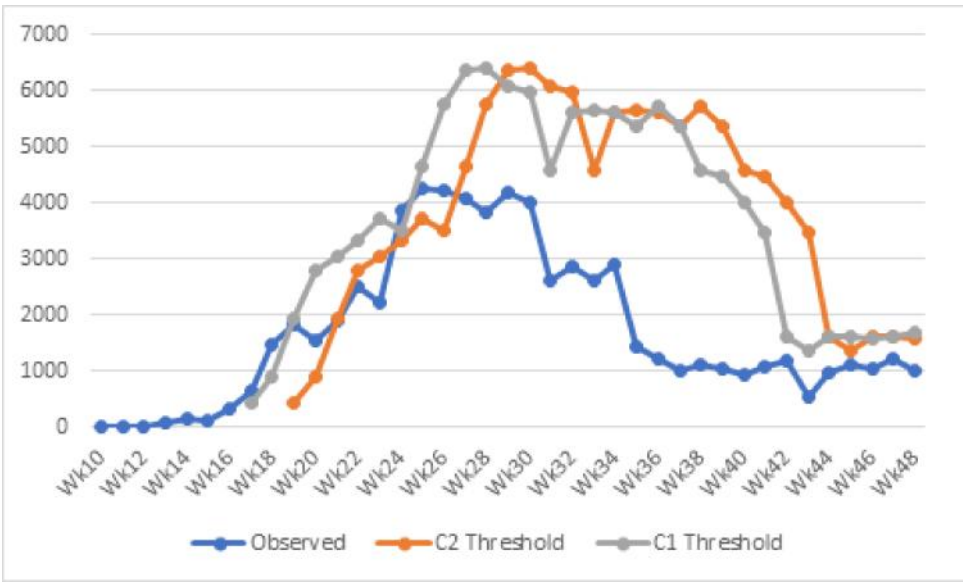


Figure 5: COVID-19 Cumulative sum C2 and Cumulative sum C1 epidemic thresholds for Nigeria

70-100 compared to the observed data which ranged from about 25-70 weekly confirmed cases. From the four most recent surveillance points, the thresholds and the observed confirmed cases appeared to converge.

For Oyo state, the maximum C2 and C1 estimated was 708 during the peak of the epidemic (Figure 4). The four most recent thresholds ranged from about 140-180 compared to the observed data which ranged from about 20-100 weekly confirmed cases. From the four most recent surveillance points, the thresholds and the observed confirmed cases appeared to converge and then diverge.

For the whole Nigeria data, the maximum C2 and C1 estimated was 6393 during the peak of the epidemic (Figure 5). The four most recent thresholds ranged from about 1400-1700 compared to the observed data which ranged from about 1000-1200 weekly confirmed cases. From the four most recent surveillance points, the thresholds and the observed confirmed cases appeared to run closely parallel.

For all analyses, both C2 and C1 were mirror image of each other with the C2 lagging behind C1 by two surveillance points.

DISCUSSION

To our knowledge, this is the first attempt at developing an epidemic threshold for COVID-19 in Nigeria. The method we have chosen is simple, popular and performs better than other methods when historical data is limited. It is best suited for COVID-19 because of the short secular trajectory. The thresholds developed shows a clear increase in the force of infection for Ogun state where the observed data has already converged on both the C1 and C2 thresholds but more on the C1 threshold and the number of confirmed cases appeared set to cross the epidemic thresholds which may indicate an early signal. The concept of moving averages has been applied in a variety of fields such as manufacturing, financial markets and medicine. The underlying rationale is to detect a change in some underlying force. This force in epidemiology is synonymous with the gradient of an epidemic curve or the force of infection or the reproduction rate. Moving averages help to detect a recent change in the force of infection which may imply that an infection has gained a new energy that warrants timely investigation or control interventions.

Moving averages are sensitive to the time scale adopted. The choice of the weekly time scale was to give a fair representation of the medium term as the daily short term may be a bit biased towards recent events and may be influenced by a one-off random event. The monthly time scale on the other hand appears best when the disease has a long term history and is well understood. However, the COVID-19 data collected globally is still under a year old representing a maximum of 11 surveillance points.

As shown in this study, both C1 and C2 thresholds appeared as the mirror image of each other. The C1 is a leading indicator when compared to C2 because of the skipped surveillance points in estimating the C2 threshold. To be conservative, the C1 threshold may be taken as the alert threshold because it tends to flag a signal earlier than C2, while the C2 may be taken as the epidemic threshold in the absence of clearly defined thresholds for COVID-19.

COVID-19 has attained the phase of community transmission in Nigeria and most part of the globe. It is still unclear whether the disease would become endemic in some countries. Thus, with greater understanding of the disease epidemiology and with more historical data, the historical limit's method for developing epidemic thresholds may become relevant. COVID-19 testing was grossly inadequate for the population of Nigeria at the early phase of the pandemic and this may be a limitation when extrapolating the thresholds developed in this study. As at the onset of the COVID-19 surveillance activities in Nigeria, there were only three molecular laboratory that were being used for real time PCR COVID-19. Although, the capacity for testing has grown to about 70 laboratories distributed in the six geopolitical regions of the country, it is still grossly inadequate. Thus, the data may underestimate the events in the underlying population. To improve the representativeness, the ministry of health is working on validating point of care (POC) testing that can be used in remote health care facilities. The POC test is also cheaper and faster.

CONCLUSION

In conclusion, the C2 and C1 thresholds developed for three states in southwest Nigeria showed that only Ogun state showed an increase in the gradient and force of infection as the number of confirmed cases appeared set to cross the epidemic thresholds. A closer monitor of the surveillance data for the state is recommended for possible public health interventions. We recommend that the COVID-19 task forces in the states should continue the enforcement of COVID-19 prevention measures such as restriction of public gatherings, compulsory wearing of face masks in public places and the routine hygiene measures of frequent hand washing to control the infection.

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