APPLICATION AND ASSESSMENT OF ARTIFICIAL NEURAL NETWORKS IN MODERN MEDICINE FOR PREDICTING AND CUSHIONING THE EFFECT OF COVID-19 PANDEMIC

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Abstract

COVID-19 pandemic has become the greatest worldwide threat, as it has spread rapidly among individuals in most countries around the world. The study assess artificial neural networks in modern medicine for predicting and cushioning the effect if covid-19 pandemic. The study used artificial neural networks forecasting models to identify nonlinear relationships between the variables. A secondary data from Nigeria Centre For Disease Control (NCDC) related to COVID-19 infection cases in Nigerian states for the period between 28 February 2020 and 26 July 2022 was used for prediction. The study revealed that there was an increasing trend in the number of new COVID-19 infections by the end of June, until 16 July for some states while for the rest of them the ANN model predicted a constant to decreasing trend for the next 30 days. The allocation of medical resources, the management of the pandemic's spread, and the improvement of health care system preparedness would be greatly aided by the prediction to cushion the effect of the pandemic.

Keywords: Artificial Neural Networks, COVID-19, Pandemic, Medicine, Prediction, Treatment, Vaccine, Global health crisis, Data analysis, Machine learning.

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INTRODUCTION

The World Health Organization (WHO) proclaimed the corona-virus (COVID-19) outbreak a worldwide pandemic on March 11, 2020, forty days after it had been deemed a global emergency (Al-Najjar and Al-Rousan, 2020). As of May 31, 2020, the number of confirmed patients approached six million, while the number of death cases reached 350 thousand.

Accordingly, lockdown is seen as the most significant effect of COVID-19, which impacted all economic sectors: technological adaptation, education, the financial industry, and tourism (Shenoy *et al*., 2020; Padmavathi and Murthy, 2020). Rapid human-to-human transmission and the unknown nature of the virus have caused a catastrophic epidemic. To combat the COVID-19 epidemic, effective and evidence-based measures must be done globally. Prediction models may assist in allocating medical resources and enhancing the readiness of healthcare systems for this purpose.

In addition, the COVID-19 crisis caused strong shocks for all macroeconomic parameters, including unemployment rate, consumer spending, and debt, among others. Few experts have examined this impact and reached the conclusion that the application of lockdown decreased both the employment rate and family expectations (Coibion *et al*., 2020; Blanchard *et al*., 2020; buheji *et al*., 2020). According to Coibion *et al*. (2020) and Goolsbee and Syverson (2020), lockdown has significantly shifted consumer behavior away from non-essential activities and toward vital ones. Regarding the debt problem, Arellano *et al*. (2020) discovered that lockdown policies are effective for reducing health crises, but they have a high economic cost, and that the social benefit of debt relief may be significant since it can avert the debt crisis and save lives.

Isaac *et al*. (2018) provided Artificial neural network application difficulties, enhancements, associated performance, and evaluation methodology. Their study encompasses several applications of ANN techniques in various sectors, including as medical, computers, agriculture, technology, engineering, environmental, science, climate, art, business, and nanotechnology, among others. According to their study, neural network models such as feedforward and feedback propagation artificial neural networks perform better when applied to human problems. Based on data analysis characteristics including precision, scalability, processing speed, convergence, and performance, they suggested feedforward and feedback propagation ANN models.

In this context, mathematical, dynamical, and statistical approaches were used to predict the COVID-19 outbreak (tak, 2020). Models such as the susceptible-exposed-infectious-recovered (SEIR) model (Coibion *et al*., 2020), the logistic growth model (Dhenuvakonda *et al*., 2020), and the Adaptive Neuro-fuzzy Inference System (ANFIS) model have been proposed for this purpose (Goolsbee and Syverson, 2020). For example, Al-qaness *et al*. (2020) adapted the ANFIS model with the Pollination Algorithm and Salp Swarm Algorithm to anticipate the spread of COVID-19. Fu *et al*. (2020) used a Boltzmann function-based method to estimate the cumulative number of confirmed cases in China. Niazkar and Niazkar (2020) used multi-gen genetic programming, one of the AI models, to construct mathematical models using the exponential function for projecting the COVID-19 pandemic in seven nations, including China, the Republic of Korea, Japan, Italy, Singapore, Iran, and the United States. They proposed country-specific prediction models. They suggested that the COVID-19 epidemic in each nation should be studied independently. In addition, Li *et al*. (2021) proposed an exponential function to forecast the course of the COVID-19 epidemic. They expected that the COVID-19 pandemic will conclude in China after March 20, 2020, with 52,000 to 68,000 cases of infection and 2,400 deaths (tak, 2020). In addition, Hu *et al*. (2020) suggested a technique for real-time forecasting of COVID-19 dubbed modified stacked auto encoder, which was inspired by an artificial intelligence (AI) model. In addition, they expected that the COVID-19 pandemic will finish around the middle of April. In addition, Yang *et al*. (2020) created an SEIR model and AI technique that was trained using SARS data from 2003 to forecast COVID-19 in China.

According to our understanding, the use of Artificial Neural Networks (ANN) to forecast the COVID-19 epidemic is restricted. Al-Najjar and Al-Rousan (2019) applied ANN for the prediction of recovered and death cases by using the majority of clinical features, despite the fact that it may be difficult to collect such specific data for prediction purposes. Based on the extensive and particular input data needed by their suggested model, its efficiency was determined to be sufficient. In addition, it will not anticipate likely confirmed instances in the future. According to the available literature, the search for an accurate and trustworthy prediction model of the COVID-19 epidemic is underway. This study aimed to assess the applicability of artificial neural networks in modern medicine for predicting and cushioning the effect of covid-19 pandemic.

OBJECTIVES OF THE STUDY

The main aims of this paper is to explore the application and assessment of ANNs in modern medicine for predicting and cushioning the effect of the COVID-19 pandemic.

The objective of the study is to:

- Consider data from the beginning of the spread of the pandemic in Nigeria from 28 February 2020 to 26 July 2022 in the Nigerian States
- Establish ANN model to forecast from the point of the spread of the pandemic.

JUSTIFICATION OF THE STUDY

The COVID-19 pandemic has been incredibly influential on the global population. A lot of reasons that it has been so influential is that the discovery of COVID-19 and the ensuing pandemic was an unprecedented event that had little to no available solutions for how to diagnose, treat, or deal with infected individuals. However, we have adapted rapidly over the past 2 years and are now starting to get back to life as it was before the pandemic. However, we still need to have the tools (ANN) to forecast diseases like COVID-19 effectively so that we can adapt and cushion the effect.

METHODOLOGY

In this work, we considered data published online from Nigeria Centre For Disease Control (NCDC) related to COVID-19 infection cases in Nigerian states for the period between 28 February 2020 and 26 July 2022 considering:

- new daily regional infections from 28 February 2020 to 26 July 2022;
- the last 6 days for testing daily cases (11 July 2022 to 16 July 2022);
- the last 30 days for testing the forecasting accuracy of the second wave.

The forecasting was conducted through the R package "forecasting", which provides methods and tools for forecasting univariate time series. We implemented an Artificial Neural Network model considering the Mean absolute Error (MAE). In order to validate the performance of each items and ascertain its fitness, mean absolute error (MAE) was computed as shown in Equation 1.

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|A_i - P_i| \quad (1)$$

Where, N is the total number of samples, A_i is the actual class of sample i, P_i is the predicted class of sample i.

Artificial Neural Networks forecasting models are nonlinear models inspired by biological neural networks that identify and model nonlinear relationships between the variables. They are compounds of a collection of neurons, grouped in input, hidden, and output layers, and map a set of inputs into a set of output variables, through hidden layers of neurons. Their ability to learn from a training procedure and previous examples makes them a powerful forecasting tool. They have the ability to analyze new data based on previous results.

An ANN is composed of several layers:

− The first layer, known as the input layer, is the one that takes the data in input.

−The last layer, called the output layer, gives the results of the analysis or the solution to the problem.

−The hidden layers, through which data flows from the input layer to the output. This is where the data is analyzed and the outputs are taken. The nodes of the hidden layers detect the features in the pattern of the data and the relationships between them. Then, the requested output is sent from the hidden layer to the output layer.

In our study, considering the traits of the new COVID-19 cases trend for Nigerian States, we chose a (28-5-1) network, with 28 lags as input nodes and 1 hidden layer with 5 nodes. It has the form of a feedforward three-layer ANN, where neurons have a one-way connection with the neurons of the next layers. The data set was divided into training set (70%) and testing set (15%), while the last 6 days data were used for the validation.

The forecasting performance of all the model was evaluated using the Mean Absolute Error (MAE), while the model fits were evaluated using AIC (Akaike Information Criterion), reported in Table 1.

Selection and accuracy measures for the forecasting ANN model is reported in Table 1. MAE was used to measure the performance of the model. It can be clearly seen, the above values of the table show that the ANN model has given more accurate forecasting values for every states in which Lagos has the highest value. According to MAE, ANN improved the forecasting accuracy.

RESULT

In Table 2 we present the MAE value for the last 6 days data, considered as testing data. Once again, we can observe that the ANN model is the best for forecasting COVID-19 new cases in Nigerian States.

Table 1. MAE (%) for forecasting model accuracy

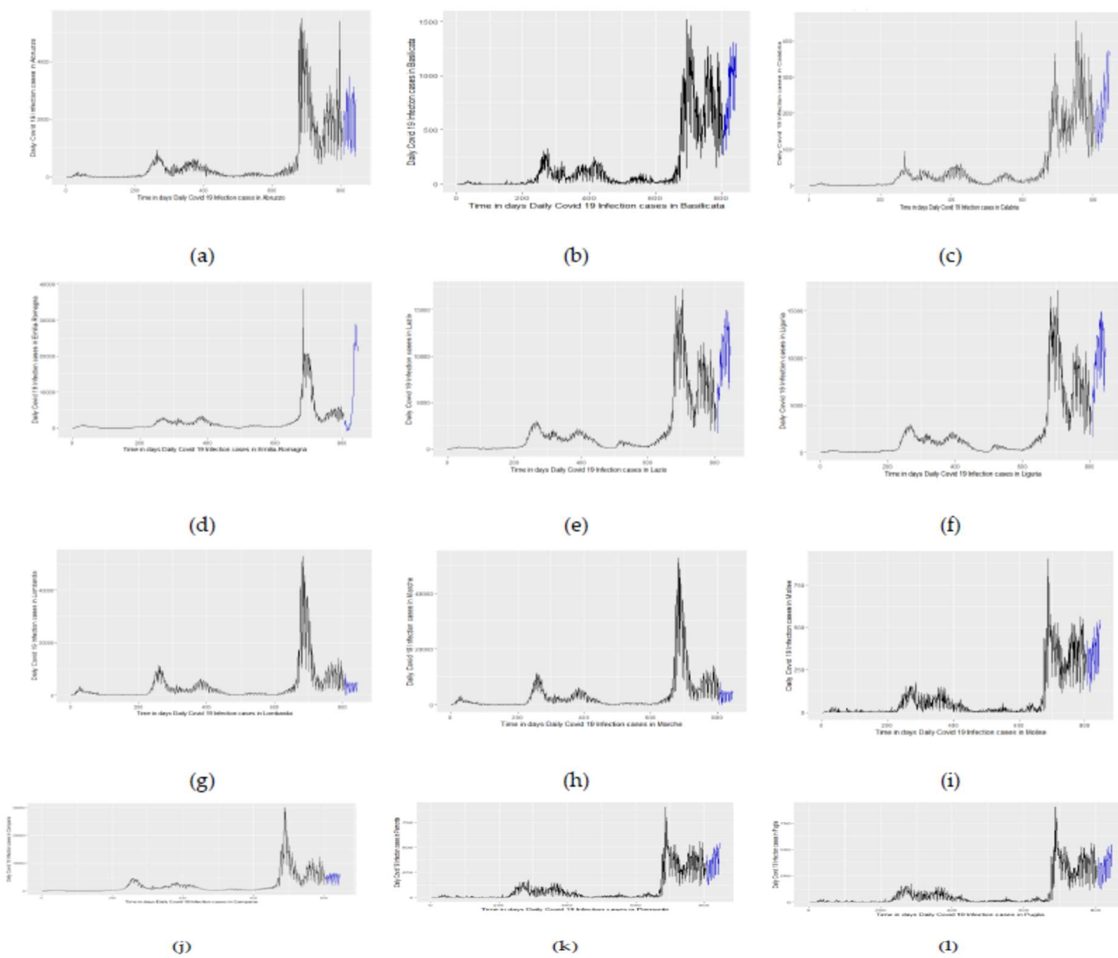
States	ANN
Abuja	32.14
Kaduna	12.28
Kano	28.07
Lagos	34.15
Ogun	25.64
Oyo	20.18
Osun	24.52
Ondo	22.46
Rivers	30.16
Anambra	13.54
Imo	11.37
Ekiti	14.56
Abia	26.45
Bayelsa	27.09
Akwa Ibom	20.33
Kwara	27.89
Niger	24.18
Plateau	18.52
Nassarawa	19.15
Jigawa	20.05

Table 2. MAPE (%) for 6 days' accuracy of ANN forecasting model for Nigerian States

States	11-Jul-22	12-Jul-22	13-Jul-22	14-Jul-22	15-Jul-22	16-Jul-22
Abuja	13.54	14.42	10.28	12.96	13.08	12.84
Kaduna	12.52	10.85	12.27	13.63	11.05	12.71
Kano	25.32	24.12	16.05	22.41	15.33	20.82
Lagos	23.45	18.96	17.05	21.21	26.84	20.36
Ogun	28.97	32.12	30.54	33	29.06	31.80
Oyo	20.45	17.33	19.56	17.84	19.07	21.32
Osun	21.46	22.30	27.18	19.36	20.08	22.18
Ondo	20.97	21.54	19.75	21.13	16.33	19.54
Rivers	31.84	30.46	32.56	28.72	31.88	32.99
Anambra	12.72	14.56	16.22	15.02	13.21	11.88
Imo	10.76	11.64	12.12	10.98	12.54	10.35
Ekiti	28.12	25.12	22.31	20.64	29.22	31.60
Abia	23.40	21.44	20.16	25.39	22.48	24.56
Bayelsa	21.39	17.96	17.75	23.41	24.84	20.36
Akwa Ibom	22.83	21.78	20.05	21.44	26.45	22.02
Kwara	22.18	18.56	19.34	21.12	20.88	20.52
Niger	26.59	23.17	16.75	24.31	15.42	20.78
Plateau	18.52	21.56	16.45	19.02	23.21	20.82
Nassarawa	19.15	17.33	26.02	15.25	13.54	15.65
Jigawa	20.05	24.06	26.69	18.43	18.28	17.98

We performed the forecasting for new COVID-19 cases in Nigerian States using the above model. We conducted a 30-days-ahead forecast (until 16 July 2022) and compared the forecasting data with the testing data for 6 days (11 Jul 2022–16 Jul 2022), applying the forecasting models to the confirmed cases for the last 8 days data and compared the results with the actual COVID-19 data. We calculated the MAE values as the difference between actual data and forecast values. The MAPE values for ANN forecasting model are represented in Table 2. Based on our analysis, we concluded that the prediction performance of the models was similar to the real data. In particular, the ANN model gave more accurate predictions, as its MAE values were lower compared to the other models. We observed decreasing MAE values, in particular for the last 6 days' testing values, as its values decreased from about 7% to 1%. This implies that the decreased in Covid-19 cases will aid to cushion the effects.

Figure 1 presents the forecasting results of ANN model for the following 30 days for COVID-19 new confirmed cases in Nigerian States.



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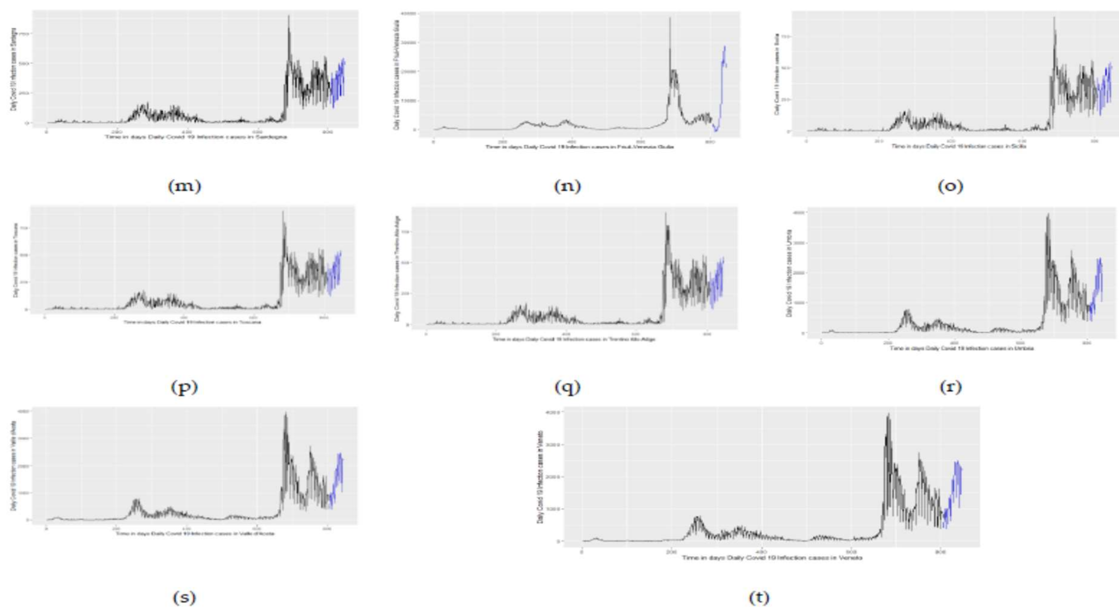

Figure 1: a Abuja, b Kaduna, c Kano, d Lagos, e Ogun, f Oyo, g Osun, h Ondo, I Rivers,

J Anambra, k Imo, l Ekiti, m Abia, n Bayelsa, o Akwa Ibom, p Kwara, q Niger, r Plateau,

S Nassarawa, t Jigawa

Figure 1 shows the trend of the number of new cases predicted by the ANN model for eachof the states, obtained considering 28 lags as inputs and 5 nodes in the hidden layer. According to the ANN (28-5-1) model, there will be an increasing trend in the number of new COVID-19 infections by the end of June, until 16 July in the following states: Abuja, Kaduna, Kano, Ogun, Oyo, Rivers, Imo, Ekiti, Abia and Jigawa, while for the rest of them the ANN model predicted a constant to decreasing trend for the next 30 days.

Discussion

In this study, we assessed of artificial neural networks in modern medicine for predicting and cushioning the effect of covid-19 pandemic. Using the ANN model. It was used based on MAE value, as it had the lowest value among all the forecasting models. The ANN (28-5) model gives better results in all the considered indicators with a considerable difference from the indicators of the other linear models. It predicted an increase in the number of new COVID-19 infections by the end of July 2022, in almost all the Nigerian State. Other measures of cushioning the effect of covid-19 can be influenced by other factors such as vaccination, immunization of the population, and measures taken by government authorities to limit the spread of the infection.

CONCLUSION

The ANN model may be deployed on fresh data as they become available in order to increase the accuracy of future COVID-19 cases forecasting, perhaps taking into account other patients' parameters as inputs for the ANN model, since extra data will improve predicting performance. The allocation of medical resources, the management of the pandemic's spread, and the improvement of health care system preparedness would be greatly aided by the prediction of potential future new cases. It might be highly useful for future forecasts about interventions for limiting and controlling the spread of the virus for those involved in decision-making.

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