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USING ARTIFICIAL NEURAL NETWORKS FOR PREDICTING CHICKENPOX CASES AT CHITUNGWIZA URBAN DISTRICT IN ZIMBABWE

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ABSTRACT:

Despite the fact that chickenpox is rarely a fatal disease, it is still a real public health challenge; even in this 21st century. The current study used monthly time series data on chickenpox caseloads diagnosed and managed within Chitungwiza urban district in Chitungwiza, Zimbabwe, from Janaury 2012 to December 2019, to predict chickenpox cases over the period January 2020 to December 2021. We applied the well-known ANN (12, 12, 1) model. Residual analysis of this model indicated that the model is stable and thus suitable for forecasting chickenpox case volumes in Chitungwiza urban district over the out-of-sample period. The results of the study reveal that chickenpox cases will generally be on a downwards trajectory in Chitungwiza urban district over the out-of-sample period. This implies that even-though the disease is highly contagious, its spread over the out-of-sample is likely to be reduced. The study recommends compulsory varicella-zoster vaccination of all children as well as treatment of all infected persons.

INTRODUCTION:

Chickenpox is a highly contagious and yet rarely fatal disease varicella-zoster virus (Corberan-Vallet et al., 2018). Its main symptoms are a blister-like rash, itching, tiredness and fever (CDC, 2017). Chickenpox is widely transmitted through touching the fluids from chickenpox blister. The varicella-zoster virus is spread either by direct contact with a person with active chickenpox or shingles, or by direct contact with clothes or other articles infected with vesicle fluid, saliva, nasal discharge, or by air bone spread of small droplets of infected mucous of fluid (Edward et al., 2014). This disease mainly affects children younger than ten years of age, although older children and adults can also get it. Most people suffer from the disease during childhood and reinfection is very strange (CDC, 2017). In non-vaccinated populations, primary infections tend to occur at a younger age (Gershon, 2008). The occurrence of chickenpox differs according to geographical zones. In temperate countries chickenpox is usually mild, self-limiting infection, affecting pre-school children (Vyse et al., 2004), however, the incidence of chickenpox in these areas is increasing in adolescents and adults (Fairley & Miller, 1996), probably due to increased world travel and economic migration of vulnerable individuals. In many tropical countries, the epidemiology is different, with approximately 60% of adults being immune (Lee, 1998).

1.1 OBJECTIVES OF THE STUDY:

i. To investigate chickenpox cases in Chitungwiza urban district over the period January 2012 to December 2019.
ii. To forecast chickenpox cases for Chitungwiza urban district over the period January 2020 to December 2021.

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iii. To assess whether chickenpox cases are increasing or decreasing for Chitungwiza urban district over the out of sample period.

RELATED STUDIES:

In a Tanzanian study, Edward et al. (2014) applied a deterministic model to analyze chickenpox and established that the combination of vaccination and treatment is the most effective way to combat the epidemiology of varicella-zoster virus in Tanzania. Using a deterministic, age-stratified SIR (susceptible-infected-recovered) model, Zibolenova et al. (2015) predicted the influence of vaccination administered in different ages on the disease occurrence in different age groups in Slovakia. The study found out that increase of vaccination coverage has a positive impact on the incidence of varicella in Slovakia. Based on ARIMA and SARIMA models, Sierra et al. (2018) forecasted the incidence rate of varicella in Bogota and found out that the SARIMA $(3, 0, 1)(1, 0, 1)_{12}$ model was the optimal model for forecasting the incidence of chickenpox in Bogota. Employing a Bayesian stochastic susceptible-infectious-recovered model, Corberan-Vallet et al. (2018) investigated chickenpox transmission in the Valencian community in Spain. The researchers concluded that their model was accurate in terms of computation of forecasts and prediction intervals and can thus be used in chickenpox surveillance. No similar Zimbabwean study has been done. This paper will be the first of its kind not only Chitungwiza urban district but for the entire country at large and will go a long way in aiding chickenpox surveillance in the country.

METHODOLOGY:

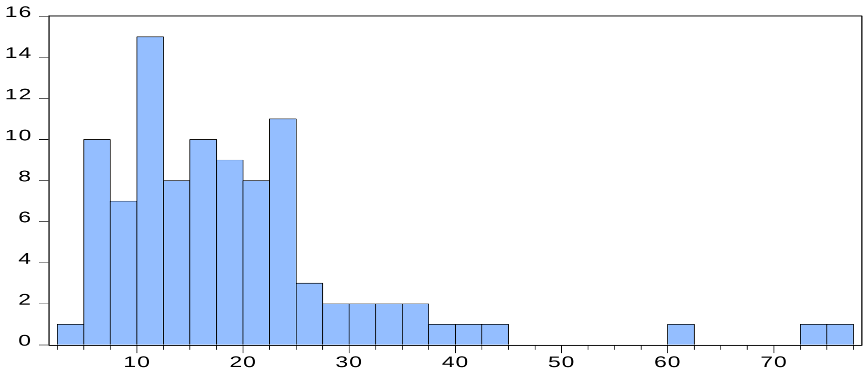
The study employed the Artificial Neural Network (ANN) approach in modeling and forecasting monthly chickenpox cases in Chitungwiza urban district. Guided by Fischer & Gopal (1994), who argue that no strict rules exist for the determination of the ANN structure; the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function.

3.1 Data Issues:

This study is based on newly diagnosed monthly chickenpox cases [all age groups] (reffered to as CP series in this study) at Chitungwiza urban district. The data covers the period January 2012 to December 2019 while the out-of-sample forecast covers the period January 2020 to December 2021. All the data employed in this paper was gathered from DHIS2 Information System for Chitungwiza urban district.

FINDINGS OF THE STUDY:

4.1 Descriptive Statistics:



Series: CP	
Sample 2012M01 2019M12	
Observations 96	
Mean	18.97917
Median	16.00000
Maximum	75.00000
Minimum	3.000000
Std. Dev.	12.61326
Skewness	2.242812
Kurtosis	9.800962
Jarque-Bera	265.4956
Probability	0.000000

Figure 1: Descriptive statistics

4.2 ANN Model Summary:

Table 1: ANN model summary

Variable	CP
Observations	72 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.007456
MSE	2.063442
MAE	5.300921

Residual Analysis for the Model Presented Above

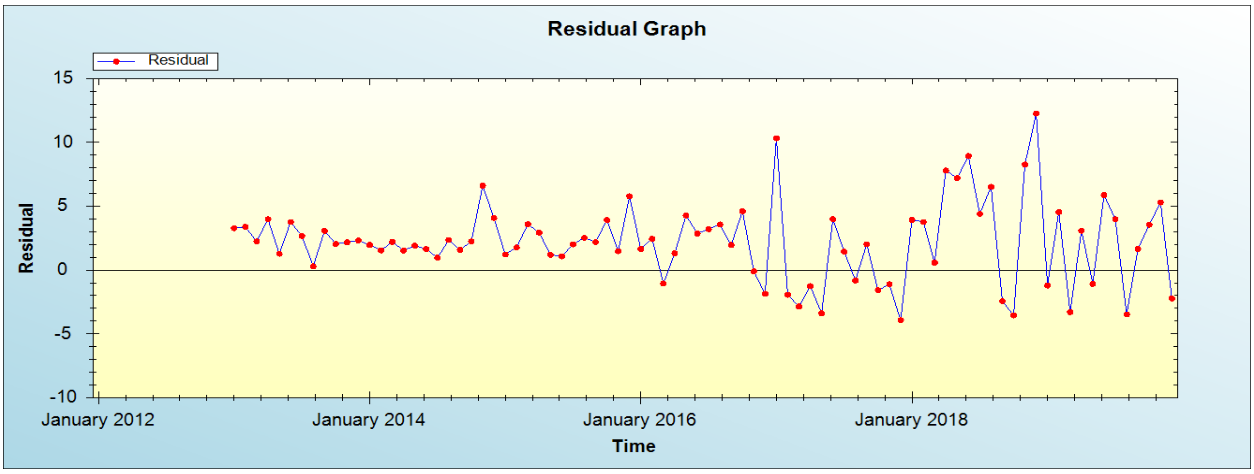


Figure 2: Residual analysis

In-sample Forecast for CP

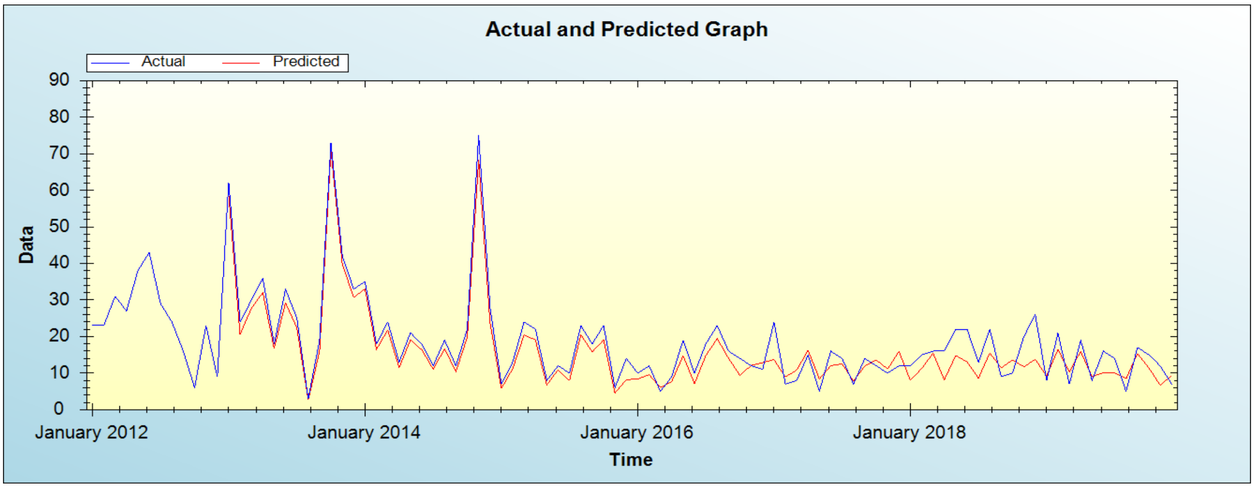


Figure 3: In-sample forecast for the CP series

Out-of-Sample Forecast for CP: Actual and Forecasted Graph

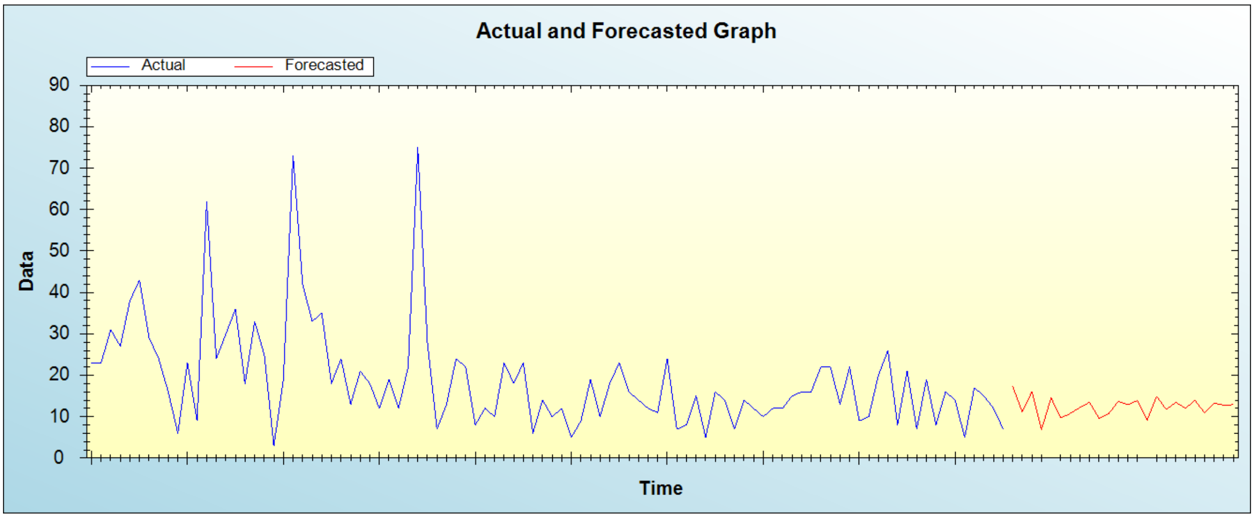


Figure 4: Out-of-sample forecast for CP: actual and forecasted graph

Out-of-Sample Forecast for CP: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Month-Year	Predicted CP
January 2020	17.3706
February 2020	11.1672
March 2020	16.0502
April 2020	6.9121
May 2020	14.5700
June 2020	9.6524
July 2020	10.7893
August 2020	12.1821
September 2020	13.4779
October 2020	9.5943
November 2020	10.7157
December 2020	13.7255
January 2021	12.8820
February 2021	13.8866
March 2021	9.1502
April 2021	14.9019
May 2021	11.7413
June 2021	13.4956
July 2021	12.0141
August 2021	13.9427
September 2021	10.8851
October 2021	13.2707
November 2021	12.7511
December 2021	12.9094

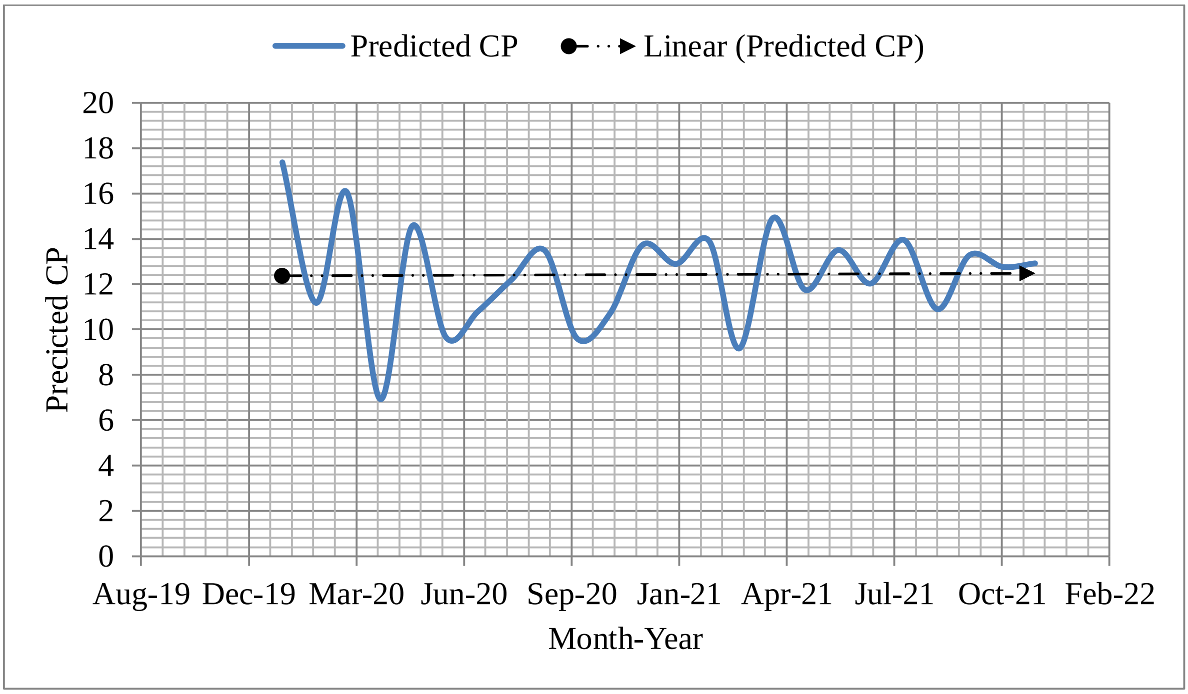


Figure 5: Graphical presentation of out-of-sample forecasts

4.3 DISCUSSION OF THE RESULTS:

Figure 1 shows the descriptive statistics of the series under consideration. The most important issue raised in this figure, is that over the period under study, there has been an average of 19 chickenpox patients per month in Chitungwiza urban district. Table 1 is the ANN model summary and basically shows the ANN (12, 12, 1) model, which is just based on the hyperbolic tangent function as its activation function. The "criteria" are the evaluation statistics and they all indicate the model is adequate and acceptable for predicting chickenpox cases for Chitungwiza urban district. Figure 2 shows the residuals of the model and, given that the residuals are as close to zero as possible, the model is stable and acceptable for generating forecasts for Chitungwiza urban district. Figure 3 shows the in-sample forecast of the model and it can be inferred that the model fits well with data. Figure 4, table 2 and figure 5 are out of sample forecasts. The results of the study show that chickenpox case volumes may, in general, slightly go down over the out-of-sample period.

5.0 CONCLUSION & RECOMMENDATIONS:

The study shows that the ANN (12, 12, 1) model is stable and suitable for forecasting chickenpox cases in Chitungwiza urban district in Chitungwiza, Zimbabwe, over the study period. The model predicts a possible slight decline in the incidence of chickenpox in Chitungwiza urban district. The study suggests that there ought to be compulsory varicella-zoster vaccination of all children as well as treatment of all infected persons in Chitungwiza urban district in order to fight-off chickenpox.

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