European Scholar Journal (ESJ)
Available Online at: https://www.scholarzest.com
Vol. 1 No. 2, October 2020,
ISSN: 2660-5562

USING ARTIFICIAL NEURAL NETWORKS FOR PREDICTING NEW CATARACT CASES AT GWERU PROVINCIAL HOSPITAL IN ZIMBABWE

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Article history:

Received September 7th 2020
Accepted: September 30th 2020
Published: October 20th 2020

Abstract:

Everyone, if they live long enough, will experience at least one eye condition in their lifetime that will require appropriate care (WHO, 2019). This study employed monthly time series data on new cataract cases recorded and managed at Gweru Provincial Hospital (GPH) from Janaury 2010 to December 2019, in order to forecast cataract cases over the period January 2020 to December 2021. The famous ANN (12, 12, 1) model was applied. Residual analysis of this model indicated that it was very stable and thus suitable for predicting cataract cases at GPH over the out-of-sample period. The results of the study indicate that cataract cases will generally, (but slightly) rise over the out-of-sample period. In order to win in the war against avoidable blindness, GPH should basically make sure that readily available surgical services capable of delivering good vision rehabilitation are accessible to all in need, no matter what their circumstances.

Keywords: Cataract cases, The famous ANN model

1.0 INTRODUCTION

In a world built on the ability to see, vision, the most dominant of our senses, is vital at every turn of our lives. Eye conditions and vision impairment are widespread, and far too often they still go untreated. Globally, at least 2.2 billion people have a vision impairment, and of these, at least 1 billion people have a vision impairment that could have been prevented or is yet to be addressed. As usual, this burden is not borne equally. It weighs more heavily on low and middle income countries, on older people, and on rural communities (WHO, 2019). Most worrying is the fact that global demand for eye care is set to surge in the coming years due to population growth, ageing and changes in lifestyle (CDC, 1983; WHO, 2019). This study will focus on modeling and forecasting cataract case volumes recorded and managed at Gweru Provincial Hospital (GPH) over the period January 2010 to December 2019. Cataract is an opacity of the natural, crystalline lens of the eye and remains the most frequent cause of blindness in the world today and apparently accounts for 50% of blindness worldwide (Javitt *et al*., 1996). Cataract remains the leading cause of blindness in Africa (Pascolini & Mariotti, 2010; Lewallen *et al*., 2010; Lewallen *et al*., 2013) and Zimbabwe is not an exception (Schwab & Kagame, 1993; Chirunga *et al*., 2016). Clearly, we have no choice but to take on this challenge (WHO, 2019) and modeling and forecasting cataract case-loads is one such way.

1.1 OBJECTIVES OF THE STUDY

i. To assess new cataract cases at GPH over the period January 2010 to December 2019.
ii. To predict cataract cases for GPH over the period January 2020 to December 2021.
iii. To determine whether cataract cases are increasing or decreasing for GPH over the out of sample period.

2.0 RELATED STUDIES

Panchapakesan *et al*. (2003) assessed the 5 year incidence of cataract surgery in an older population based prospective cohort. The study found out that the incidence of cataract in the 65 years and above age group was about 7.9%. In a Zimbabwean endeavor, Schwab & Kagame (1993) assessed blindness in the country and found out that bilateral corneal opacity was responsible for 75% of all blindness among institutionalized blind students. In a cross-sectional population-based survey, Habiyakire *et al*. (2010) estimated the prevalence and causes of avoidable blindness and visual impairment in persons 50 years of age and older and finally found out that the prevalence of blindness was very high in Kilimanjaro region of Tanzania. Based on mathematical models, Lewallen *et al*. (2013) examined cataract incidence in sub-Saharan Africa and established that the incidence varied across the continent and that the variation was largely related to genetic or cultural variations on the continent. In a study conducted in Taiwan, Horng *et al*. (2015) predicted the incidence of human cataract through retinal imaging technology. The findings of the study indicate that periodic hole arrays cause severe eyesight decline when they are centralized in the visual center. In another Zimbabwe study, which is more recent, Chirunga *et al*. (2016) investigated the prevalence of avoidable blindness in Manicaland province and generally found out the prevalence of bilateral blindness with available correction was 7.2%. All the reviewed studies never attempted to forecast the cases volumes of cataract in any of the examined age groups. This study will be the first of kind and is expected to go a long in helping public health policy makers in the fight against avoidable blindness.

3.0 METHODOLOGY

The study applies the Artificial Neural Network (ANN) approach in modeling and forecasting monthly cataract cases at GPH. Guided by Fischer & Gopal (1994), who, basically, argued 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.

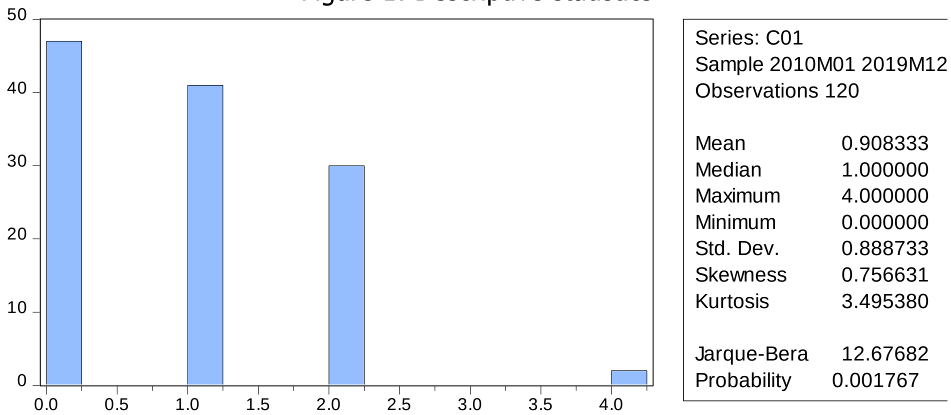
3.1 Data Issues

This study is based on newly diagnosed monthly cataract cases [elderly people: 65 years old and above] (reffered to as C series in this study) at GPH. The data covers the period January 2010 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 GPH Health Information Department.

4.0 FINDINGS OF THE STUDY

4.1 DESCRIPTIVE STATISTICS

Figure 1: Descriptive statistics



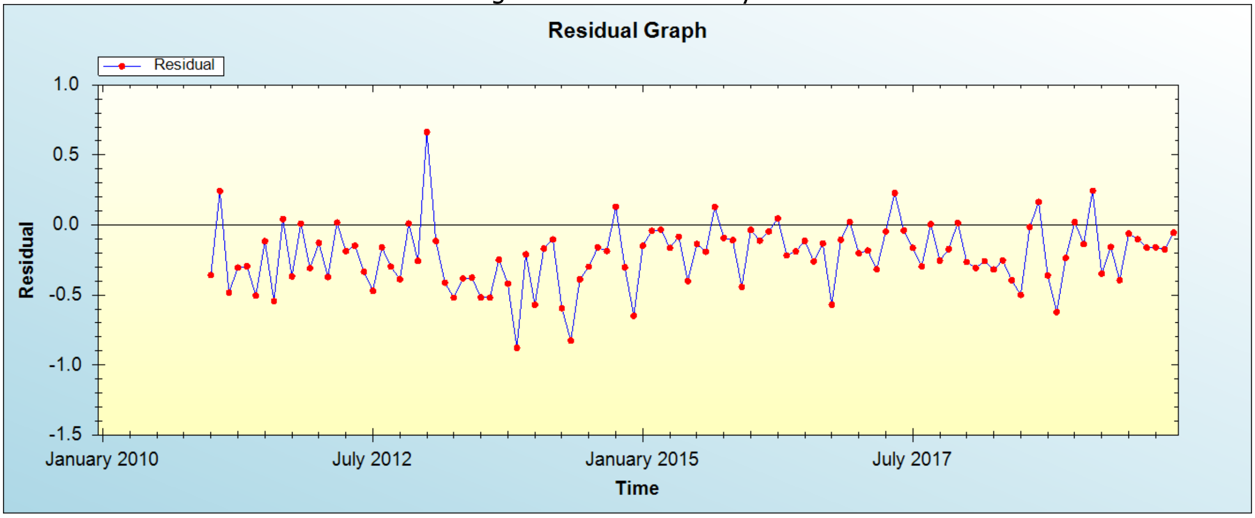
4.2 ANN Model Summary

Table 1: ANN model summary

Variable	C
Observations	108 (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	0.06633
MSE	51.443221
MAE	3.123401

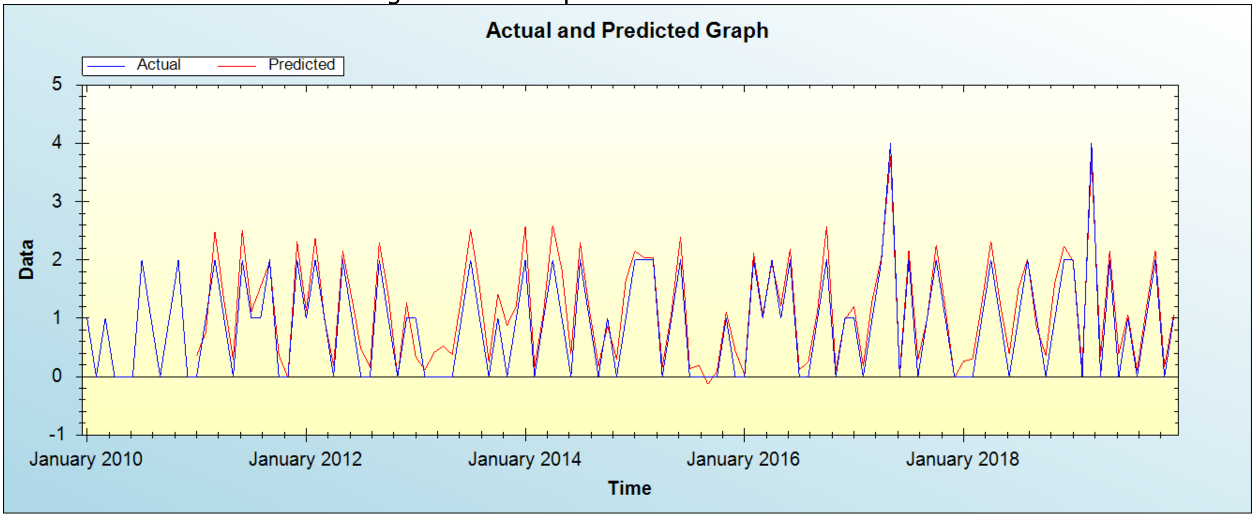
Residual Analysis for the Model Presented Above

Figure 2: Residual analysis



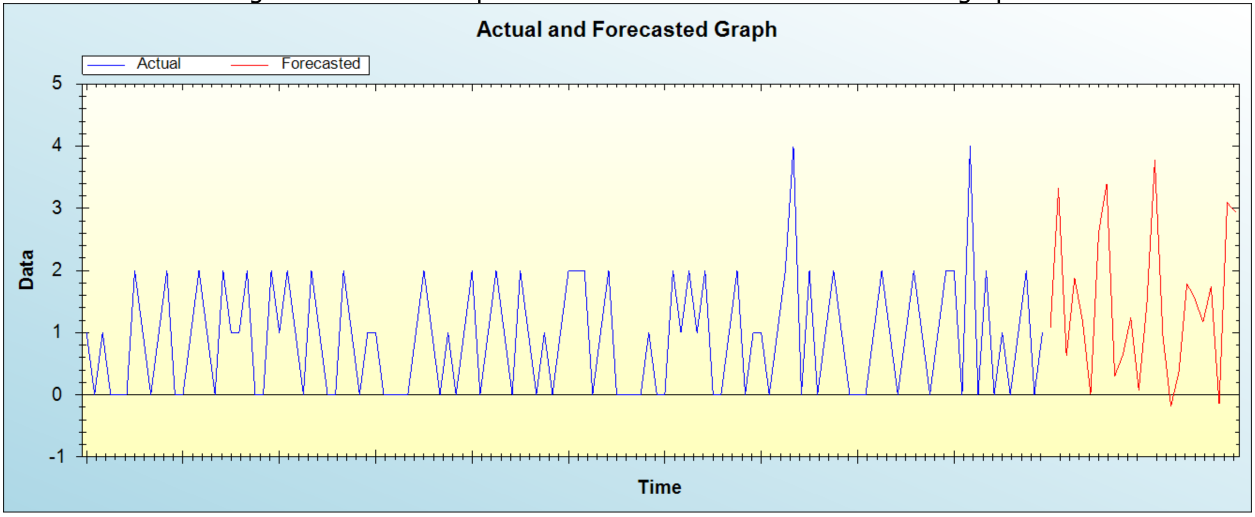
In-sample Forecast for C

Figure 3: In-sample forecast for the C series



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

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

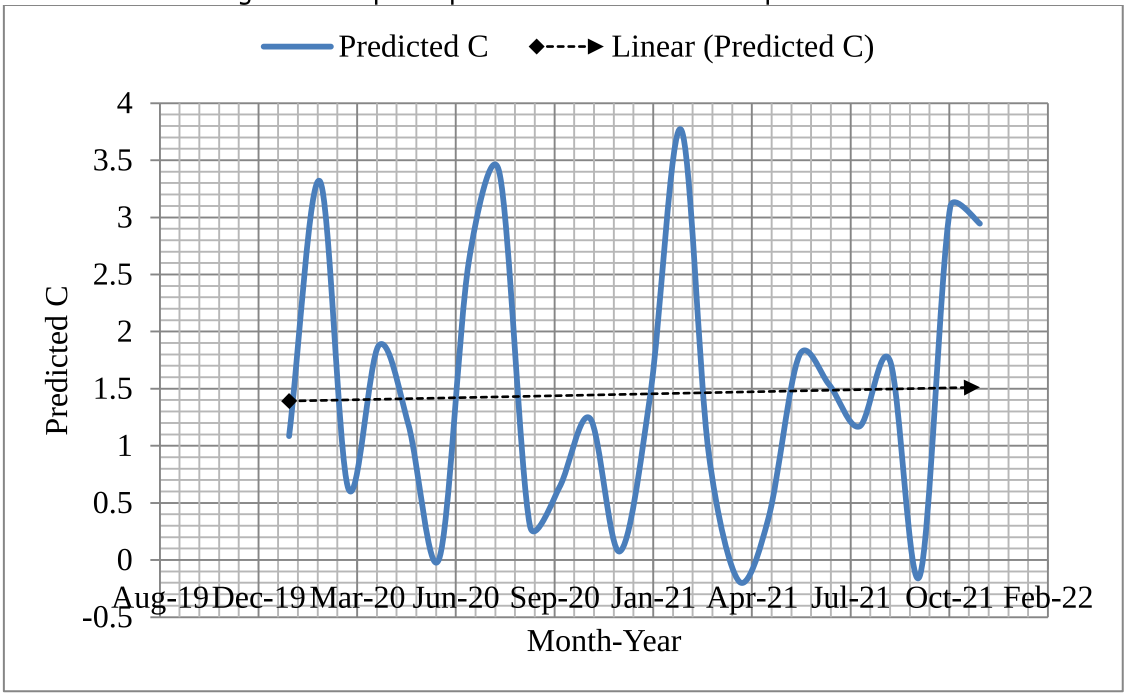


Out-of-Sample Forecast for C: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Month/Year	Predicted C
January 2020	1.0850
February 2020	3.3184
March 2020	0.6267
April 2020	1.8797
May 2020	1.1840
June 2020	0.0095
July 2020	2.6052
August 2020	3.3967
September 2020	0.3024
October 2020	0.6377
November 2020	1.2394
December 2020	0.0748
January 2021	1.4457
February 2021	3.7705
March 2021	0.9502
April 2021	-0.1876
May 2021	0.3740
June 2021	1.7902
July 2021	1.5383
August 2021	1.1693
September 2021	1.7432
October 2021	-0.1427
November 2021	3.0904
December 2021	2.9453

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



4.3 DISCUSSION OF THE RESULTS

Table 1 shows the ANN (12, 12, 1) neural network model, which has been based on the hyperbolic tangent function as its activation function. Figure 1 indicates that, over the period under study, on average, 1 cataract patient per month has been managed at GPH. The "criteria" are the evaluation statistics and they all tell us that our model is adequate. Figure 2 shows the residuals of the model and since the residuals are as close to zero as possible, the model is stable and acceptable for generating forecasts of C for GPH. Figure 3 shows the in-sample forecast of the model and it can be concluded that the model fits well with data. Figure 4, table 2 and figure 5 are out of sample forecasts. The findings of the study indicate that cataract case volumes may slightly increase over the out of sample period at GPH.

5.0 CONCLUSION & RECOMMENDATIONS

Factually, cataract prevalence increases with age. As the world ages, cataract-induced visual dysfunction and blindness is bound to be on the increase. Despite the fact that it was not widely recognized, cataract was actually a significant public health problem in the last century. In this 21st century, it is even a greater problem, the significance of which is better understood. Today, public health specialists, medical professionals and health economists have a challenge to deal with it so that it is no longer a problem, especially at the beginning of the next century. Hinged on the fact that cataract surgery has the potential to completely restore vision, blindness related to cataract is indeed avoidable and cataract surgical services are a critical element of efforts to reduce and prevent vision loss. Therefore, GPH should make sure that readily available surgical services capable of delivering good vision rehabilitation are accessible to all in need, no matter what their circumstances. Furthermore, GPH ought to ensure that it has enough resources for other corrective interventions such as spectacle correction: in this regard, the government of Zimbabwe has a role to play in availing such funding.

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