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USING ARTIFICIAL NEURAL NETWORKS FOR PREDICTING MIGRAINE CASES AT KWEKWE GENERAL HOSPITAL IN ZIMBABWE

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ABSTRACT

Migraine is one of the most common neurological disorders. In Zimbabwe is not uncommon and yet migraine studies in the country are still scanty. The current study employed monthly time series data on migraine caseloads recorded and managed at Kwekwe General Hospital (KGH) from Janaury 2010 to December 2019, to forecast migraine cases over the period January 2020 to December 2021. The study applied the ANN (12, 12, 1) model. Residual analysis of this famous model indicates that the model is stable and thus suitable for forecasting migraine case volumes at KGH over the period January 2020 to December 2021. The findings of the indicated that migraine case-loads will, in general, slightly trend upwards over the out-of-sample period. Amongst other policy suggestions, we advise KGH to promptly treat all migraine cases and also disseminate information about migraine and the need for timely hospital visits.

1.0INTRODUCTION

Migraine is a chronic recurrent headache, lasting several hours, and affects around 10% worldwide and is considered one of the most disabling diseases with great socioeconomic impact (Pagan et al., 2015), especially in terms of lost productivity and healthcare resource use (Blumenfeld et al., 2011). Worldwide, it occurs in 18% of women and 6% of men (Lipton et al., 2001; Stovner et al., 2007). Migraine is ranked as the leading cause of neurological disability worldwide and is one of the five leading causes of long-term disability (Edivinsson, 2018). Migraine is characterised by recurrent headaches, unilateral or bilateral, throbbing, moderate to severe intensity and typically worsens with exercise. It may be accompanied by sensitivity to noise, light and or odors. Sometimes, migraines are preceded or accompanied by transient neurological symptoms (visual, sensory or speech), and they are called migraines with aura (Guglielmo et al., 2013). The migraine headache definitely has hereditary foundations (Ferrari, 1998), but biological aspects play a substantial role in how the illness distresses those who endure it. Patho-physiologically, the initiation of a mechanism profound in the brain produces a discharge of pain-creating inflammatory substances in the region of blood vessels and the nerves of the brain (Spierings, 2003; Geppetti et al., 2012). Why this occurs episodically and what are the causes of the resolution

of attacks is undefined (Atif et al., 2017). Migraine's current management and treatment is normally pharmacological and depends on the chronification level of the disease (Hershey, 2010; Lopes et al., 2012; Silberstein et al., 2012; Diener et al., 2012; Guglielmo et al., 2013). Migraine in Zimbabwe, just like anywhere in Africa, is mostly self-treated due to limited availability of primary care, neurologic consultations, imaging facilities, and related investigative modalities (WHO, 2011).

Migraine is not adequately explored in Africa (Woldeamanuel et al., 2014), and yet it is ranked as the 13th leading cause of years lived with disability (Vos et al., 2012) and the same applies to Zimbabwe in particular. To the best of our knowledge, no similar study has been carried in Zimbabwe. This paper is envisioned to stimulate further scholarly debate on the need to develop forecasting and control models for better management of migraine patients. This will consequently go a long way in reducing the burden of migraine not only on patients and associated families but also on the economy of Zimbabwe.

1.1 OBJECTIVES OF THE STUDY

i. To investigate the trend of migraine cases at KGH over the period January 2010 to December 2019.
ii. To predict migraine cases for KGH over the period January 2020 to December 2021.
iii. To determine whether migraine cases are increasing or decreasing for KGH over the out of sample period.

2.0 RELATED STUDIES

In a cross-sectional study, Oshinaike et al. (2014) sought to determine the yester-year prevalence and the healthcare utilization pattern of primary headaches at a tertiary centre in Nigeria and found out that overall headache prevalence was 39.3% with female predominance. In a review article, Woldeamanuel et al. (2014) analyzed the worldwide prevalence of migraine headache and concluded that the burden of migraine is bound to increase by more than 10% DALYs within the next decade. In another review article, Atif et al. (2017) examined the global prevalence of migraine headache and found out that the global prevalence of migraine headache was approximately 11.4%. Using a longitudinal cohort forecasting model, Houle et al. (2017) developed and validated a prediction model that forecasts future migraine attacks for an individual headache sufferer and established that future headache attacks can be forecasted for a diverse group of individuals over time. No similar study has been carried in Zimbabwe. This paper is expected to stimulate further scholarly debate on the need to develop forecasting and control models for better management of migraine headaches.

3.0 METHODOLOGY

The study employs the Artificial Neural Network (ANN) approach in modeling and forecasting monthly migraine headache cases at KGH. In line with previous researchers such as Fischer & Gopal (1994), who argue that no strict rules exist for the determination of the ANN structure; this 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 [all age groups] (reffered to as MH series in this study) at KGH. 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

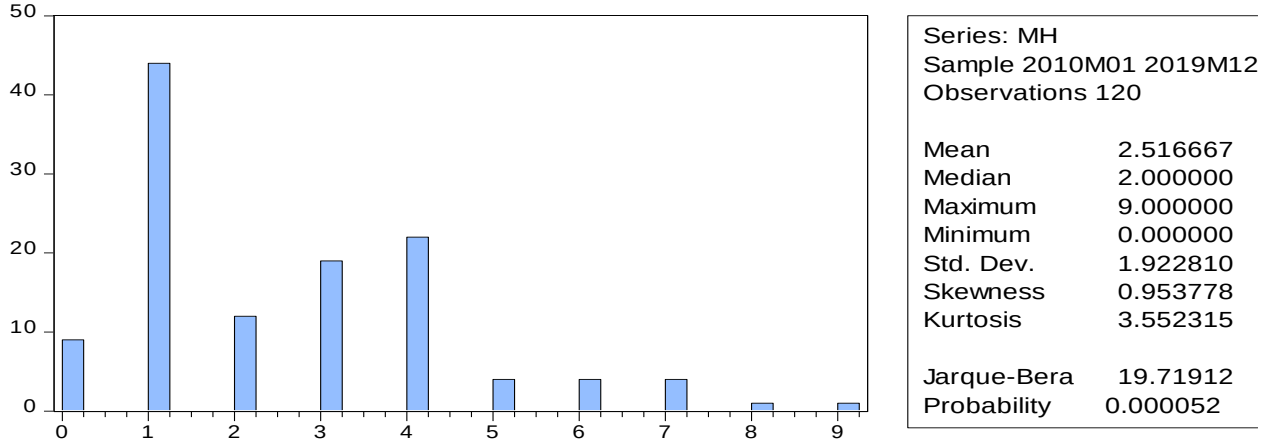

Figure 1: Descriptive statistics

4.2 ANN Model Summary

Table 1: ANN model summary

Variable	MH
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	0.107057
MSE	0.286532
MAE	0.439353

Residual Analysis for the Model Presented Above

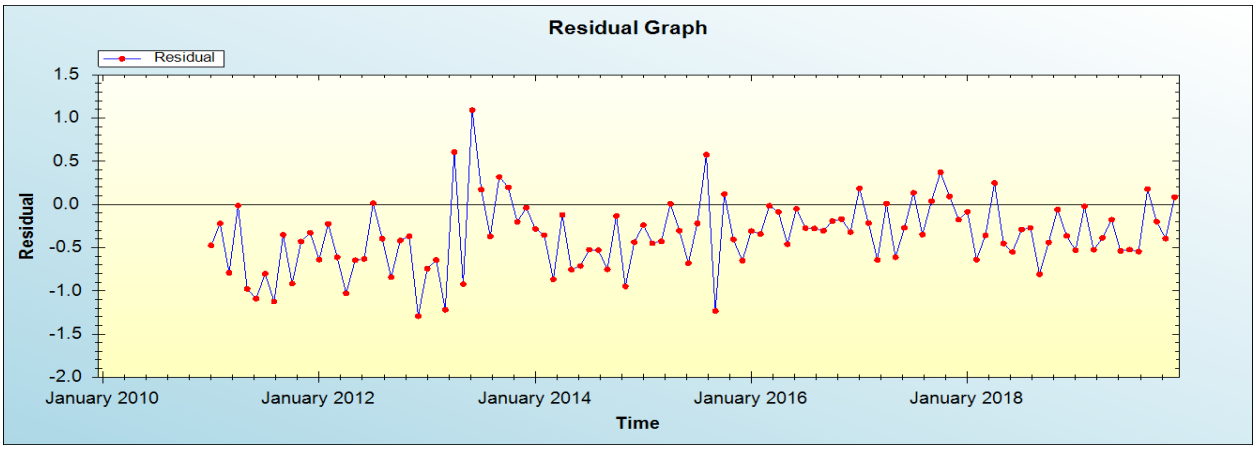

Figure 2: Residual analysis

In-sample Forecast for MH

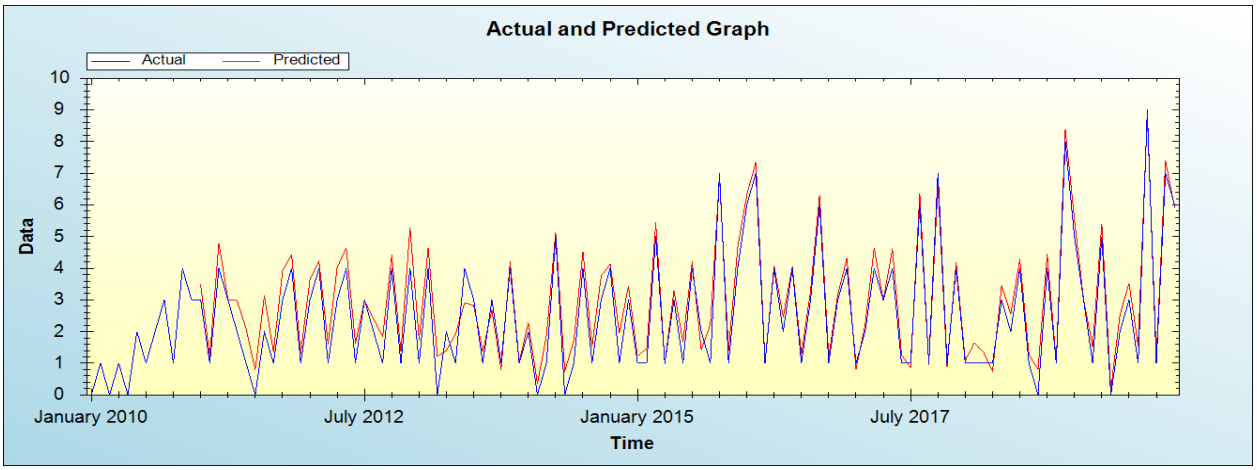

Figure 3: In-sample forecast for the MH series

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

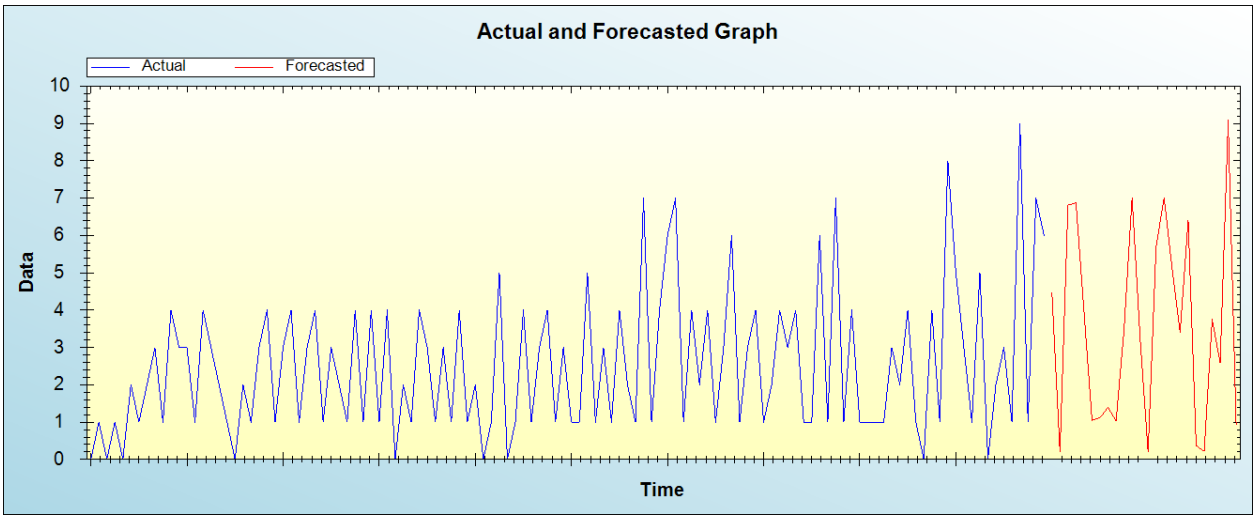

Figure 4: Out-of-sample forecast for MH: actual and forecasted graph

Out-of-Sample Forecast for MH: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Month-Year	Predicted MH
January 2020	4.4606
February 2020	0.2044
March 2020	6.8099
April 2020	6.8728
May 2020	3.9758
June 2020	1.0508
July 2020	1.1195
August 2020	1.3961
September 2020	1.0304
October 2020	3.4725
November 2020	7.0028
December 2020	3.2608
January 2021	0.1953
February 2021	5.6806
March 2021	7.0133
April 2021	5.1112
May 2021	3.3959
June 2021	6.3991
July 2021	0.3711
August 2021	0.2147
September 2021	3.7494
October 2021	2.5845
November 2021	9.0797
December 2021	0.9259

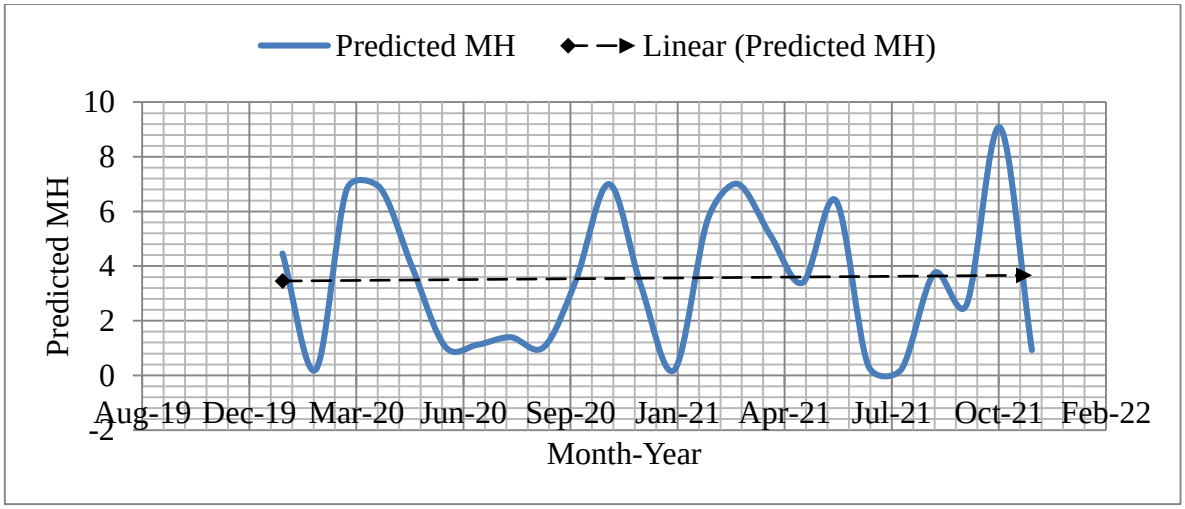

Figure 5: Graphical presentation of out-of-sample forecasts

4.3 DISCUSSION OF THE RESULTS

As shown in figure 1, an average of approximately 3 migraine patients per month was received at KGH over the study period. Table 1 is the ANN model summary and shows the

ANN (12, 12, 1) neural network model, which has been hinged on the hyperbolic tangent function as its activation function. The "criteria" or the "evaluation" statistics indicate the model is adequate. 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 of migraine monthly cases for KGH. 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 indicated that migraine case-loads will, in general, slightly trend upwards over the out-of-sample period.

5.0 CONCLUSION & RECOMMENDATIONS

Migraine is a complex neurological disorder and a serious public health problem, especially in developing countries such as Zimbabwe. Indeed, the burden of headache is enormous as it is accounts for multiple visits to the general physician and neurologist and causes significant disability characterized by reduced efficiency, poor quality of life as well as lost work days. In this paper, an ANN model has been applied to model and forecast monthly migraine cases recorded and managed at KGH. Using monthly data over the period Janaury 2010 to December 2019, the study reliably predicted monthly migraine case volumes over the period January 2020 to December 2021. The study recommends the following policy options to be put under consideration by KGH executive management team:

i. There is need for prompt treatment of migraine patients.
ii. Clinicians should assess patients properly so that they recognize the patient-specific precipitating factors of migraine. This will go a long way, especially in implementing possible preventive measures.
iii. KGH should also consider increasing awareness about migraine in its catchment areas. This will go a long way in encouraging timely hospital visits and thus improving health seeking behaviours of patients.

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