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FORECASTING HYPERTENSION CASES AT GWERU PROVINCIAL HOSPITAL USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT:

The study applied the ANN (12, 12, 1) model in order to analyze hypertension cases for Gweru Provincial Hospital. The data used in the study cover the period January 2010 to December 2019 while the out-of-sample period is January 2020 to December 2021. The applied model is quite stable and acceptable as shown by its minimum forecast evaluation statistics (i.e Error, MSE, MAE) as well as residuals which are as close to 0 as possible. The results of the study basically indicate that hypertension cases at GPH will slightly decline over the January 2020 to December 2021. The study recommends the following: [i] GPH ought to reduce bottlenecks in the management of hypertension; [ii] GPH should make sure essential medicines for treatment of hypertension are always in place; [iii] GPH should promote a healthy diet during its community-based health campaigns.

KEYWORD: ANN, Forecasting, Hypertension.

INTRODUCTION:

Hypertension (also known as High Blood Pressure) is one of the commonest causes of morbidity and mortality globally (Leung et al., 2019; Princewel et al., 2019) especially in developing countries such as Zimbabwe (Chimberengwa & Naidoo, 2019; Nyoni & Nyoni, 2020) and is apparently the leading driver of cardiovascular disease deaths in Africa (Bosu et al., 2019). The number of hypertensive patients is projected to increase to 1.56 billion people globally by the year 2025 (Kearney et al., 2005). The prevalence rate of hypertension in Zimbabwe is approximately 27% (Ministry of Health and Child Care, 2016) and this is unacceptably high and calls for urgent evidence-based policy action (Nyoni & Nyoni, 2020). A person is hypertensive, if he or she experiences a repeated elevated blood pressure exceeding 140 over 90 mmHg (Kearney et al., 2005). Predictive modeling of hypertension can render valuable information for planning health interventions (Nyoni & Nyoni, 2020). The main objective of this study is to predict hypertension cases for Gweru Provincial Hospital (GPH) over the period January 2020 to December 2021.

LITERATURE REVIEW:

In an Indian study, Samant & Rao (2013) investigated the ability of variously designed and trained Artificial Neural Network (ANN) to predict the probability of occurrence of hypertension in a mixed patient population, and found out the maximum accuracy marked by this approach was approximately 92.85%, and is quite satisfactory. In China, Ye et al. (2018), using a data set covering the period January 2013 – December 2015, applied machine learning for analyzing hypertension and concluded that machine learning is a potential source of accurate one year risk prediction models for incident hypertension. In a Romanian study, Gheorghe-Fronea et al. (2018) relied on a data set covering the period 2005 – 2016, applying SES and BLS models to analyze hypertension and found out that

hypertension trends in Romania will continue on an upward trend if no preventive strategies at population level will be implemented in the near future. In Netherlands, Hamoen et al. (2018), using monthly data over the period April 2000 – January 2006, applied the logistic regression model in order to study hypertension and revealed that the predictive logistic regression model is good at monitoring the risk of developing High Blood Pressure in children. In a Japanese study, Kanegae et al. (2018), relied on a data set covering the period 2010 – 2015, applying the CPH model to examine hypertension and found out that when using the new parameter of eating rate, uric acid, proteinuria and BMI by age, the CPH model performs better. In Zimbabwe, Nyoni & Nyoni (2020), using a data set covering the period January 2014 – December 2018, applied the Box-Jenkins SARIMA technique in order to analyze newly diagnosed hypertension cases at Silobela District Hospital (SDH), and found out that hypertension cases at SDH will basically decline over the period January 2019 to December 2020.

METHODOLOGY:

This paper applies the multi-layer perceptron neural network type of the Artificial Neural Network technique, in line with Samant & Rao (2013) and Yet et al. (2018), in order to analyze hypertension cases confirmed at GPH. We particulary apply the ANN (12, 12, 1) model.

Data Issues:

This study is based on newly diagnosed monthly HPT cases [all age groups] (reffered to as H series in this study) in all age groups at GPH. The data covers the period January 2010 to December 2019 while the out-of-sample forecast ranges over the period January 2020 to December 2021. All the data used in this paper was gathered from GPH Health Information Department.

FINDINGS OF THE STUDY:

DESCRIPTIVE STATISTICS:

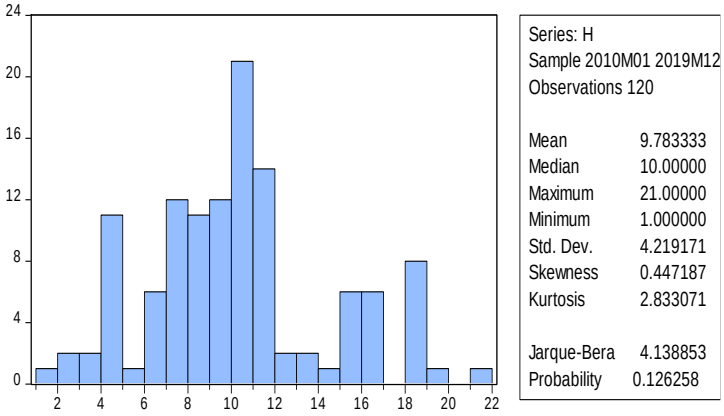

Figure 1: Descriptive statistics

The average number of hypertension cases at GPH over the study period is approximately 10 cases per month. The minimum is 1 while the maximum is 21. For a referral hospital like GPH, these are not large volumes and it is anticipated that the hospital should be in a position to handle these cases effectively. Also worthy to note is the fact that the series under consideration is normally distributed as shown by the Kurtosis statistic which is close to 3 and confirmed by the probability value which is statistically insignificant.

ANN MODEL SUMMARY FOR HPT CASES MANAGED AT GPH:

Table 1: ANN model summary

Variable	H
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	0.092800
MSE	1.063188
MAE	0.899059

Residual Analysis for the ANN model

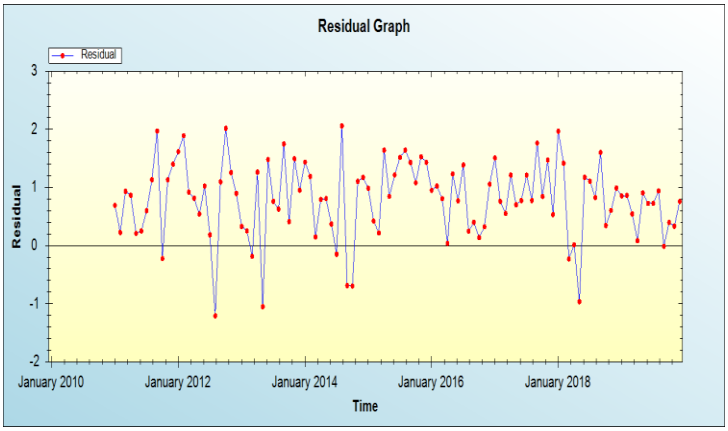

Figure 2: Residual analysis

In-sample Forecast for H

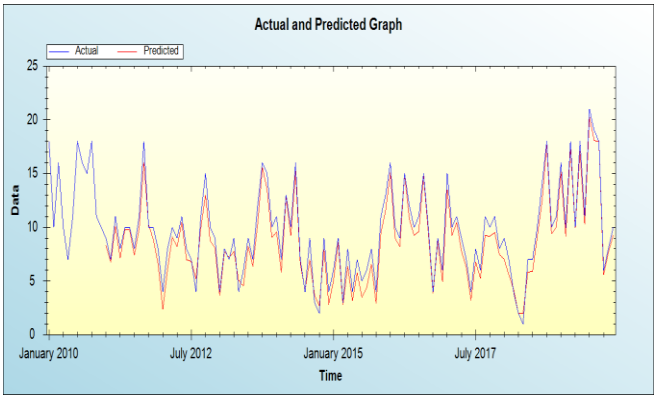

Figure 3: In-sample forecast for the H series

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

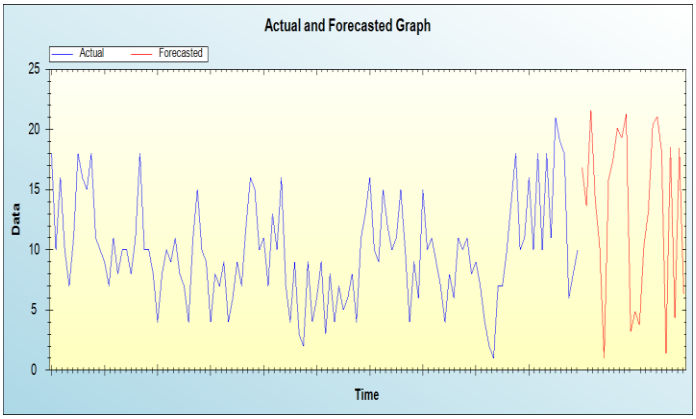

Figure 4: Out-of-sample forecast for H: actual and forecasted graph

Out-of-Sample Forecast for H: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Month/Year	Predicted H
January 2020	16.8535
February 2020	13.6710
March 2020	21.5991
April 2020	14.0547
May 2020	10.3046
June 2020	1.0290
July 2020	15.8292
August 2020	17.4285
September 2020	20.1013
October 2020	19.2930
November 2020	21.2789
December 2020	3.2090
January 2021	4.8665
February 2021	3.7504
March 2021	10.4061
April 2021	13.1330
May 2021	20.3990
June 2021	21.0725
July 2021	18.1840
August 2021	1.3562
September 2021	18.5339
October 2021	4.3076
November 2021	18.4288
December 2021	6.3476

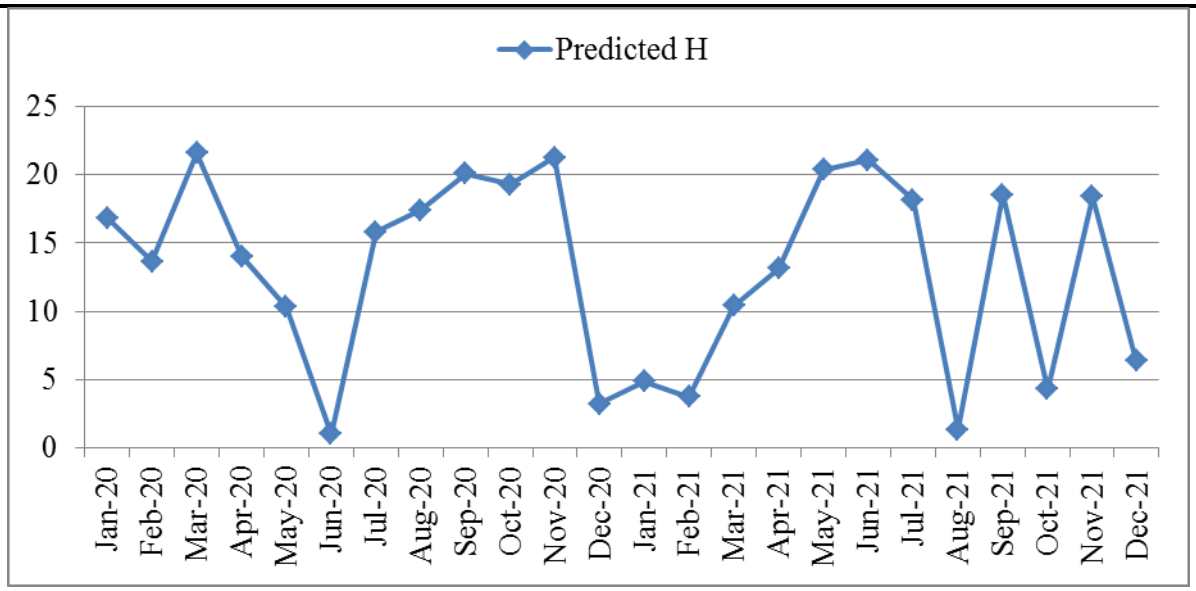

Figure 5: Graphical presentation of out-of-sample forecasts

Table 1 shows the ANN (12, 12, 1) model summary. Figure 2 shows the residual analysis of the model. The applied model is generally acceptable as most of its residuals are close to 0. Figure 3 shows the in-sample forecasts of the series under consideration. Figure 4 and 5 as well as table 2 display the out-of-sample forecasts. The overall predicted trend is generally downwards and this is quite desirable. It could be attributed to the fact that district hospitals that refer patients to GPH are now able to properly manage most of their hypertension cases and hence they refer relatively less patient volumes who really need further medical attention. The results of this study are consistent with Nyoni & Nyoni (2020) for SDH, which is one of GPH's sources of reffered (unconfirmed) hypertension patients.

RECOMMENDATIONS:

i. GPH ought to reduce bottlenecks in the management of hypertension.
ii. GPH should make sure essential medicines for treatment of hypertension are always in place.
iii. GPH should promote a healthy diet during its community-based health campaigns.

CONCLUSION:

Hypertension control is still suboptimal worldwide (Hajjar et al., 2006) and Zimbabwe is not an exception (Mufunda et al., 2000; Mungati et al., 2014; Chimberengwa & Naidoo, 2019; Nyoni & Nyoni, 2020). The study applied neural networks to model and forecast hypertension cases at GPH. While the results of the study show a generally downwards trends in the out-of-sample projections, it is prudent for policy makers not to wait until hypertension cases reach alarming levels for them to react. This is actually the right time for GPH to plan for the future in terms of securing resources for the control of hypertension not only in its catchment area but also in district hospitals and general hospitals who refer patients to GPH. The study is the first of its kind, at tertiary level of the health referral system in the country. Further studies may sought to model and forecast hypertension cases in individual district hospitals that refer patients to GPH. This may potentially reveal interesting research output, especially in light of community-specific policy recommendations.

REFERENCES:

1) Bosu, W. K., et al. (2019). Hypertension in Older Adults in Africa A Systematic Review and Meta-Analysis, PLoS ONE, 14 (4): 1 – 25.
2) Chimberengwa, P. T., & Naidoo, M. (2019). Knowledge, Attitudes and Practices Related to Hypertension Among Residents of a Disadvantaged Rural Community in Southern Zimbabwe, PLoS ONE, 14 (6): 1 – 16.
3) Gheorghe-Fronea, O., et al. (2018). Statistical Model for Prediction of Future Trend in Hypertension Disease in Adult Population of Romania, Romanian Statistical Review, 3: 79 – 92.
4) Hajjar, I., Kotchen, J. M., & Kotchen, T. A. (2006). Hypertension: Trends in Prevalence, Incidence and Control, Annual Review of Public Health, 27: 465 – 490.
5) Hamoen, M., et al. (2018). Dynamic Prediction of Childhood Blood Pressure in a Population-based Birth Cohort: A Model Development Study, BMJ Open, 8: 1 – 11.
6) Kanegae, H., et al. (2018). Developing and Validating a New Precise Risk Prediction Model for New Onset Hypertension: The JG Model, Wiley, pp: 1 – 11.
7) Kearney, P. M., et al. (2005). Global Burden of Hypertension – Analysis of World Data, Lancet, 365: 217 – 223.
8) Leung, A. A., et al. (2019). Risk Factors in Hypertension in Canada, Health Report No. 82.
9) Ministry of Health and Child Care (2016). National Health Strategy for Zimbabwe: 2016 – 2020, Government Printers, Harare.
10) Mufunda, J., et al. (2000). Correlates of Blood Pressure in an Urban Zimbabwean Population and Comparison to Other Populations of African Origin, Journal of Human Hypertension, 14: 65 – 73.
11) Mungati, M., et al. (2014). Hypertension in Zimbabwe, BMC Cardiovascular Disorders, 14 (102): 1 – 12.
12) Nyoni, S. P., & Nyoni, T. (2020). Hypertension Trends in Silobela District Hospital (SDH): An Application of the Box-Jenkins Model, International Journal of Multidisciplinary Research, 6 (1): 109 – 120.
13) Princewel, F., et al. (2019). Prevalence and Risk Factors Associated With Hypertension Among Adults in a Rural Setting: The Case of Ombe, Cameroon, Pan African Medical Journal, 34 (147): 1 – 9.
14) Samant, R., & Rao, S. (2013). Evaluation of Artificial Neural Networks in Prediction of Essential Hypertension, International Journal of Computer Applications, 81 (12): 34 – 38.
15) Ye, C., et al. (2018). Prediction of Incident Hypertension Within the Next Year: Prospective Study Using Statewide Electronic Health Records and Machine Learning, Journal of Medical Internet Research, 20 (1): 1 – 19.