Using Artificial Neural Networks for Predicting New Pregnancy Induced Hypertension Cases at Silobela District Hospital (SDH) in Zimbabwe

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Abstract - **In this research paper, the ANN approach was applied to analyze Pregnancy Induced Hypertension (PIH) cases at Silobela District Hospital (SDH). The employed data covers the period January 2010 to December 2019 and the out-of-sample period ranges over the period January 2020 to December 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model basically indicate that the model is stable in forecasting PIH cases at SDH. The results of the study indicate that PIH cases are likely to be either 1 or 2 and sometimes zero per month over the period January 2020 – December 2020. A 3-fold policy recommendation has been put forward in order to handle the projected PIH trends in the SDH catchment area.**

I. INTRODUCTION

Hypertension disorders (high blood pressure) is the most familiar medical complication of pregnancy, it is the hope of every mother to give birth without experiencing such. Ashad *et al* (2011) estimated that pregnancy induced hypertension (PIH), is one of the hypertensive disorders of pregnancy. He went on to highlight that it affects about 5-8 % of all pregnant women worldwide. In other sources PIH is defined as acute hypertension developing in a mother whose blood pressure was normal before the third trimester of pregnancy, normality ends and blood pressure will be elevated to at least 140/90 mmH. (Sibai, 2003), Zhang *et al* (1997) and Anand (2012) reported that PIH is a major pregnancy complication associated with premature delivery, intra-uterine growth retardation (IUGR), abruption placentae, and intra-uterine death, as well as maternal morbidity and mortality. In developed countries some form of hypertension is said to occur in approximately 15-20% of pregnancies (Hofmeyr et al, 2018). The authors went on to estimate that 9.1% of maternal deaths in Africa are due to hypertensive disorders of pregnancy. According to the Ministry of Health and Child Care (MOHCC), (2015) hypertensive disease during pregnancy is the main cause of perinatal mortality and morbidity in Zimbabwe. However, it is extremely difficult to provide figures for the true incidence of hypertension during pregnancy because of different diagnostic criteria and because of the fact that most reports are based on hospital studies rather than on general populations. The MOHCC in 2012 reported that, birth asphyxia and neonatal sepsis contribute to 29% of the deaths and that 39% of neonatal deaths are caused by preterm birth complications. In another study by the Zimbabwe Maternal and Perinatal Mortality initiative in 2007, PIH was recorded to be among the top five causes of maternal mortality and the third highest reason for referral in labor. No other disease in pregnancy has been surrounded for so long by so many uncertainties and controversies, concerning its etiology, pathophysiology and treatment (Muti *et al*, 2015) with the exception of PIH disease. The etiology of pregnancy-induced hypertensive disease remains unknown, hence the need for this study to adopt ANN networks to help predict this incidence at Silobela District Hospital (SDH) and help prevent the unwanted forth coming effects of PIH.

1.1 OBJECTIVES OF THE STUDY

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

1.2 RELEVANCE OF THE STUDY

SDH is a rural district hospital located in the Midlands Province of Zimbabwe. Placed 63km northwest of Kwekwe town, SDH is a referral center for 35 clinics in the district. An estimated 300 000 people are said to live in the district. With the status of

district hospital, SDH became a referral hospital with all district clinics reporting to the hospital (Nyoni& Nyoni, 2019).A notable number in referrals of pregnant women due to PIH has been reported from the various clinics within the catchment area of SDH. The concern over the increase in PIH and the possible consequences necessitated an investigation into past, current and future trends of PIH among women seeking maternity services at SDH. Prior to this study, no investigation had been done to establish the characteristics of the women affected or how they were being managed. This study was conducted to predict and assess new (PIH) cases at SDH and see whether they are increasing or decreasing. Results of the study will be used to inform reproductive health programming at SDH.

II. RELATED STUDIES

Muti *et al* (2015) found that delay in seeking care and shortages of resources were the major reported challenges in the proper management of PIH, hence PIH prevalence was 19.4 %. Women with PIH were three times more likely to deliver low birth weight babies. Tachiwenyika *et al* (2011) also found that PIH was associated with an increased risk of perinatal mortality. Maylawati *et al* (2017), showed that ANN could be applied to predict the disorders in pregnancy well enough with percentage of accuracy around 78,25%. Mello *et al* (2001) advocated that ANN networks can be used to aid early identification of pregnant women at high risk of PIH. The use of ANN followed by increased clinical surveillance and prophylactic treatments, might lead to better pregnancy outcomes. Shopen *et el* (2016) also found that PIH had 11-fold higher age-adjusted risk in pregnant women, older women had a high chance of having HIP. These women also had a higher body mass index (BMI), and were more likely to develop diabetes mellitus (DM), more deliveries before the index pregnancy and coronary artery disease, during follow-up. For Zimbabwe, reviewed studies never attempted to forecast the cases of HIP using ANN networks. This study will be the first of its kind and is expected to go a long in helping public health policy makers in the fight to reduce these pregnancy related deaths and complications.

III. METHODOLOGY

This study will apply the Artificial Neural Network (ANN) approach in modeling and forecasting monthly HIP cases at SDH. In line with 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 pregnancy induced hypertensioncases [for all age groups] (reffered to as PIH series in this study) at SDH. 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 SDHHealth Information Department.

IV. FINDINGS OF THE STUDY

4.1 DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Summary Statistics, using the observations 2012:01 - 2019:12 for the variable PIH (96 valid observations)

Mean	Median	Minimum	Maximum
0.97917	1.0000	0.0000	3.0000
Std. Dev.	C.V.	Skewness	Ex. kurtosis
0.83325	0.85097	0.36807	-0.71601
5% Perc.	95% Perc.	IQ range	Missing obs.
0.0000	2.0000	2.0000	0

4.2 ANN Model Summary

Table 2: ANN model summary

Variable	PIH
Observations	84 (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	0.171649
MSE	0.081843
MAE	0.221472

Residual Analysis for the Applied Model
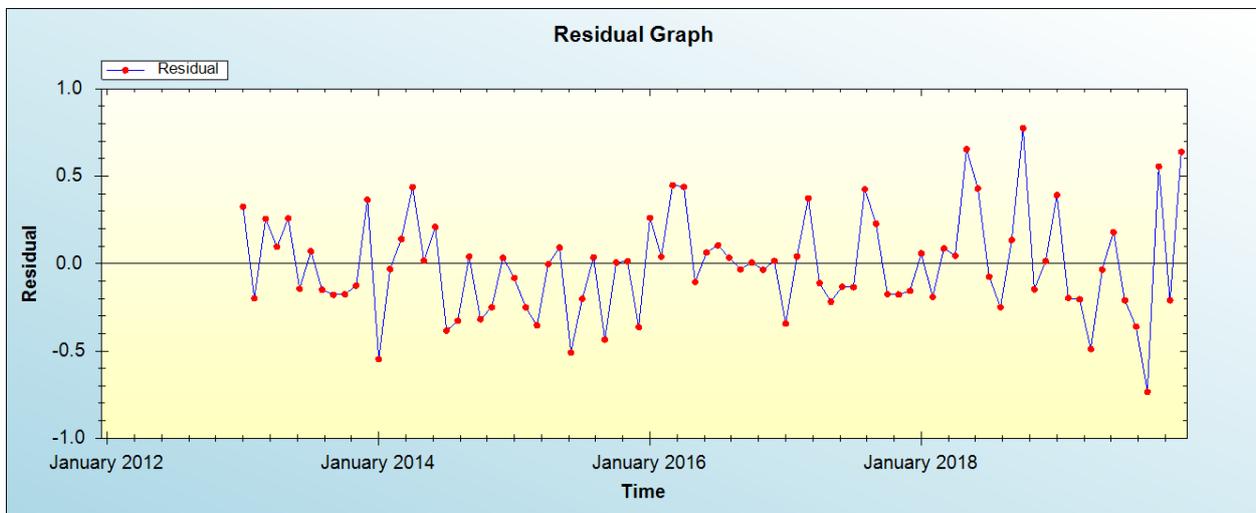
Figure 1: Residual analysis
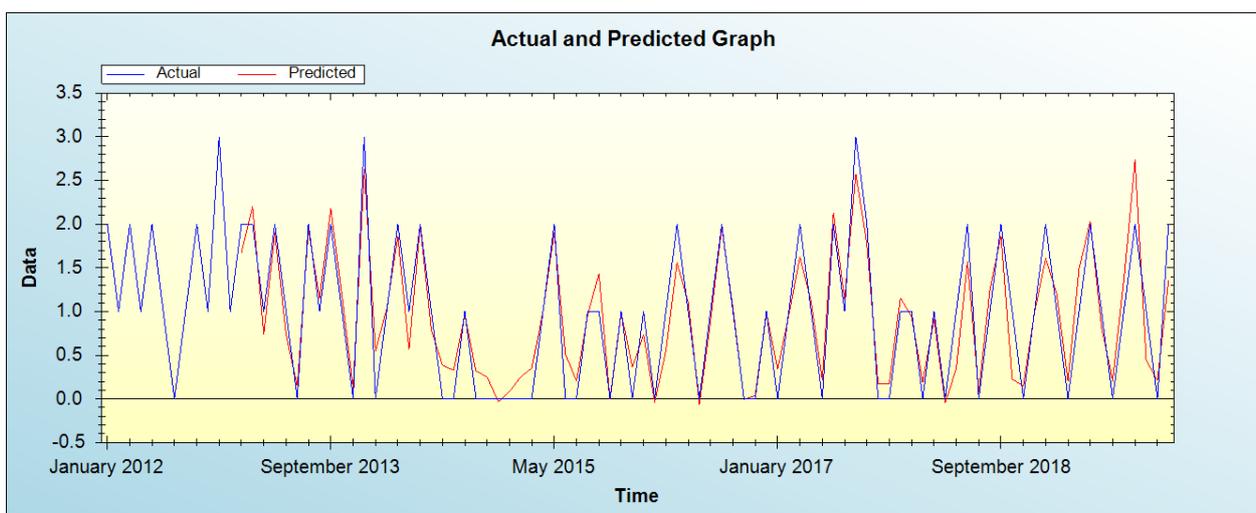
In-sample Forecast for PIH

Figure 2: In-sample forecast for the PIH series

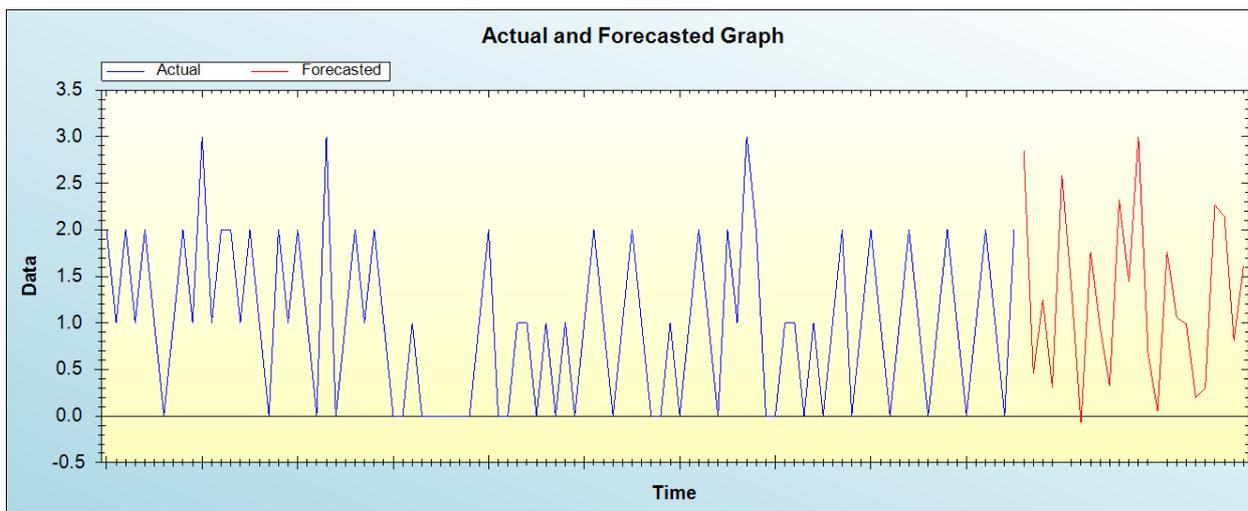*Out-of-Sample Forecast for PIH: Actual and Forecasted Graph*

Figure 3: Out-of-sample forecast for PIH: actual and forecasted graph

Out-of-Sample Forecast for PIH: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Month/Year	Forecasts
January 2020	2.8505
February 2020	0.4555
March 2020	1.2492
April 2020	0.3091
May 2020	2.5832
June 2020	1.3713
July 2020	-0.0718
August 2020	1.7625
September 2020	0.9524
October 2020	0.3288
November 2020	2.3196
December 2020	1.4425
January 2021	2.9948
February 2021	0.6846
March 2021	0.0573
April 2021	1.7658
May 2021	1.0595
June 2021	0.9891
July 2021	0.1996
August 2021	0.3030
September 2021	2.2637
October 2021	2.1397
November 2021	0.8122
December 2021	1.6049

4.3 DISCUSSION OF THE RESULTS

Table 1 shows the descriptive statistics of series under consideration. Table 2 is the ANN model summary and precisely illustrates the ANN (12, 12, 1) neural network model, which has been based on the hyperbolic tangent function as its activation function. The "criteria" are the evaluation statistics and they all indicate the model is satisfactorily adequate. Figure 1 shows the residuals of the model and since the residuals are as close to zero as possible, the model is quite stable and acceptable for generating forecasts of PIH cases for SDH. Figure 2 shows the in-sample forecast of the model and we can inference that the model fits well with data. Figure 3 and table 3 are out of sample forecasts. A striking feature of our forecast is that the PIH cases at SDH over the period January 2020 – December 2021 will be either 1 or 2, in general.

4.4 RECOMMENDATIONS

i. There is need for continuous education on the management of PIH for health staff at SDH.
ii. Screening tests for PIH should be done earlier and more regularly.
iii. The MOHCC is also advised to engage international partners in developed nations and those that have managed to combat the effects of PIH. This will ensure sufficient knowledge and funding is readily available to reduce new PIH cases.

V. CONCLUSION

PIH continues to be a serious threat to public health of women and families in Zimbabwe. There is need for continual monitoring of this pestilence in order to cut morbidity and mortality cases. Technical know-how of the management of PIH cases in a busy ward should be employed so that unnecessary referrals are mitigated and that on-the-spot decisions to deal with HIP cases are done with efficacy and prevent deaths.

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