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

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ABSTRACT

Snakes are well known to human race, as they continue to be associated with a plethora of epics, myths, superstitions, folklore, and tales and so on. In Zimbabwe, just like in any part of the world, when a snake it seen, it is usually killed. Snakes are also considered as sacred and sometimes certain rituals are performed when certain snakes are found. Unfortunately, snake bites remain a source of considerable morbidity and mortality in many parts of the world, especially in developing countries such as Zimbabwe. The current study used monthly time series data on snake bite caseloads recorded and managed at Gweru Provincial Hospital (GPH) from Janaury 2010 to December 2019, to predict snake bite cases over the period January 2020 to December 2021. We applied the ANN (12, 12, 1) model. Residual analysis of the applied model indicates that the model is stable and thus suitable for forecasting snake bite case volumes at GPH over the out-of-sample period. The results of the study reveal that snake bite cases will generally be on a downwards trajectory at GPH over the out-of-sample period. The study, amongst other policy suggestions, encourages the GPH management team to always make sure that there is prompt administration of antisnake venom (ASV) to victims in order to save life from this preventable public health threat.

1.0 INTRODUCTION

The current "global snake bite crisis" as a disease of poverty (Musah *et al*., 2019), has been misunderstood, underrated, ignored or neglected as a public health issue (Gutierrez *et al*., 2006; Cruz *et al*., 2009; Simpson & Norris, 2009; Chippaux, 2017) and has lately regained importance as one of the most important "neglected tropical diseases" (WHO, 2017). Snake bite envenomations constitute of the most important human-wildlife conflicts (Kasturiratne *et al*., 2008), causing tens of thousands of deaths and hundred thousands of injuries in many developing tropical countries annually, and sub-Saharan Africa represents an epitome example of this neglected tropical disease (Musah *et al*., 2019). Worldwide, out of more than 3500 snake species, 600 are venomous, and 280 are medically important, resulting in at least 1.2 million snake bite envenomations with 100000 deaths and more than 400000 cases of morbidity annually (Kasturiratne *et al*., 2008; Gutierrez *et al*., 2013; Figueroa *et al*., 2016; Longbottom *et al*., 2018). Of the estimated 76 species of snakes, belonging to 7 families, that are found in Zimbabwe; only 19 species are of medical importance with respect to envenomation (Muguti *et al*., 1994; Spawls & Branch, 1995).

People engaged in farming, hunting, fishing and other rural activities are at highest risk, mostly bitten on their limbs during work (Harrison *et al*., 2009; Chippaux *et al*., 2016) and that is the reason why snake bite envenomation is reffered to as a disease of poverty, with developing countries in the tropics recording the highest rates of incidence, morbidity and mortality (Cruz *et al*., 2009; Harrison *et al*., 2009; Longbottom *et al*., 2018). In many parts of sub-Saharan Africa (including Zimbabwe), the high mortality and morbidity rates are attributed to increased vulnerability caused by both high work risk and exposure to diverse snake habitats, as well as poor infrastructure and limited access to appropriate medical treatment and health facilities (Kasturiratne *et al*., 2008; Gutierrez *et al*., 2010; Longbottom *et al*., 2018). In Zimbabwe, snake bite is the 4th most important cause of hospital admissions to major referral hospitals due to toxic exposures

after poisoning with pesticides, pharmaceuticals and household chemicals (Tagwireyi *et al*., 2002). Snake bite envenoming has a multitude of consequences for the individuals affected and their families. In many cases it pushes poor people into further poverty by virtue of high treatment costs and (sometimes) loss of life, loss of income and enforced borrowing (WHO, 2018). In sub-Saharan Africa (including Zimbabwe), the direct cost of antivenom alone generally ranges from US$55 to US$640 for an effective treatment, using recommended doses, with the average cost being approximately US$124 (Brown, 2012).

In order to understand the epidemiological nature of snake bites (Gutierrez *et al*., 2006; Williams *et al*., 2010; Chippaux, 2017; Longbottom *et al*., 2018) and dynamics of human-wildlife conflict such as snake bite vulnerability, and constitute the baseline information needed to provide adequate health facilities and supply antivenin and other therapeutical innovations (Molesworth *et al*., 2003; Kasturiratne *et al*., 2008; Gutierrez *et al*., 2010; Gutierrez *et al*., 2013), there is urgent need for modelling and forecasting of snake bite case volumes. This study will model and forecast snake bite cases recorded and managed at Gweru Provincial Hospital (GPH) in Gweru, in the Midlands province of Zimbabwe. The findings of this study are envisioned to assist public health policy makers in the management of snake bites not only in the GPH catchment area but also in other parts of the country that are at risk.

1.1 OBJECTIVES OF THE STUDY

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

2.0 RELATED STUDIES

In the case of Zimbabwe, Tagwireyi *et al*. (2011) retrospectively described the toxicoepidemiology of snakebite admissions to 8 major referral hospitals in the country, that is; 4 quaternary level hospitals: Harare (now Sally Mugabe), Parirenyatwa, Mpilo and United Bulawayo Hospitals as well as 4 tertiary level hospitals: Gwanda, Bindura, Gweru and Mutare hospitals. The study established that most snake bites in Zimbabwe occur to the feet and are usually from puff adders. The study also found out that the tourniquet is the most commonly employed first aid measure for snake bite in the country and that snake bite victims still consult traditional healers. In a review article, Chippaux (2017) examined the incidence and mortality due to snake bite in the Americas and found out that for the Americas the incidence of snake bites influenced by the abundance of snakes. In an Iranian study, Ebrahimi *et al*. (2018) predicted snake bite cases in the tropical south and found out that the SARMA $(1, 0)(1, 1)_{12}$ as the best process for the monthly trend of snakebite and to predict the incidence of snakebites. This study will be the first of its kind in the country and will go a long way in reducing the incidence and impact of snake bites in the GPH catchment area.

3.0 METHODOLOGY

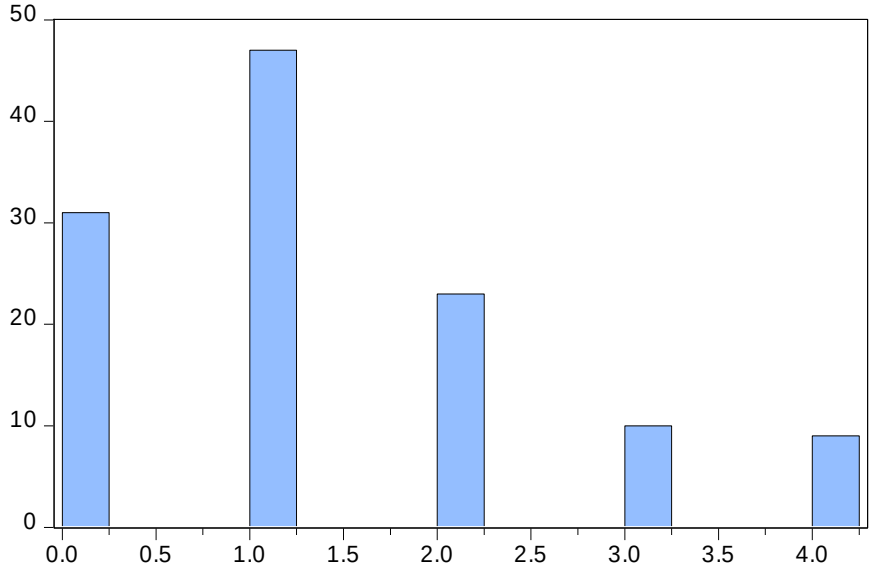
The study applies the Artificial Neural Network (ANN) approach in modeling and forecasting monthly snake bite cases at GPH. Guided by Fischer & Gopal (1994), who argue that no strict rules exist for the determination of the ANN structure; the study applies the popular ANN (12, 12, 1) model based on the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

3.1 Data Issues

This study is based on newly diagnosed monthly snake bite cases [all age groups] (reffered to as SB 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



Series: SB
Sample 2010M01 2019M12
Observations 120

Mean	1.325000
Median	1.000000
Maximum	4.000000
Minimum	0.000000
Std. Dev.	1.167936
Skewness	0.808363
Kurtosis	2.916452
Jarque-Bera	13.10390
Probability	0.001427

Figure 1: Descriptive statistics

4.2 ANN Model Summary

Table 1: ANN model summary

Variable	SB
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	0.140039
MSE	0.096844
MAE	0.250265

Residual Analysis for the Snake Bite Cases Model

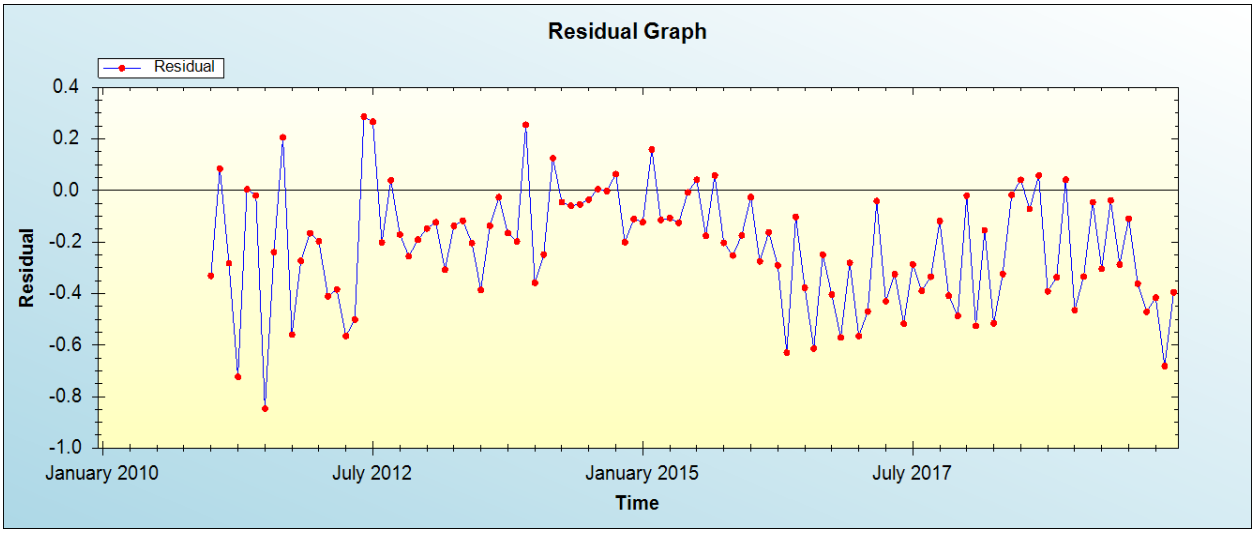


Figure 2: Residual analysis

In-sample Forecast for SB

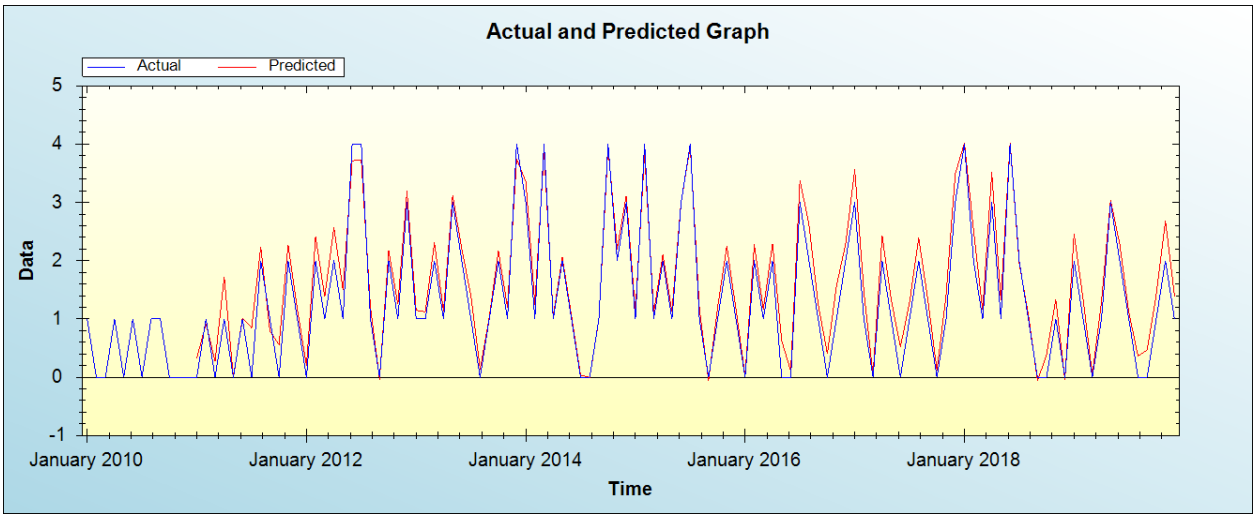


Figure 3: In-sample forecast for the SB series

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

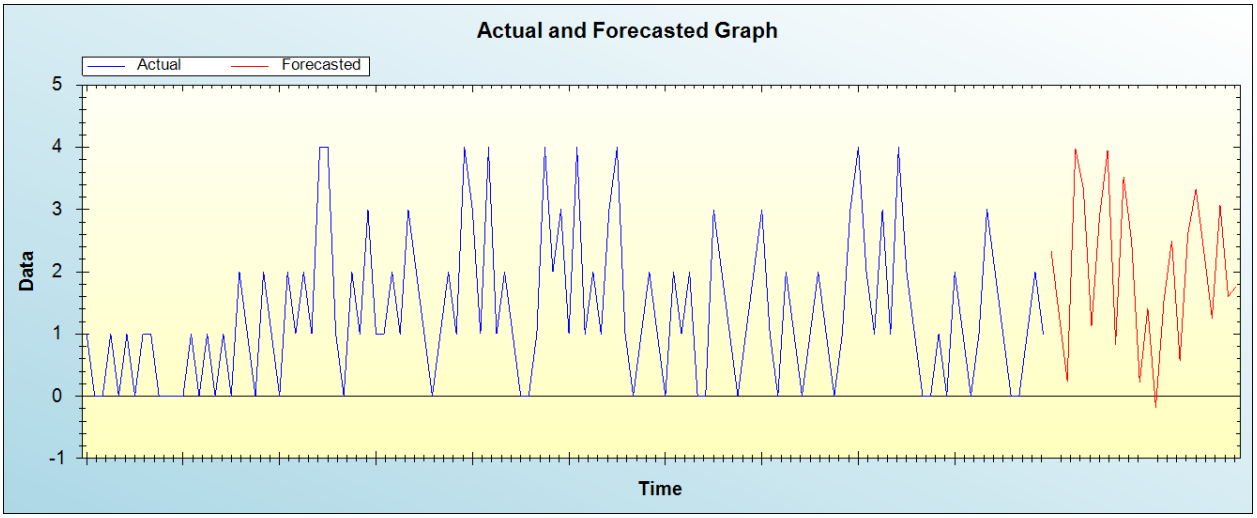


Figure 4: Out-of-sample forecast for SB: actual and forecasted graph

Out-of-Sample Forecast for SB: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Month/Year	Predicted SB
January 2020	2.3323
February 2020	1.2837
March 2020	0.2441
April 2020	3.9783
May 2020	3.3266
June 2020	1.1255
July 2020	2.8798
August 2020	3.9440
September 2020	0.8358
October 2020	3.5265
November 2020	2.4711
December 2020	0.2308
January 2021	1.4122
February 2021	-0.1775
March 2021	1.5234
April 2021	2.4997
May 2021	0.5761
June 2021	2.6059
July 2021	3.3311
August 2021	2.3142
September 2021	1.2563
October 2021	3.0681
November 2021	1.6025
December 2021	1.7633

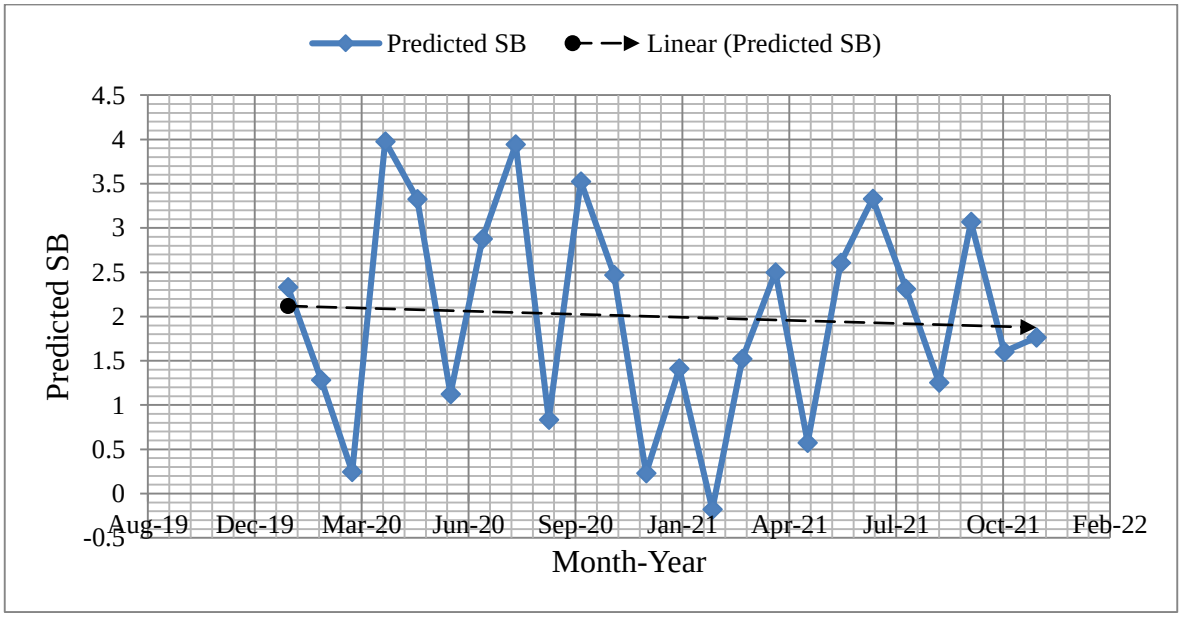


Figure 5: Graphical presentation of out-of-sample forecasts

4.3 DISCUSSION OF THE RESULTS

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" are the evaluation statistics and they all prove that the model is adequate. According to figure 1, an average of 1 person per month has been a victim of snake bite over the study period. Figure 2 shows the residuals of the ANN (12, 12, 1) model and since the residuals are as close to zero as possible, the model is indeed stable and acceptable for making predictions of snake bite case volumes at GPH. Figure 3 shows the in-sample forecast of the model and it can be generalized that the model fits well with data. Figure 4, table 2 and figure 5 show out of sample forecasts. A striking characteristic of our forecast is that the snake bite cases may decrease over the out-of-sample period, but of course, slowly.

5.0 CONCLUSION & RECOMMENDATIONS

Snake bite is an acute life threatening time limiting medical emergency, very common in developing countries such as Zimbabwe, especially in rural areas. However, it is indeed a preventable public health hazard. This study applied an ANN (12, 12, 1) model to predict snake bite cases at GPH in Zimbabwe. The study used a monthly data set spanning over the period January 2010 to December 2019. The following policy directions are thus suggested:

i. The GPH hospital management team should ensure that there is prompt administration of antisnake venom (ASV) to victims.
ii. GPH ought to have readily available and usable medical equipments for management of snake bite victims, for example, ventilators as well as bags and valves.
iii. At GPH, (as well as in other referral health facilities in the country); there is need for specialized training of clinicians in the management of snake bites in order to avoid misdiagnosis which may cause undue delay in ASV therapy or unnecessary waiting until the victim develops systemic manifestations resulting in systemic envenoming and high fatality.
iv. GPH should also consider engaging in public health campaigns about snake bites in its catchment area. In this regard, communities need to be educated on simple and basic first aid for snake bite victims. Communities should be educated on the importance of taking appropriate preventive measures and also sensitized on the need to have a good health-seeking behaviour. This will go a long way in saving lives.

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