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USING ARTIFICIAL NEURAL NETWORKS FOR PREDICTING SCABIES CASE VOLUMES AT CHITUNGWIZA URBAN DISTRICT IN ZIMBABWE

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ABSTRACT

Around the world, millions upon millions of people are affected by scabies, especially the disadvantaged populations living in crowded conditions in tropical areas. However, scabies is still a neglected tropical disease of the skin. Motivated by World Health Organization (WHO)'s recognition for the need for "a global strategy for scabies control", the current study used monthly time series data on scabies caseloads recorded and managed within Chitungwiza urban district from Janaury 2012 to December 2019, to predict scabies cases over the period January 2020 to December 2021. We applied the famous ANN (12, 12, 1) model. Residual analysis of this popular model indicates that the model is very stable and thus suitable for forecasting scabies case volumes in Chitungwiza urban district over the out-of-sample period. The results of the study reveal that scabies cases will be on a relatively sharp downwards trajectory in Chitungwiza urban district over the out-of-sample period. The study, amongst other policy suggestions, encourages the government of Zimbabwe to always make sure that there is prompt administration of relevant drugs to infected patients as well as mite resistance monitoring programs in Chitungwiza urban district.

INTRODUCTION

Scabies occurs worldwide, and is estimated to affect over 200 million people at any single time (GBD, 2015). The highest prevalence of scabies occurs in tropical areas, especially in disadvantaged populations, and especially among children and the elderly. Scabies directly accounts for approximately 0.21% of global disability-adjusted life years (Karimkhani et al., 2017). The causative agent of human scabies is the mite, Scarcoptes scabiei. The scabies mites are thought to be a single species but with several physiological varieties or subspecies. The human scabies mites can only develop and reproduce on a human host. The human scabies mites tend to prefer areas of folded skin, for example, between fingers, under buttocks, elbow and wrist area or even around genitals; for burrowing (Michigan Department of Community Health, 2005). Transmission of scabies is predominantly via skin-to-skin contact. Transmission from bedding or clothes is rare in ordinary scabies, but can occur in crusted scabies due to its tremendous mite burden. The risk of transmission of scabies increases with higher levels of population density, reflected by high endemicity observed in

communities living in poverty associated with crowded housing conditions, and by outbreaks in residential care facilities, prisons, schools, and refugee camps. Patients with underlying immunodeficiency from any cause, such as human immunodeficiency virus, human T-lymphotropic virus type 1 or corticosteroid treatment, or those with neurological conditions, are at an increased risk of crusted scabies (Chosidow, 2006; Walton et al., 2008; Davis et al., 2013).

Scabies causes considerable suffering due to the intense itch and associated scratching, leading to sleep disturbances which, in turn, on school and work attendance and performance, and ultimately the economic productivity of whole communities (Worth et al., 2012). The fissures associated with scabies provide a portal of entry for bacteria, potentially resulting in secondary infections, sepsis, indirect effects on renal and cardiovascular function, and death due to complications (Goldstein, 2017). Scabies is also associated with social stigma and leads to social exclusion because of the appearance of the affected individual and attendant feeling of shame, as well as fears within the community of spread of infection (Worth et al., 2012; Hofstraat & Brakel, 2016).

1.1 OBJECTIVES OF THE STUDY

i. To assess new scabies cases at Chitungwiza urban district over the period January 2012 to December 2019.
ii. To predict scabies cases for Chitungwiza urban district over the period January 2020 to December 2021.
iii. To determine whether scabies cases are increasing or decreasing for Chitungwiza urban district over the out of sample period.

2.0 RELATED STUDIES

Scabies prevalence is not well documented and studied, especially in African countries such as Zimbabwe (Hoek et al., 2008) and Chitungwiza urban district is not an exception. In this section of the study, we pick two most relevant papers and then review them. It is important at this juncture to highlight that forecasting models related to scabies are scanty, especially in Zimbabwe. In an institutional-based cross-sectional survey, Dagne et al. (2019) assessed the prevalence of scabies and associated factors among students in primary schools in Dabat district, northwest Ethiopia. The findings of the study indicated that the prevalence of scabies was 93%. In a Zimbabwean paper, Bhunu et al. (2013) formulated a deterministic model to examine the possible impact vaccination will have on scabies control. The results of the study indicated that vaccination in addition to treatment will help greatly in reducing the spread of scabies infestation. Indeed, no similar study on scabies has been done in the country. This research article is the first of its kind in Zimbabwe and will go a long way in controlling the spread of scabies in Chitungwiza urban district.

3.0 METHODOLOGY

The study applies the Artificial Neural Network (ANN) approach in modeling and forecasting monthly scabies cases in Chitungwiza urban district. Guided by Fischer & Gopal (1994), who strongly argue that no strict guidelines 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 scabies cases [all age groups] (reffered to as SI series in this study). The data covers the period January 2012 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 the DHIS2 system for Chitungwiza urban district.

4.0 FINDINGS OF THE STUDY

4.1 DESCRIPTIVE STATISTICS

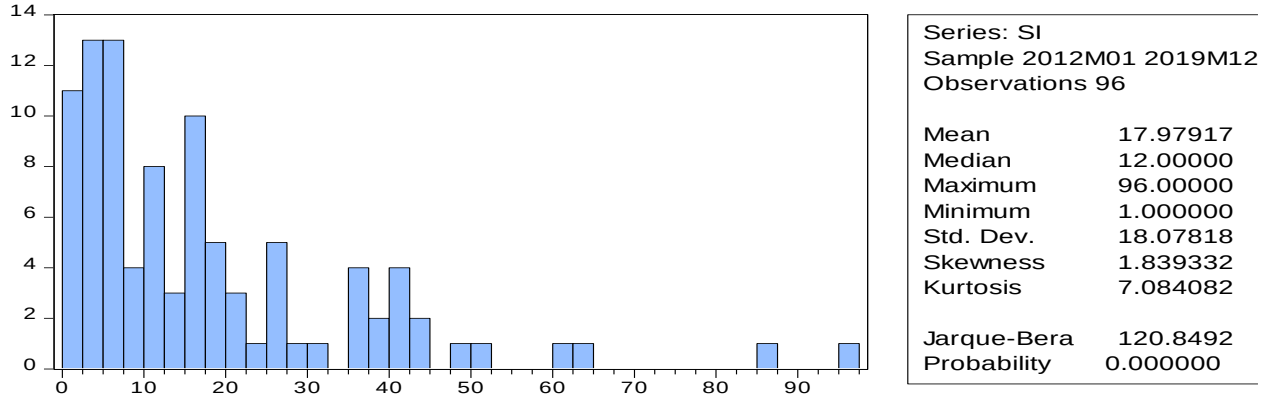


Figure 1: Descriptive statistics

4.2 ANN Model Summary

Table 1: ANN model summary

Variable	SI
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	0.105107
MSE	30.772579
MAE	4.171531

Residual Analysis for the Model Presented Above

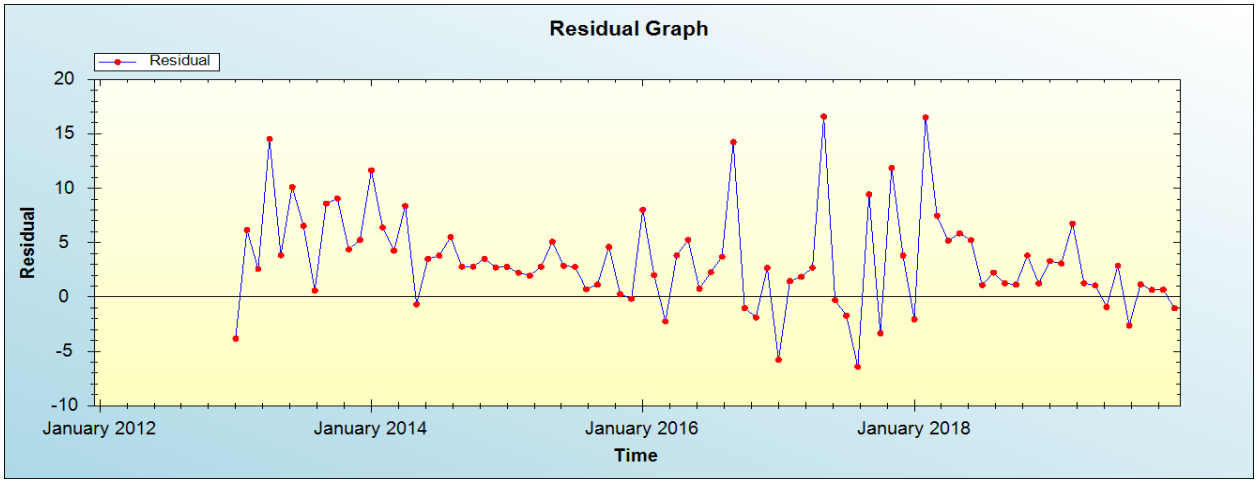


Figure 2: Residual analysis

In-sample Forecast for SI

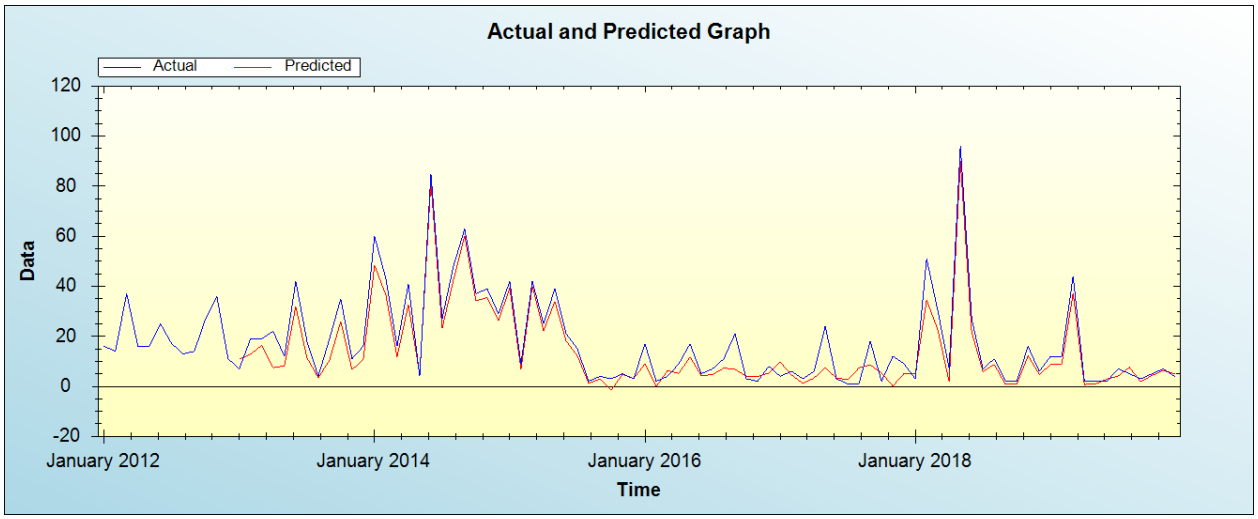
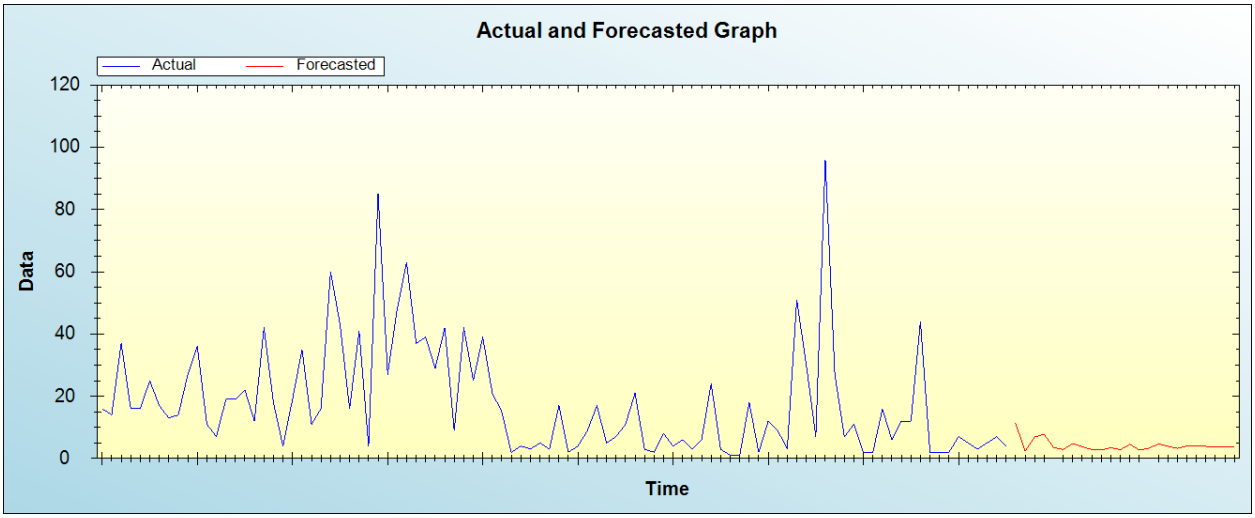


Figure 3: In-sample forecast for the SI series

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

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



Out-of-Sample Forecast for SI: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Month-Year	Predicted SI
January 2020	11.2976
February 2020	2.3084
March 2020	6.9441
April 2020	7.7491
May 2020	3.5427
June 2020	2.8558
July 2020	4.7897
August 2020	3.7502
September 2020	2.9074
October 2020	2.7218
November 2020	3.4730
December 2020	2.7816
January 2021	4.5463
February 2021	2.7406
March 2021	3.2359
April 2021	4.7328
May 2021	3.9007
June 2021	3.2475
July 2021	4.0227
August 2021	4.1001
September 2021	3.8873
October 2021	3.6137
November 2021	3.6688
December 2021	3.5933

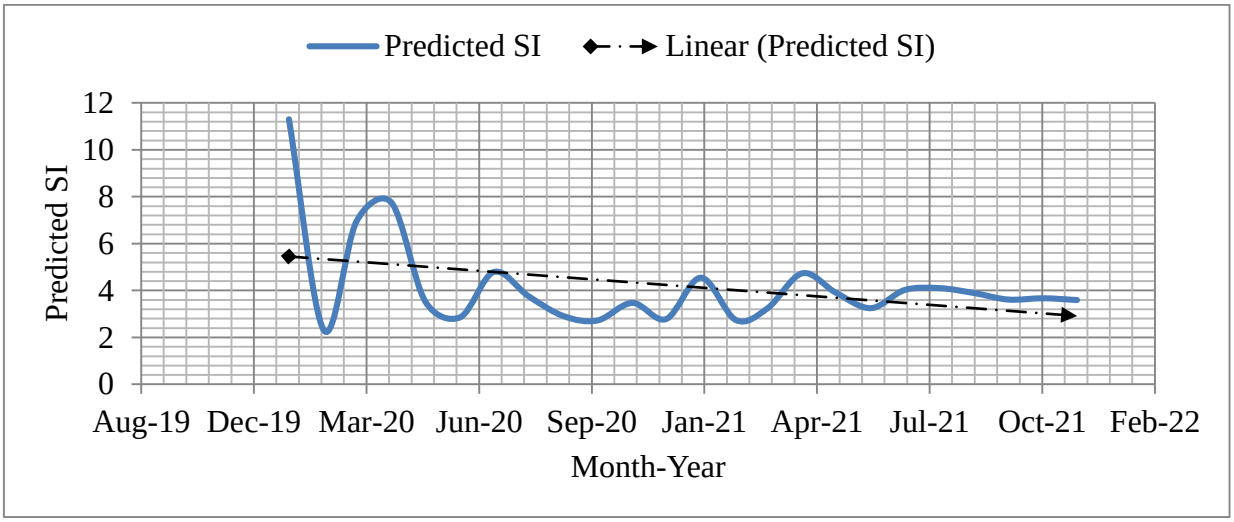


Figure 5: Graphical presentation of out-of-sample forecasts

4.3 DISCUSSION OF THE RESULTS

As shown in figure 1, an average of about 18 monthly scabies have been diagnosed and managed in Chitungwiza urban district. This is a relatively high case volume for the district,

especially given that scabies is a highly contagious disease. Table 1 shows the ANN (12, 12, 1) neural network model, which has basically been based on the hyperbolic tangent function as its activation function. The "criteria" are the evaluation statistics and they all concur that the 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 quite stable and acceptable for generating forecasts of scabies monthly case volumes for Chitungwiza urban district. 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 are out of sample forecasts. The findings of the study reveal that scabies cases will be on a relatively sharp downwards trajectory in Chitungwiza urban district over the out-of-sample period.

5.0 CONCLUSION & RECOMMENDATIONS

Although infestation is not life-threating, scabies is a nuisance (Michigan Department of Community Health, 2005) dermatological condition (Swe et al., 2017). Indeed, it is a neglected tropical disease, with major costs on healthcare systems worldwide. In this piece of work, an ANN model was applied to estimate monthly scabies cases as well as forecasting their likely future trend in Chitungwiza urban district. Using monthly data over the period Janaury 2012 to December 2019, the study accurately predicted monthly scabies case volumes over the out-of-sample period. The following policy directions are recommended:

i. All health facilities in Chitungwiza urban district must uphold a policy of screening newly admitted patients for scabies during initial assessment. In this regard, any suspect patient should be immediately placed on contact precautions until examined for scabies.
ii. Health institutions in Chitungwiza urban district are also encouraged to have a policy of early identification and treatment of patients with atypical scabies. In this regard, skin scraping is highly recommended prior to treatment for patients diagnosed with atypical scabies.
iii. The government of Zimbabwe, with support from its development partners, has a role to play in ensuring that there is continued reliable drug supply in Chitungwiza urban district.
iv. Last but not least, the need for mite resistance monitoring cannot be undermined in Chitungwiza urban district.

REFERENCES

[1] Bhunu, C. P., Mushayabasa, S., & Monera, T. G. (2013). Assessing the Impact of Vaccination on Controlling the Spread of Human Scabies, ISRN Computational Biology, pp: 1 – 8.
[2] Chosidow, O. (2006). Clinical Practices – Scabies, New England Journal of Medicine, 354: 1718 – 1727.

[3] Dagne, H., et al. (2019). Prevalence and Associated Factors of Scabies Among School Children in Dabat District, Northwest Ethiopia, 2018, Environmental Health and Preventive Medicine, 24 (67): 1 – 8.

[4] Davis, J. S., et al. (2013). A Novel Clinical Grading Scale to Guide the Management of Crusted Scabies, PLOS – Neglected Tropical Diseases, 7: 1 – 9.

[5] Fischer, M. M., & Gopal, S. (1994). Artificial Neural Networks: A New Approach to Modeling Interregional Telecommunication Flows, Journal of Regional Science, 34 (4): 503 – 527.

[6] GBD (2015). A Systematic Analysis for the Global Burden of Disease, Lancet, 388: 1545 – 1602.

[7] Goldstein, B. (2017). Scabies, UTS, New York.

[8] Hoek, J. A., et al. (2008). A Persistant Problem With Scabies in and Outside a Nursing Home in Amsterdam: Indications for Resistance to Lindane and Ivermectin, Euro Surveillance, 13 (48): 5 – 6.

[9] Hofstraat, K., & Brakel, W. H. (2016). Social Stigma Towards Neglected Tropical Diseases: A Systematic Review, International Health, 8 (1): 53 – 70.

[10] Karimkhani, C., et al. (2017). The Global Burden of Scabies: A Cross-sectional Analysis, Infectious Diseases, 17: 1247 – 1254.

[11] Michigan Department of Community Health (2005). Scabies Prevention and Control Manual, Michigan Department of Community Health, Michigan.

[12] Swe, P. M., et al. (2017). Complement Inhibition by Scarcoptes Scabiei Protects Streptococcus Pyogenes, PLOS – Neglected Tropical Diseases, 11 (3): 1 – 8.

[13] Walton, S. F., et al. (2008). New Insights into Disease Pathogenesis in Crusted (Norwegian) Scabies: The Skin Immune Response in Crusted Scabies, British Journal of Dermatology, 158: 1247 – 1255.

[14] Worth, C., et al. (2012). Impaired Quality of Life in Adults and Children With Scabies From an Impoverished Community in Brazil, International Journal of Dermatology, 51: 275 – 282.