SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

GENITAL ULCER DISEASE IN CHITUNGWIZA URBAN DISTRICT IN ZIMBABWE: LATEST INSIGHTS FROM ARTIFICIAL NEURAL NETWORKS

Dr. Smartson. P. NYONI
ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe

Mr. Thabani NYONI
Department of Economics, University of Zimbabwe, Harare, Zimbabwe

ABSTRACT

In this paper, ANN models were applied in forecasting GUD cases in people living in Chitungwiza urban district. The employed data covers the period January 2012 to December 2018 and the out-of-sample period ranges over the period January 2019 to December 2020. The residuals and forecast evaluation criteria of the applied models indicate that the models are adequate in predicting GUD cases in Chitungwiza urban district over the out-of-sample period. The results of the study basically indicate that more GUD cases are being confirmed in male than female patients and this trend has been forecasted to persist into the out-of-sample period. However, GUD cases for both males and females have been shown to be decrease in Chitungwiza urban district and this basically indicates that the war against GUD in Chitungwiza urban district is being won, although slowly. Therefore, there is need to implement the suggested 3-fold policy recommendations.

1.0 INTRODUCTION

Genital Ulcer Disease (GUD) is an important health problem in many developing countries (Wasserheit, 1991) and Zimbabwe is not an exception. GUD is caused by either infectious (genital herpes simplex virus, syphilis, chancroid, lymphogranuloma venereum, granuloma inguinale [donovanosis], fungal infections such as candida, and secondary bacterial infection) or noninfectious (behcet syndrome, fixed drug eruption, psoriasis, sexual trauma, and Wegener granulomatosis) etiologies (Augenbraun, 2009; Louden & Jorizzo, 2009; Workowski & Berman, 2011). In Zimbabwe, herpes simplex virus is the most common cause of GUD (Mungati *et al.* 2018) and a major risk factor in the acquisition and transmission of Human Immunodeficiency Virus (HIV) (Kilmarx *et al.* 2018).

The global incidence of GUD is more than 20 million cases annually (Low *et al.* 2006). In Africa, GUD is a significant risk factor in the acquisition and transmission of HIV (Wawer *et al.* 2005; Paz Bailey *et al.* 2010a & b; Phiri *et al.* 2013). The diagnosis of GUD is based on the presence of one or more mucocutaneous ulcers involving the genitalia, perineum or anus (Cohen & Mayer, 2007). Diagnosing the specific cause of GUD is based on history, physical examination and laboratory findings (Roett *et al.* 2012). Appropriate management of GUD is a public health priority (Kularatne *et al.* 2018). Against this precise background, there is need for modeling and forecasting GUD cases in Zimbabwe in order to inform policy makers. This study will focus on Chitungwiza urban district. The figure below shows the trends in GUD cases in Chitungwiza urban district:

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

Figure 1: GUD cases in Chitungwiza urban district

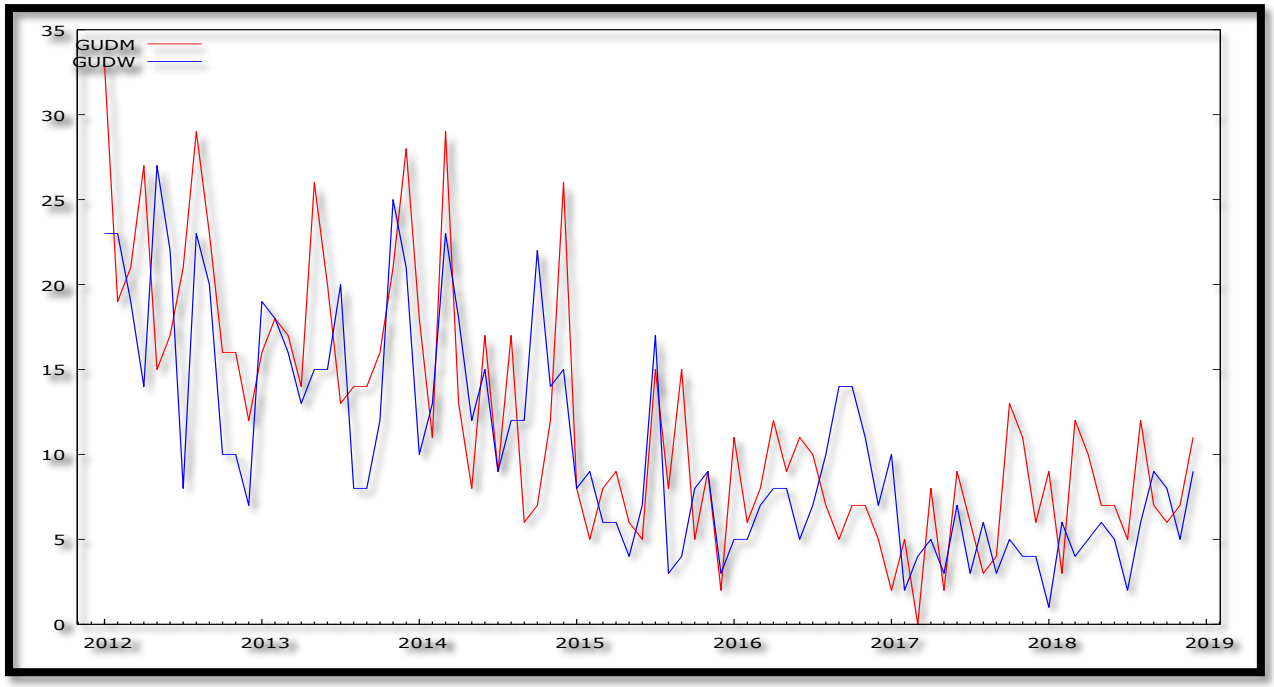


Figure 1 above basically shows that in Chitungwiza urban district, most GUD cases have been recorded for males than females over the study period. Hence, in Chitungwiza urban district, more male than female patients suffer from GUD. This could imply that there is need for sexual behaviour change programmes in Chitungwiza urban district, especially for men.

1.1 OBJECTIVES

i. To analyze GUD cases in Chitungwiza urban district over the period January 2012 to December 2018.
ii. To forecast GUD cases in Chitungwiza urban district over the period January 2019 to December 2020.
iii. To determine whether GUD cases in Chitungwiza urban district are increasing or decreasing over the out of sample period.

2.0 RELATED STUDIES

Makasa (2012) examined the epidemiological context of sexually transmitted infections in Zambia using data from various surveys and laboratory tests and basically concluded that there an overall significant decline in syphilis trends between 1994 and 2008 among urban and rural women in Zambia. Phiri *et al.* (2013) assessed the etiology of GUD and its association with HIV infection in Malawi using cross-sectional analysis and finally concluded that herpes simplex virus type 2 ulcers were highly prevalent and strongly associated with HIV. In India, Muralidhar *et al.* (2013) investigated GUD prevalence using specimens from 90 patients as well as blood samples. Their results indicate that the prevalence of GUD was 7.45 with mean age at initial sexual experience as 19.2 years. Kularatne *et al.* (2018) analyzed trend in the prevalence of GUD in South Africa using surveys and generally concluded that HSV remains the leading adding of pathogen-detectable GUD in South Africa. In Zimbabwe, Mungati *et al.* (2018) carried out an etiology of GUD using data from six geographically diverse clinics in Zimbabwe. Their results basically indicate that herpes simplex virus was the leading cause of GUD in their survey. No study has been done to forecast GUD cases in Zimbabwe or elsewhere, to the best of our knowledge. This paper will be the first of its kind, not only in Zimbabwe but also within the research community.

3. METHODOLOGY

There are a plethora of methods for the development and implementation of neural network model of forecasting (Ali *et al.* 2017). However, there

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

are many problems faced in trying to find the appropriate network size for predicting real-world time series (Zhang *et al.* 1998), no wonder why in many empirical works, feedforward neural network topology with back propagation learning algorithm is used, mostly in form of the Multilayer Perceptron Neural Network (MLPNN) type of the Artificial Neural Network (ANN) approach (Wang *et al.* 2006). MLP model belongs to a general class structure of ANN called feedforward neural network, which is a basic type of neural network that is capable of approximating both continuous and integrable functions (Ali *et al.* 2017). This study employs the MLPNN type of the ANN approach. Since there are no hard and fast rules that are used to determine the correct structure of a neural network (Fischer & Gopal, 1994), this study will be guided by Babic *et al.* (2011) who employed the ANN (12,12,1) model based on the sigmoid activation function. However, in this paper, we seldom use the sigmoid activation but rather we adopt the more efficient hyperbolic tangent activation function.

3.1 Data Issues

The GUDM (for male patients) and GUDW (for female patients) series used in this covers the period January 2012 to December 2018 and was recorded for people living in Chitungwiza urban district, aged between 10 and over 50 years. All the data was gathered from the DHIS2 system for Chitungwiza urban district.

4. FINDINGS OF THE STUDY

4.1 DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Variable	Mean	Median	Minimum	Maximum
GUDM	11.869	10.500	0.0000	33.000
GUDW	10.452	8.5000	1.0000	27.000
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
GUDM	7.1453	0.60201	0.91096	0.34593
GUDW	6.4123	0.61348	0.76901	-0.40016
Variable	5% Perc.	95% Perc.	IQ range	Missing obs.
GUDM	2.2500	27.750	9.0000	0
GUDW	3.0000	23.000	9.7500	0

Table 1 shows the descriptive statistics on GUD cases in Chitungwiza urban district. The average number of GUD cases for men, over the period of study; is approximately 12 cases per month while that of women is approximately 10 per month. The maximum number of GUD cases in men is 33 while that of women is 27. These statistics indicate that basically men are leading in GUD cases in Chitungwiza urban district. All the series are not normally districted as shown by the skewness statistics which indicate that the series under consideration are positively skewed.

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

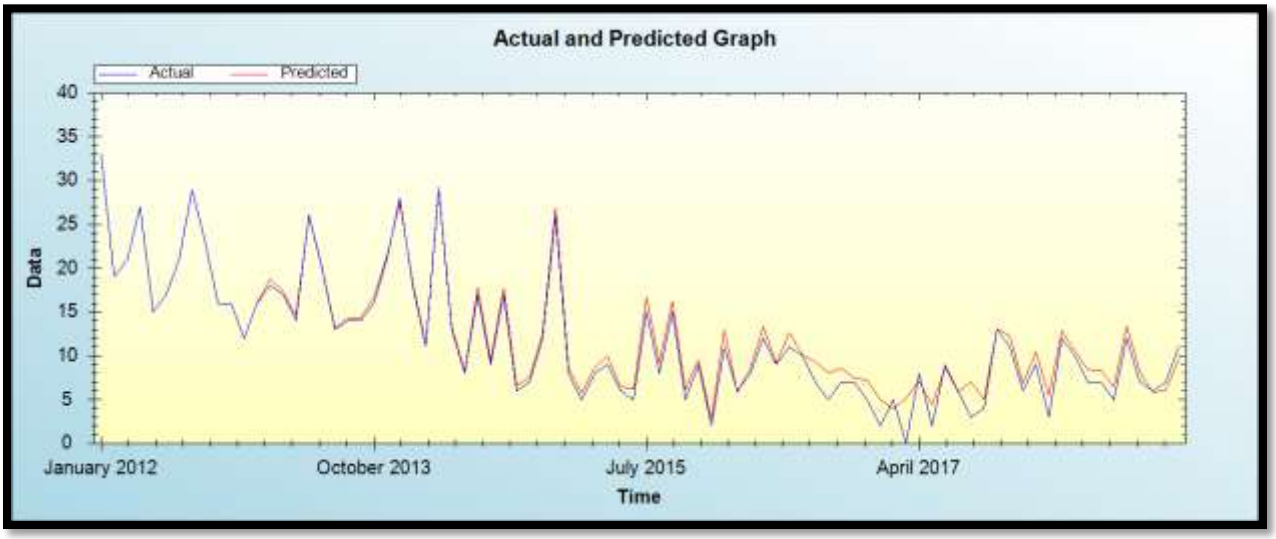
4.2 ANN MODEL SUMMARY-GUD IN MEN

Table 2: ANN model summary – GUD in men

Variable	GUDM
Observations	72 (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	0.074109
MSE	1.845970
MAE	0.996610

In-sample Forecast – GUD in Men

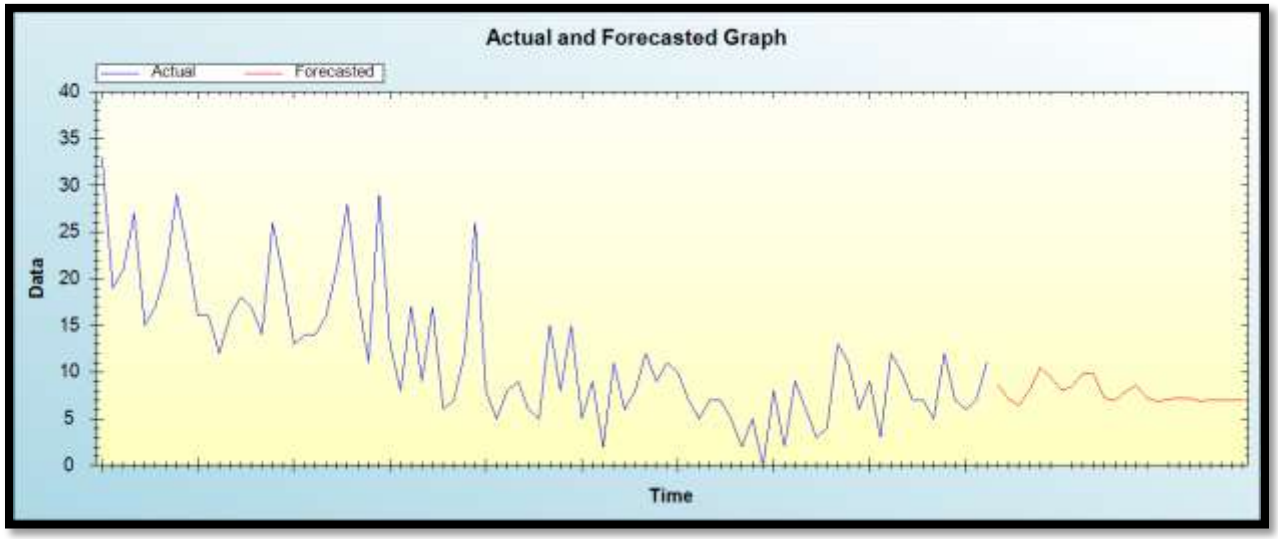
Figure 2: In-sample forecast – GUD in men



Out-of-Sample Forecast – GUD in Men: Actual and Forecasted Graph

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

Figure 3: Out-of-sample forecast – GUD in men: actual and forecasted graph



Out-of-Sample Forecast – GUD in Men: Forecasts only

Table 3: Out-of-sample forecast – GUD in men: forecasts only

Month – Year	Predicted New Cases of GUDM
January 2019	8.6878
February 2019	7.1246
March 2019	6.4367
April 2019	8.0795
May 2019	10.4584
June 2019	9.4318
July 2019	8.0454
August 2019	8.4560
September 2019	9.8660
October 2019	9.8158
November 2019	7.2219
December 2019	6.9724
January 2020	7.8815
February 2020	8.5752
March 2020	7.2305
April 2020	6.8274
May 2020	7.0818
June 2020	7.2434
July 2020	7.2014
August 2020	6.8923
September 2020	6.9940
October 2020	6.9712
November 2020	6.9496
December 2020	6.9562

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

Figure 4: Graphical presentation – GUDM: out-of-sample forecasts only

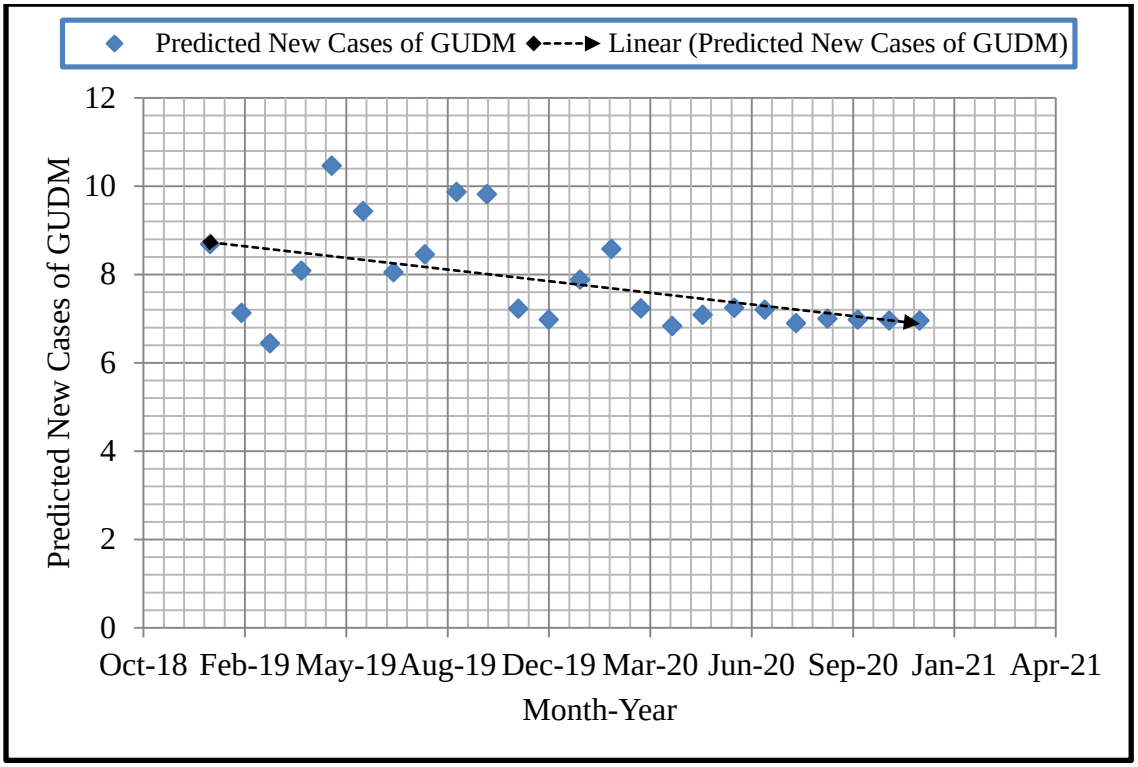


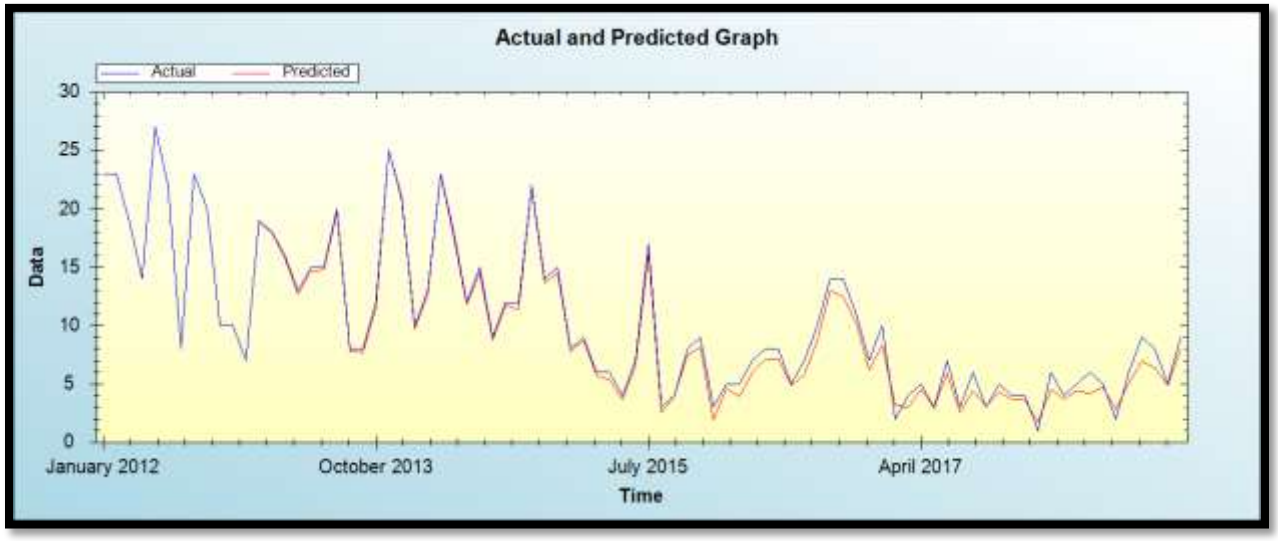
Table 4: ANN model summary – GUD in women

Variable	GUDW
Observations	72 (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	0.054039
MSE	0.609277
MAE	0.617563

In-sample Forecast – GUD in Women

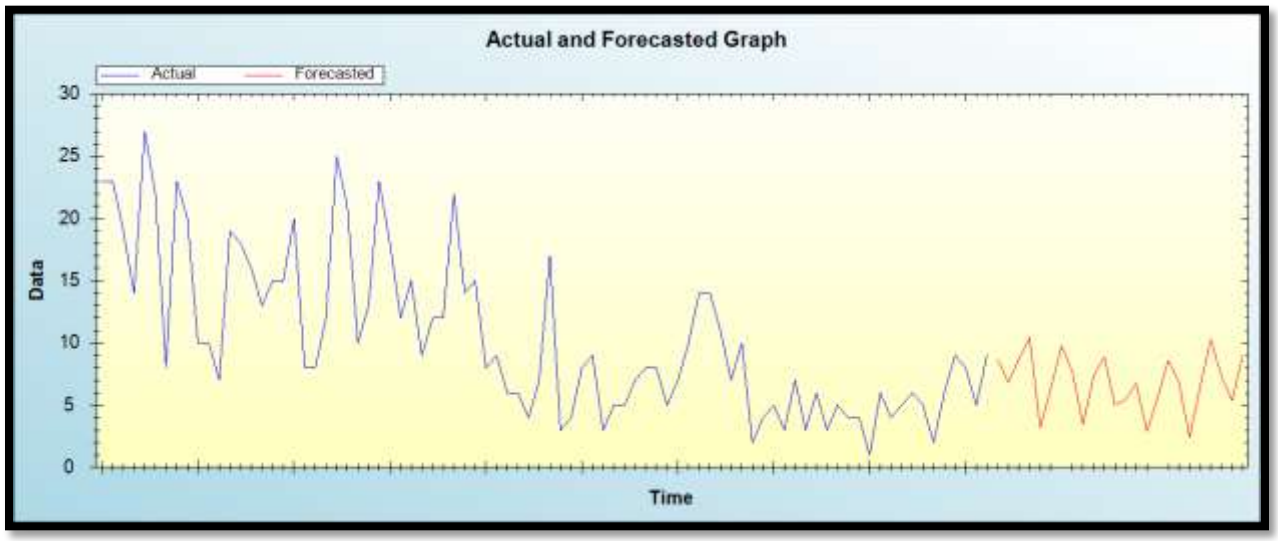
SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

Figure 5: In-sample forecast – GUD in women



Out-of-Sample Forecast – GUD in Women: Actual and Forecasted Graph

Figure 6: Out-of-sample forecast – GUD in women: actual and forecasted graph



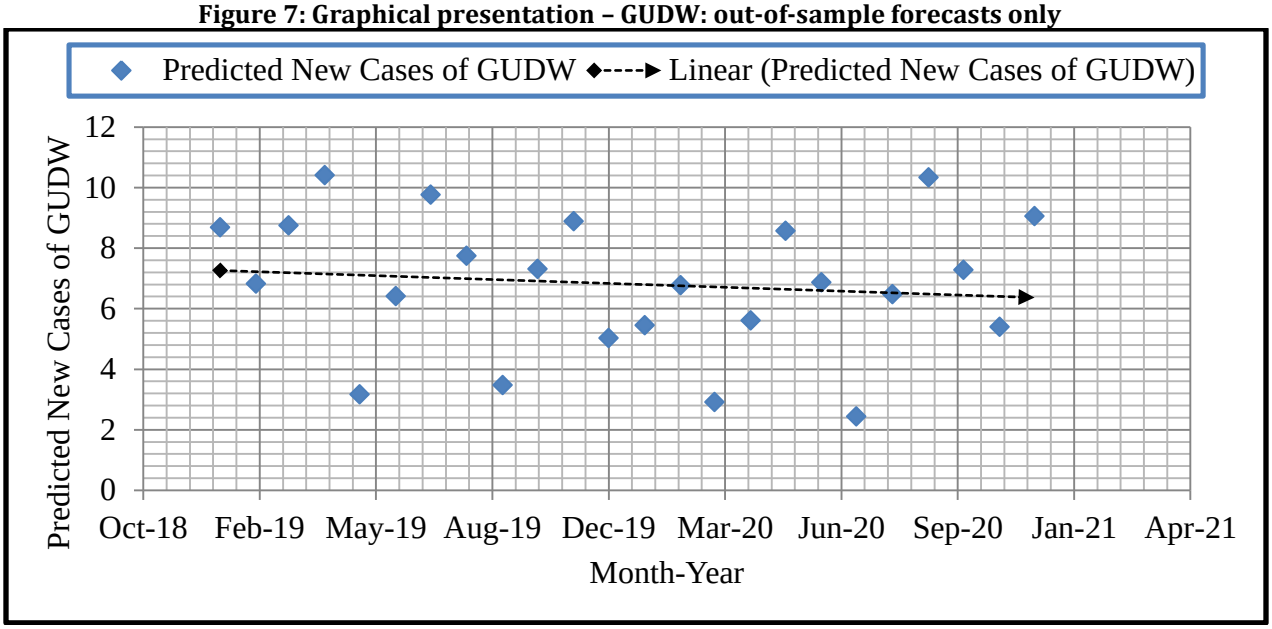
Out-of-Sample Forecast – GUD in Women: Forecasts only

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

Table 5: Out-of-sample forecast – GUD in women: forecasts only

Month – Year	Predicted New Cases of GUDW
January 2019	8.6875
February 2019	6.8213
March 2019	8.7443
April 2019	10.4042
May 2019	3.1633
June 2019	6.4078
July 2019	9.7564
August 2019	7.7418
September 2019	3.4679
October 2019	7.3101
November 2019	8.8831
December 2019	5.0245
January 2020	5.4489
February 2020	6.7742
March 2020	2.9064
April 2020	5.6053
May 2020	8.5699
June 2020	6.8696
July 2020	2.4404
August 2020	6.4775
September 2020	10.3341
October 2020	7.2746
November 2020	5.3940
December 2020	9.0481

Figure 7: Graphical presentation – GUDW: out-of-sample forecasts only



Predicted GUDM and GUDW on a Single Graph

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

Table 2 and 4 show the summaries of the ANN models for GUDM and GUDW. Both models use the hyperbolic tangent function as the activation function. Figure 2 and 5 are in-sample forecasts for both models. Table 3 and figure 3 & 4 are out-of-sample forecasts for GUDM while table 5 and figure 6 & 7 show out-of-sample forecasts for GUDW. The most striking feature is that figures 4 and 7 show downwards trends in both GUDM and GUDW. However, the trend line in figure 4 is generally steeper than the one in figure 7 indicating that GUDM cases are decreasing at a faster rate as compared to GUDW cases. The reasons for the observed decline in GUD cases in Chitungwiza are:

i. Behavior change programmes which are carried out in the district.
ii. Clinic staff who are well trained in the management of Sexually Transmitted Infections (STIs) and integration of STI management and OI/ART program.
iii. Scaling up of Voluntary Medical Male Circumcision (VMMC) program.

Figure 8: Predicted GUDM and GUDW on a single graph

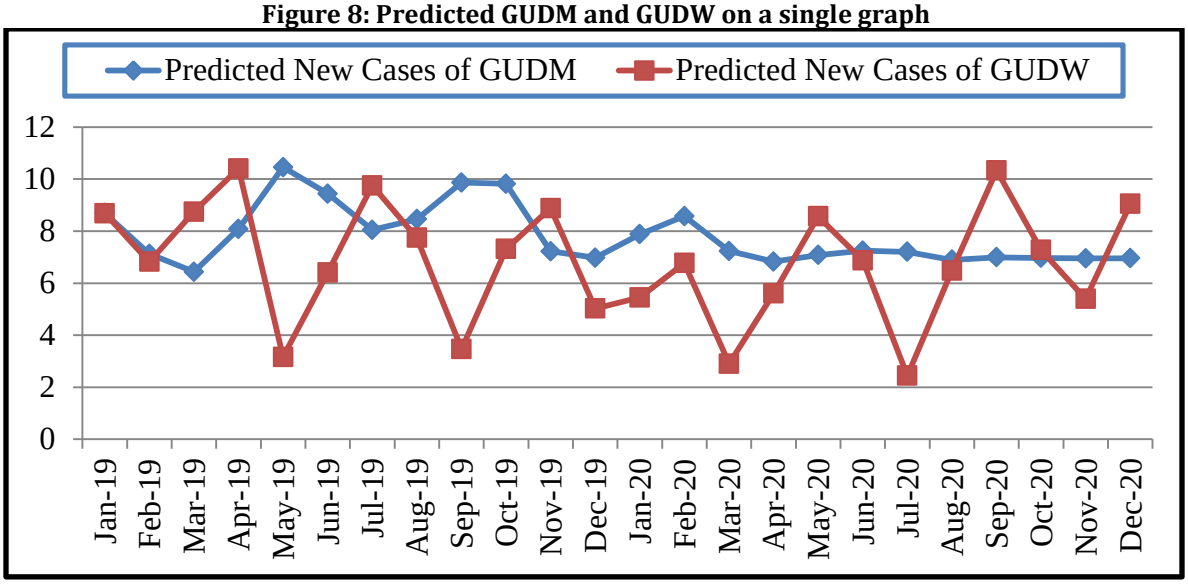
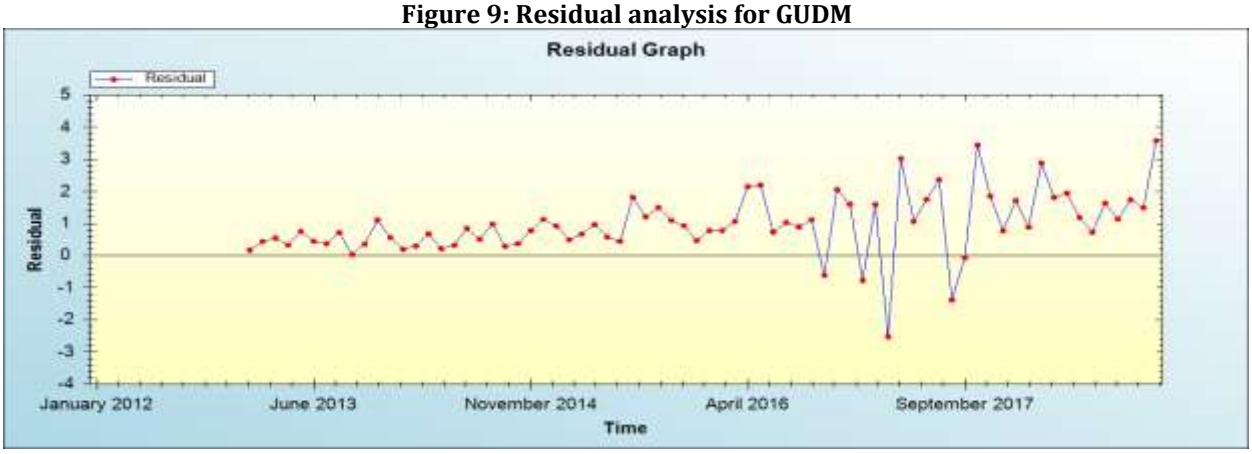


Figure shows the predictions of GUDM and GUDW cases plotted on the same graph. Ideally, both cases should be declining rapidly if sexual health programmes are achieving the desired health outcomes in Chitungwiza urban district. However, figure 8 indicates that GUDM is largely above GUDW in most instances and confirms the previous trends shown in figure 1, where more males than females have been shown to be suffering from GUD.

Residual Analysis and Forecast Evaluation for the ANNs

Residual Analysis for GUDM

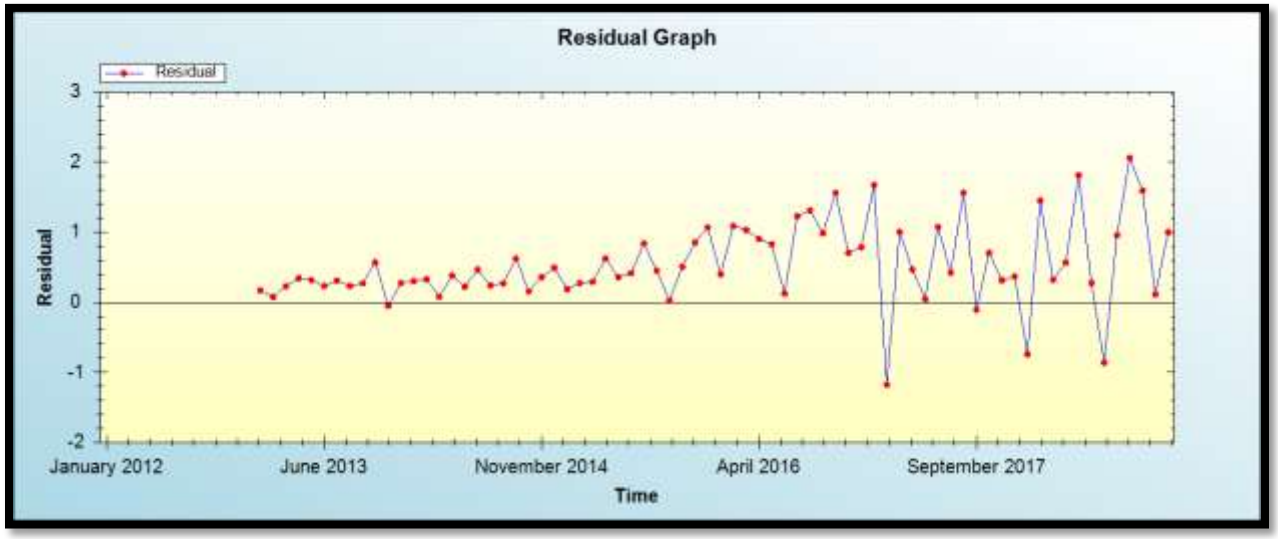
Figure 9: Residual analysis for GUDM



Residual Analysis for GUDW

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

Figure 10: Residual analysis for GUDW



Forecast Evaluation Statistics for Both GUDM and GUDW ANNs

Table 6: Forecast evaluation statistics

Evaluation Statistic	GUDM ANN	GUDW ANN
Error	0.074109	0.054039
MSE	1.845970	0.609277
MAE	0.996610	0.617563

Figure 9 and 10 show the residual of the models applied in this paper. In both instances, the residuals are reasonably as close to zero as possible; hence the models are quite acceptable for predicting GUD cases in Chitungwiza urban district. Table 6 shows the model criteria. These statistics should ideally be as minimum as possible. As shown in table 6, the evaluation statistics are quite very low and hence the models are relatively more accurate.

4.3 DISCUSSION OF THE FINDINGS

GUD is a fundamental risk factor in the transmission and acquisition of HIV. For Chitungwiza urban district, given that more male than female patients suffer from GUDs and our forecasts indicate that the trend is likely to continue; it leaves a lot to be desired in terms of the prevalence of HIV, especially in men as compared to women in Chitungwiza urban district. It is common knowledge than men have a poor healthcare seeking behaviour as compared to women and this is the case for Chitungwiza. Furthermore, a lot of young men in Chitungwiza abuse alcohol and other drugs and end up not using condoms consistently during their sexual encounters. The results of this study are not surprising given the fact most people in developing countries such as Zimbabwe lack adequate knowledge on sexual health. However, the decreasing trends shown in figure 4 and 7, generally indicate that relevant authorities in Chitungwiza urban district are doing their best to reduce the incidence of GUDs in Chitungwiza. This study will go a long way consolidating existing policy frameworks in Chitungwiza urban district.

4.4 RECOMMENDATIONS

i. Intensification of behaviour change and sexual & reproductive health programs which involve dissemination of information on correct and consistent use of condoms during sexual encounters, as well as putting emphasis on STI prevention, early detection and treatment.
ii. Scaling up of VMMC programmes.
iii. More programmes in general sexual health education, especially at community level.

5. CONCLUSION

It is almost unnecessary to reiterate the fact that GUD in Zimbabwe is of concern to public health policy makers. Patients diagnosed as having GUD in Zimbabwe receive a combination of antimicrobials to

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

treat syphilis, chancroid, lymphogranuloma venereum and genital herpes. Along with etiological studies of GUD in Zimbabwe such as Mungati *et al.* (2018), this paper further consolidates the current health policy framework not only for Chitungwiza urban district but also for the whole country at large. This paper analyzed GUD cases in Chitungwiza urban district for a monthly data set ranging over the period January 2012 – December 2018 using ANN models. Further studies can look into constructing various models for each variant of GUD and for each age group, that is: 10-24; 25-49 & 50 and above; this could potentially uncover further empirical evidence on the incidence of each variant of GUD such as syphilis, chancroid and so on with regards to specific age groups. A similar study can also be done for the whole country in order to get a full picture of GUD dynamics in Zimbabwe. Even though the results of this paper could be generalized for other similar urban districts in Zimbabwe, it is imprudent to undermine the fact that they are specifically applicable to Chitungwiza urban district.

REFERENCES

1. *Ali, Z., Hussain, I., Faisal, M., Nazir, H. M., Hussain, T., Shad, M. Y., Shoukry, A. M., & Gani, S. H. (2017). Forecasting Drought Using Multilayer Perceptron Artificial Neural Network Model, Advances in Meteorology, pp: 1 – 10.*
2. *Augenbraun, M. H. (2009). Diseases of the Reproductive Organs and Sexually Transmitted Diseases: Genital Skin and Mucous Membrane Lesions, In: Mandel et al. (eds), Mandel, Douglas and Bennett's Principles and Practice of Infectious Diseases, 7th Edition, Churchill Livingstone, Philadelphia.*
3. *Babic, R. S., Grgurevic, I., & Majic, Z. (2011). Comparison of Air Travel Demand Forecasting Methods, Proceedings of the 14th International Conference on Transport, Maritime and Logistics Science (ICTS'11), Zagreb, Croatia.*
4. *Cohen, D. E., & Mayer, K. (2007). Genital Ulcer Disease, In: Klauser, J. D., & Hook, E. W. (eds), Current Diagnosis and Treatment of Sexually Transmitted Diseases, McGraw-Hill Medical, New York.*
5. *Fischer, M. M., & Gopal, S. (1994). Artificial Neural Networks: A New Approach to Modelling Interregional Telecommunication Flows, Journal of Regional Science, 34 (4): 503 – 527.*
6. *Kilmarx, P. H., Gonese, E., Lewis, D. A., Chirenje, Z. M., Barr, B. A. T., Latif, A. S., Gwanzura, L., Handsfield, H. H., Machiha, A., Mugurungi, O., & Reitmeijer, C. A. (2018). HIV Infection In Patients With Sexually Transmitted Infections in Zimbabwe – Results From the Zimbabwe STI Etiology Study, PLoS ONE, 13 (6): 1 – 10.*
7. *Kularatne, R. S., Muller, E. E., Maseko, D. V., Kufa-Chakezha, T., & Lewis, D. A. (2018). Trends in the Relative Prevalence of Genital Ulcer Disease Pathogens and Association With HIV Infection in Johannesburg, South Africa, 2007 – 2015, PLoS ONE, 13 (4): 1 – 13.*
8. *Louden, B. A., & Jorizzo, J. L. (2009). Behcet's Disease, In: Firestein et al. (eds), Kelly's Textbook of Rheumatology, 8th Edition, Elsevier Inc, Philadelphia.*
9. *Low, N., Broulet, N., Adu, S. Y., Barton, P., Hossain, M., & Hawkes, S. (2006). Global Control of Sexually Transmitted Infections, Lancet, 368 (9551): 2001 – 2016.*
10. *Makasa, M. (2012). Epidemiological Context of Sexually Transmitted Infections in Zambia: Determinants, Aetiological Agents and Trend Over Time, PhD Thesis, University of Bergen.*
11. *Mungati, M., Machiha, A., Mugurungi, O., Tshimanga, M., Kilmarx, P. H., Nyakura, J., Shambira, G., Kupara, V., Lewis, D. A., Gonese, E., Barr, B. A. T., Handsfield, H. H., & Rietmeijer, C. A. (2018). The Etiology of Genital Ulcer Disease and Coinfections With Chlamydia Trachomatis and Neisseria Gonorrhoeae in Zimbabwe: Results From the Zimbabwe STI Etiology Study, Sexually Transmitted Diseases, 45 (1): 61 – 68.*
12. *Muralidhar, S., Talwar, R., Kumar, D. A., Kumar, J., Bala, M., Khan, N., & Ramesh, V. (2013). Genital Ulcer Disease: How Worrisome it Today? A Status Report From New Delhi, India, Journal of Sexually Transmitted Diseases, pp: 1 – 8.*
13. *Paz Bailey, G., Sternberg, M., Lewis, D. A., & Puren, A. (2010a). Acute HIV Infections Among Men With Genital Ulcer Disease in South Africa, Journal of Infectious Diseases, 201 (12): 1811 – 1815.*
14. *Paz Baily, G., Sternberg, M., Puren, A., Steele, L., & Lewis, D. A. (2010b). Determinants of HIV Type 1 Shedding From Genital Ulcers Among Men in South Africa, Clinical Infectious Diseases, 50 (7): 1060 – 1067.*
15. *Phiri, S., Zadrozny, S., Weiss, H. A., Martinson, F., Nyirenda, N., & Chen, C. Y. (2013). Etiology of Genital Ulcer Disease and Association With HIV Infection in Malawi, Sexually Transmitted Diseases, 40 (12): 923 – 928.*
16. *Roett, M. A., Mayor, M., & Uduhiri, K. A. (2012). Diagnosis and Management of Genital Ulcers, American Family Physician, 85 (3): 254 – 262.*
17. *Wang, W., Van Gelder, P. H., Vrijling, J., & Ma, J. (2006). Forecasting Daily Streamflow Using Hybrid ANN Models, Journal of Hydrology, 324 (1): 383 – 399.*

SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

18. *Wasserheit, J. (1991). Epidemiologic Synergy; Interrelationships Between Human Immunodeficiency Virus Infection and Other Sexually Transmitted Diseases, Sexually Transmitted Diseases, 19: 62 – 64.*
19. *Wawer, M. J., Gray, R. H., Sewankambo N. K., Serwadda, D., Li, X., & Laeyendecker, O. (2005). Rates of HIV-1 Transmission per Coital Act, by Stage of HIV-1 Infection, in Rakai, Uganda, Journal of Infectious Diseases, 191 (9): 1403 – 1409.*
20. *Workowski, K. A., & Berman, S. (2011). Sexually Transmitted Diseases Treatment Guidelines, MMWR, 60 (1): 1 – 110.*
21. *Zhang, G., Patuwo, B. E., & Hu, M. Y. (1998). Forecasting With Artificial Neural Networks: The State of the Art, International Journal of Forecasting, 14 (1): 35 – 62.*