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

USING ARTIFICIAL NEURAL NETWORKS FOR PREDICTING NEW DYSENTRY CASES IN CHILDREN UNDER 5 YEARS OF AGE IN CHITUNGWIZA URBAN DISTRICT, ZIMBABWE

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 research article, the Artificial Neural Network (ANN) model has been successfully used to model new dysentery cases in children under 5 years of age in Chitungwiza urban district in Zimbabwe. The study covers the period January 2012 to December 2018. The out of sample forecasts range over the period January 2019 to December 2020. The applied neural networks have been evaluated using the Error, Mean Square Error (MSE) and Mean Absolute Error (MAE). These model evaluation criteria show that the applied ANN model is adequate. The residual analysis of the model also further indicates that the ANN model applied in this paper is stable and suitable for forecasting new dysentery cases in children under 5 years of age in Chitungwiza urban district. The forecasts show a generally downwards trajectory of new dysentery cases in children under 5 years of age in Chitungwiza urban district. This is commendable for the relevant authorities in Chitungwiza for being able to keep the disease under reasonable control. However, there is need to improve the standards if a dysentery-free Chitungwiza is to be materialized any time soon.

1.0 INTRODUCTION

Zimbabwe continues to battle water-borne diseases such as bacillary dysentery, which have been mainly attributed to erratic water supplies, poor hygiene practices and inadequate sanitation (UN-OCHA, 2012). Bacillary dysentery, caused by different species of the Shigella bacteria, is the most regular acute intestinal infectious disease, and symptoms include fever, abdominal pain, and uncontrolled loose or watery stools containing visible red blood (Sampson & Leslie, 1979). Excessive dehydration due to dysentery can be fatal in some severe cases and is responsible for 120 million cases of severe dysentery, the majority of which occur in developing countries, especially among children (Kotloff *et al.* 1999; Von Seidlein *et al.* 2006; WHO, 2009). Bacillary dysentery is generally transmitted through faecal-oral route via contaminated food and water, and occurs more frequently in developing countries with poor sanitation and unsafe water supply (Yan *et al.* 2017). Shigella infections are a leading cause of diarrhoeal death among children in developing countries (Tickell *et al.* 2017) such as Zimbabwe, where an outbreak of dysentery is usually characterized by high mortality, especially in children since they tend to develop hemolytic uremic syndrome (HUS) (Oneko *et al.* 2001). This warranties the need for effective dysentery forecasting models in order to improve health policy formulation.

Zimbabwe's urban areas are choking under the weight of over-crowdedness amidst dilapidated infrastructure that is characterized by constant failure. The water and sewer systems of the country's major urban centres are on the verge of collapse, thus putting millions of people in danger of consuming

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

contaminated water, including that from underground sources. This situation has resulted in the transmission of such communicable diseases as dysentery amongst others (Makwara & Tavuyanago, 2012). In fact, all of Zimbabwe's major urban centres, especially Chitungwiza, are haunted by an inadequate water supply. The already bad situation is compounded by poor sanitation and hygiene that has characterized literally the whole country. Due to fast growing urbanization, this phenomenon has become "express" in Chitungwiza urban district. It thus becomes instructive to reflect on dysentery patterns that have been recorded in Chitungwiza urban district, especially for children under 5 years of age because they are the most vulnerable group.

1.1 OBJECTIVES

i. To assess new dysentery cases in children under 5 years of age in Chitungwiza urban district over the period January 2012 to December 2018.
ii. To predict dysentery cases for Chitungwiza urban district over the period January 2019 to December 2020.
iii. To determine whether dysentery cases are increasing or decreasing for Chitungwiza urban district over the out of sample period.

1.2 RELEVANCE OF THE STUDY

Dysentery, as a major global health problem (Tang *et al.* 2014), poses serious threats to developing countries (Kotloff *et al.* 1999), with no exception for Zimbabwe and yet effective models for forecasting dysentery cases or incidences are lacking (Yan *et al.* 2017). In Zimbabwe, no study has been done in this regard and yet the burden of dysentery is on the rise. This study will be the first of its kind in Zimbabwe and will focus on Chitungwiza urban district which is one of the most overcrowded urban areas in Zimbabwe and is always characterized by perennial water shortages and poor sewage systems. From a public health perspective, Chitungwiza is at risk of dysentery outbreaks and thus is imperative to analyze the past trends of dysentery cases in order to consolidate health policy with regards to dysentery prevention and control.

2.0 RELATED STUDIES

Yan *et al.* (2010) employed hybrid models for dysentery forecasting in Yichang city in China and basically found out that the SARIMA-GRNN model outperforms the SARIMA model. Tang *et al.* (2014) analyzed Shigella trends and risk factors in Jiangsu province in China using GIS tools and ARIMA models and found out that the ARIMA (1, 12, 0) predicted well for cases from August to December 2011. In another Jiangsu study, Wang *et al.* (2016) predicted the incidence of dysentery in China, using SARIMA models and found out that the best fit model was the SARIMA $(1,1,1)(1,1,2)_{12}$ model. Yan *et al.* (2017) examined the impact of meteorological factors on the incidence of bacillary dysentery in Beijing, China using the ARIMAX model and found out that temperature with 2-month and 7-month lags and rainfall with 12-month lag were positively correlated with the number of bacillary dysentery cases in Beijing. Comprehensive studies on modeling and forecasting dysentery cases are generally scanty in literature. Reviewed studies in the current study have been done in China, probably due to the high correlation between dysentery incidence and meteorological factors in China. No similar study has been in Zimbabwe. This paper will be the first of its kind and will go a long way in aiding the prevention and control of dysentery in Chitungwiza urban district.

3.0 METHODOLOGY

Researchers have recently analyzed how well the neural network model performs compared with the linear model using data from industry, finance, medical research and others (Guang *et al.* 2004; Wu *et al.* 2006; Hamdy *et al.* 2007) and have basically found out that the Artificial Neural Networks (ANNs) have the advantage of approximating nonlinear functions (Yan *et al.* 2010), especially those series for which the mathematical knowledge of the stochastic process behind the series is either unknown or difficult to rationalize (Castiglione, 2001). In the current study, our data exhibits nonlinear patterns (Guan *et al.* 2008), hence the need to use ANNs for forecasting. This study will not be the first one to use ANN in forecasting dysentery cases; we follow Yan *et al.* (2010) who used the hybrid models whose structure was combined with neural networks. However, we differentiate our approach from Yan *et al* (2010) by just using an ordinary feed-forward ANN approach based on the Multi Layer Perceptron Neural Network (MLPNN) without combining it with any other method.

3.1 Data Issues

This study is based on newly diagnosed monthly dysentery (DS) cases in children under 5 years of age in Chitungwiza urban district. The data cover the period January 2012 to December 2018 while the out-of-sample forecast covers the period January 2019 to December 2020. All the data employed in this paper

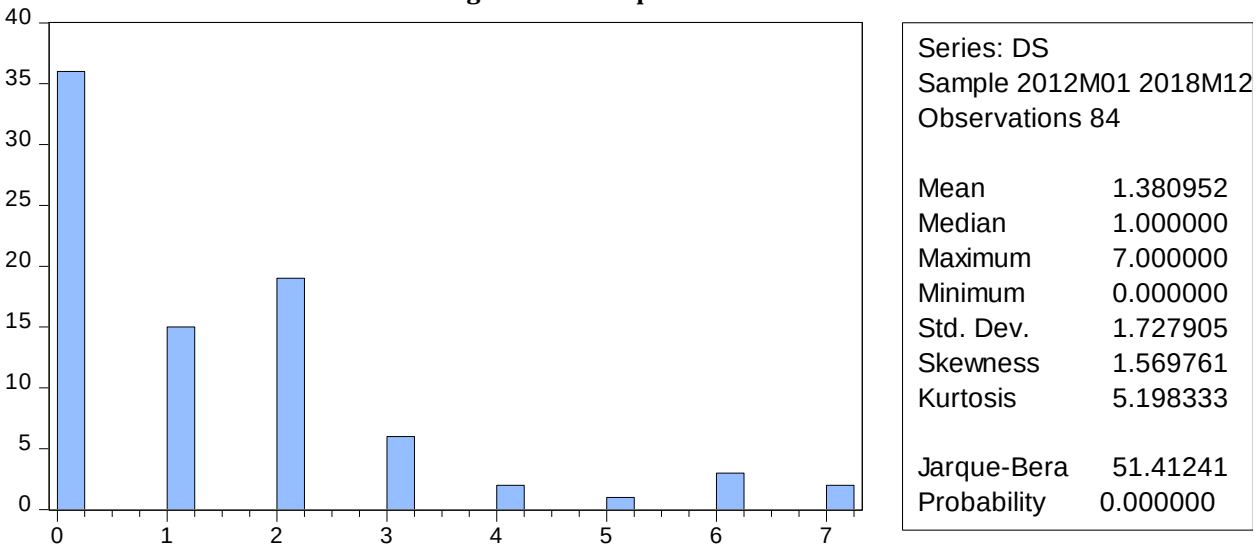
SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

was gathered from Chitungwiza City Health Information Department.

4.0 FINDINGS OF THE STUDY

4.1 DESCRIPTIVE STATISTICS

Figure 1: Descriptive statistics



From figure 1 above, the average number of dysentery cases in children under 5 years of age over the period under study is approximately 1 child per month. The maximum is 7 while the minimum is 0. The series under consideration is not normally distributed as shown by the Jarque-Bera statistic but rather it is positively skewed as indicated by the skewness statistic.

4.2 ANN MODEL SUMMARY FOR DYSENTRY CASES IN CHITUNGWIZA URBAN DISTRICT

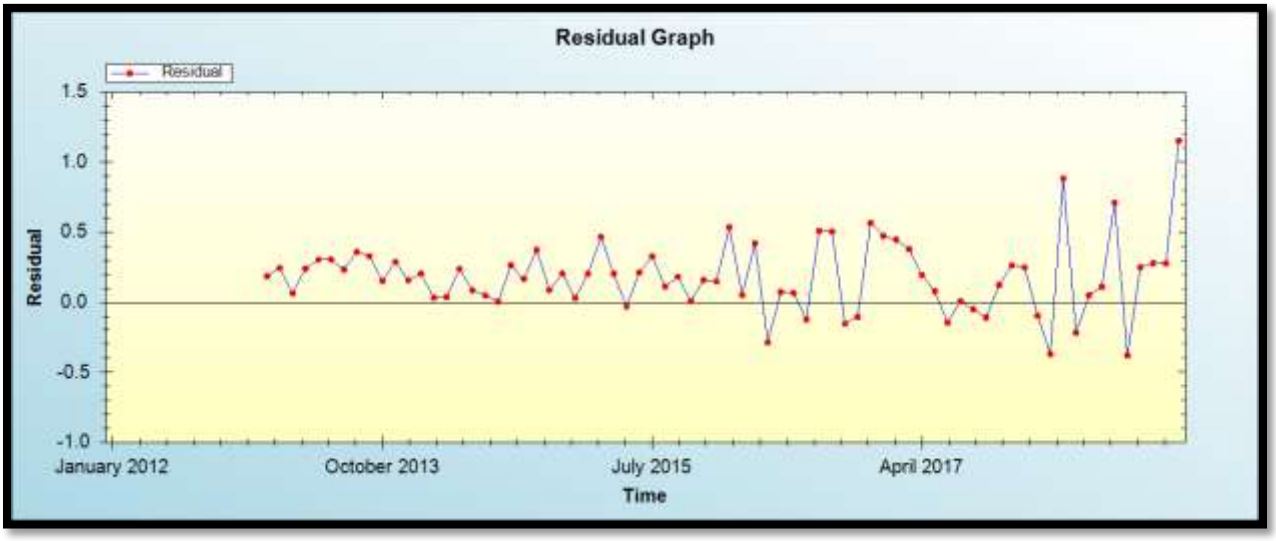
Table 1: ANN model summary

Variable	DS
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	0.08081
MSE	0.24117
MAE	0.09877

Residual Analysis for Chitungwiza Urban District (under 5) Dysentery cases

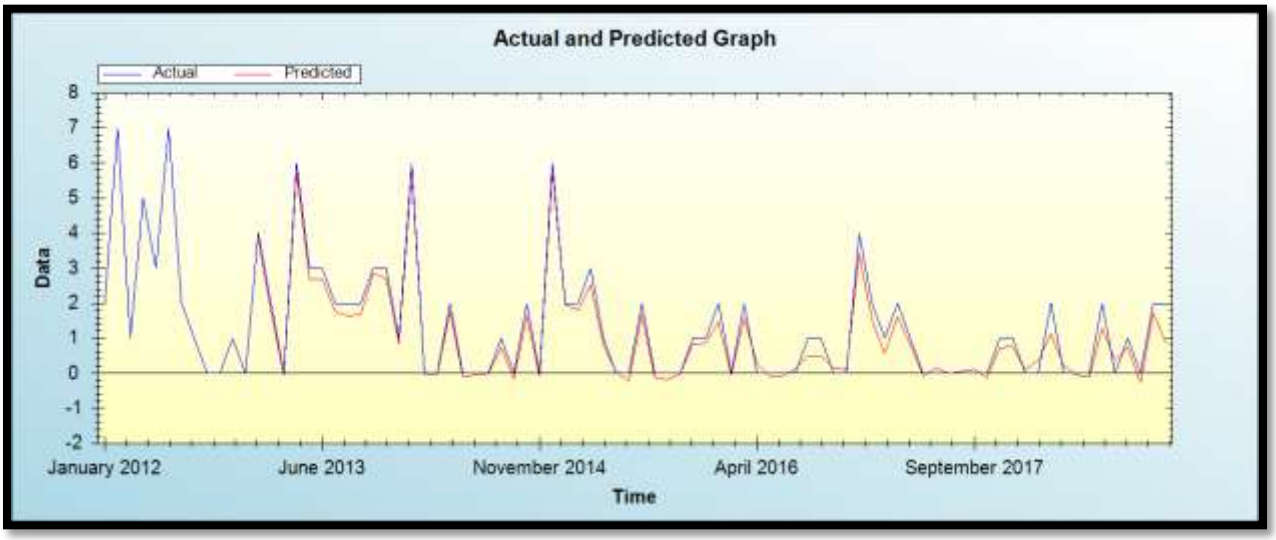
SJIF Impact Factor: 6.260| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 5 | Issue: 2 | February 2020 - Peer Reviewed Journal

Figure 2: Residual analysis for Chitungwiza urban district under 5 dysentery cases



In-sample Forecast for DS (dysentery)

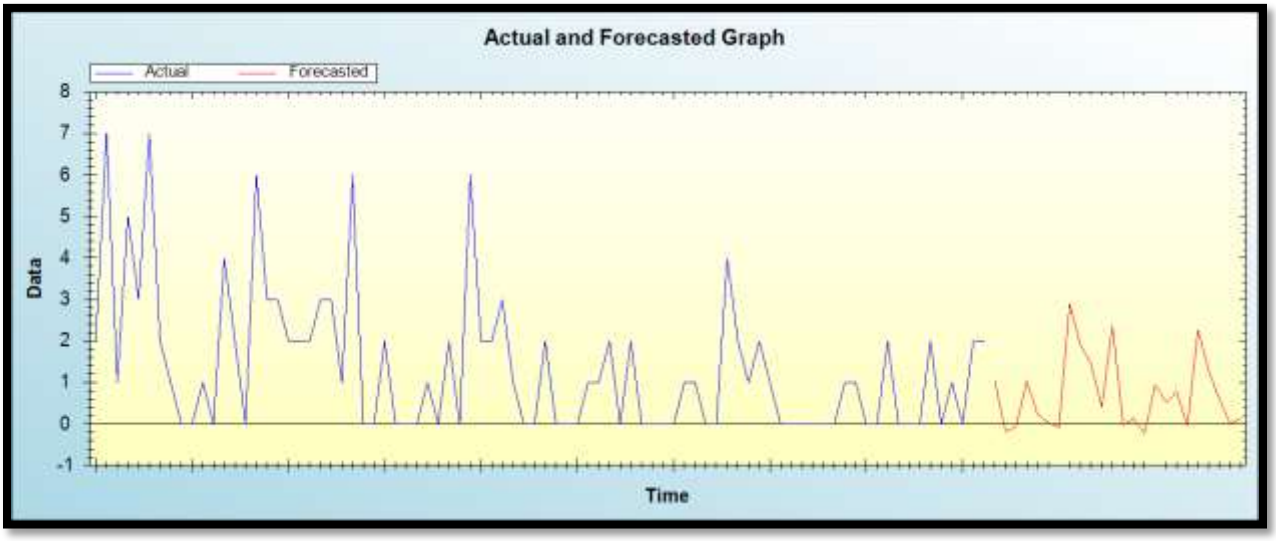
Figure 3: In-sample forecast for DS series



Out-of-Sample Forecast for DS: 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 4: Out-of-sample forecast for DS: actual and forecasted graph



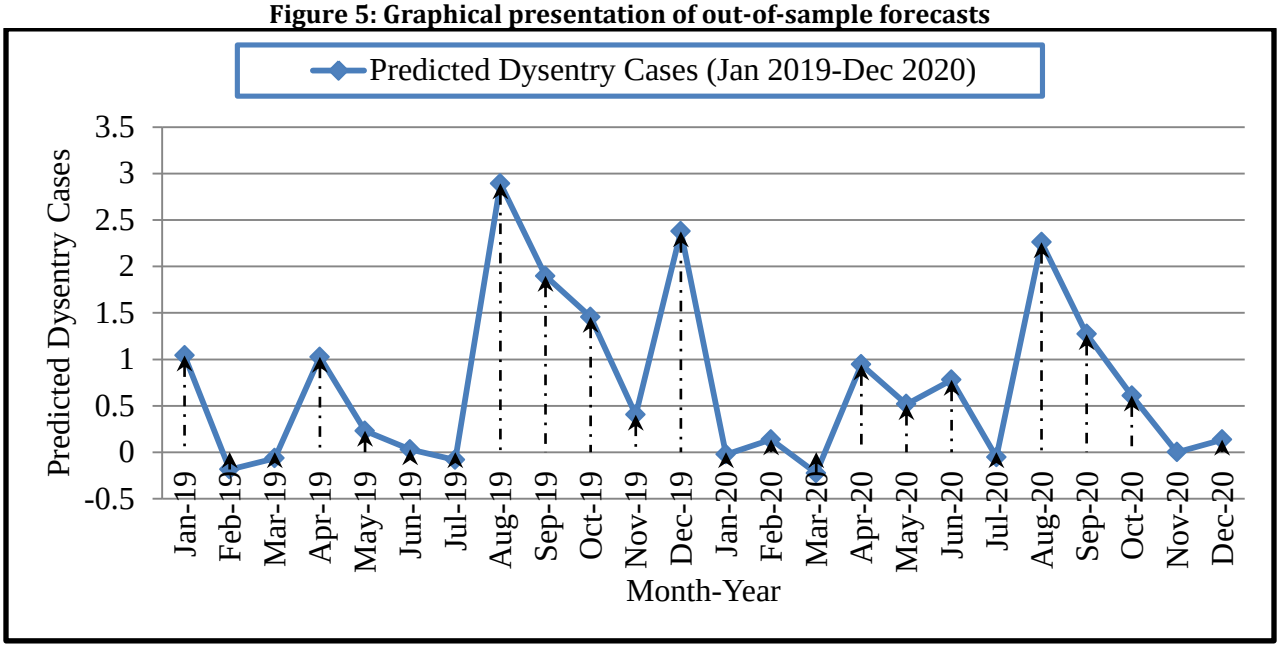
Out-of-Sample Forecast for DS: Forecasts only

Table 2: Tabulated out-of-sample forecasts

January 2019	1.0406
February 2019	-0.1847
March 2019	-0.0643
April 2019	1.0259
May 2019	0.2292
June 2019	0.0303
July 2019	-0.0811
August 2019	2.8917
September 2019	1.8969
October 2019	1.4559
November 2019	0.4045
December 2019	2.3778
January 2020	-0.0225
February 2020	0.1373
March 2020	-0.2245
April 2020	0.9441
May 2020	0.5179
June 2020	0.7796
July 2020	-0.0526
August 2020	2.2599
September 2020	1.2710
October 2020	0.6083
November 2020	0.0009
December 2020	0.1353

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: Graphical presentation of out-of-sample forecasts



4.3 DISCUSSION OF THE RESULTS

Table 1 is the ANN model summary and basically shows 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 adequate. Figure 2 shows the residuals of the model and since the residuals are as close to zero as possible, the model is stable and acceptable for generating forecasts for Chitungwiza urban district. Figure 3 shows the in-sample forecast of the model and it can be inference that the model fits well with data. Figure 4, table 2 and figure 5 are out of sample forecasts. A striking feature of our forecast is that the dysentery cases will be highest in the month of August each year in the out of sample; for example, for August 2019, nearly 3 cases were predicted and for August 2020, approximately 2 cases have been predicted to occur at Chitungwiza urban district. Mostly importantly, the predicted DS cases are shown to be going downwards and this is clear indication that the war against dysentery in children under 5 years of age is being gradually won in Chitungwiza urban district. In order to maintain this, a 3-fold policy recommendation has been put forward as shown below in section 4.4 of the study.

4.4 RECOMMENDATIONS

i. Improvement of sanitation and hygiene should be strengthened not only in Chitungwiza urban district but also in all other parts of Zimbabwe.
ii. The government of Zimbabwe should improve access to safe water in Chitungwiza, for example, through drilling additional boreholes and repairing & maintaining existing ones; in order to cope with increasing demand for water.
iii. The government of Zimbabwe and its relevant partners and donors should continue to provide medical supplies for the treatment of dysentery in Chitungwiza urban district, just like in other parts of the country.

5.0 CONCLUSION

Children under 5 years of age are the most vulnerable group of patients when it comes to dysentery outbreaks, hence the need for this paper. The paper employed the ANN approach in order to analyze the trends of dysentery cases in Chitungwiza urban district over the period under study. Results are encouraging as they indicate victory against the disease but still there is need for continuous fight against dysentery in order to materialize a dysentery-free country. The study is the first of its kind in Zimbabwe and is expected to steer-up a scholarly debate especially with regards to modeling and forecasting dysentery cases.

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

REFERENCES

1. *Castiglione, F. (2001). Forecasting the Price Increments Using An Artificial Neural Network, Advanced Complex Systems, 1: 45 – 56.*
2. *Guan, P., Huang, D. S., & Zhou, B. S. (2004). Forecasting Models for the Incidence of Hepatitis A Based on Artificial Neural Network, World Journal of Gastroenterology, 10: 3579 – 3582.*
3. *Guan, P., Huang, D., & Guo, J. (2008). Bacillary Dysentery and Meteorological Factors in Northeastern China: A Historical Review Based on Classification and Regression Trees, Japan Journal of Infectious Diseases, 61: 356 – 360.*
4. *Hamdy, K. E., Yosry, A. A., & Farag, I. Y. (2007). Prediction of Hourly and Daily Diffuse Fraction Using Neural Network, As Compared to Linear Regression Models, Energy, 32: 1513 – 1523.*
5. *Kotloff, K. L., Winickoff, J. P., & Ivanoff, B. (1999). Global Burden of Shigella Infections: Implications for Vaccine Development and Implementation of Control Strategies, Bulletin of World Health Organisation, 77: 651 – 666.*
6. *Makwara, E. C., & Tavuyanago, B. (2012). Water Woes in Zimbabwe's Urban Areas in the Middist of Plenty: 2000 – Present, European Journal of Sustainable Development, 1 (2): 151 – 180.*
7. *Oneka, M., Nyathi, M. N., & Doehring, E. (2001). Post-dysenteric Hemolytic Uremic Syndrome in Bulawayo, Zimbabwe, Pediatric Nephrology, 16: 1142 – 1145.*
8. *Sampson, C. C., & Leslie, B. (1979). Shigellosis: Analysis of 176 Isolations, Journal of National Medical Association, 71: 35 – 36.*
9. *Tang, F., Cheng, Y., Bao, C., Hu, C., Hu, J., Liu, W., Liang, Q., Wu, Y., Norris, J., Peng, Z., Yu, R., Shen, H., & Chen, F. (2014). Spatio-Temporal Trends and Risk Factors for Shigella from 2001 to 2011 in Jiangsu Province, People's Republic of China, PLoS ONE, 9 (1): 1 – 11.*
10. *Tickell, K. D., Brander, R., Atlas, H. E., Pernica, J. M., Walson, J. L., & Pavlinac, P. B. (2017). Identification and Management of Shigella Infection in Children With Diarrhoea: A Systematic Review and Meta-Analysis, Lancet Global Health, pp: 1 – 14.*
11. *UN-OCHA (2012). Zimbabwe Battles Food Insecurity & Waterborne Diseases, Humanitarian Bulletin Zimbabwe, pp: 1 – 4.*
12. *Von Seidlein, L., Kim, D. R., & Ali, M. (2006). A Multicenter Study of Shigella Diarrhoea in Six Asian Countries: Disease Burden, Clinical Manifestations and Microbiology, PLoS Medicine, 3: 1 – 18.*
13. *Wang, K., Song, W., Li, J., Lu, W., Yu, J., & Han, X. (2016). The Use of An Autoregressive Integrated Moving Average Model for Prediction of the Incidence of Dysentery in Jiangsu, China, Asia Pacific Journal of Public Health, 28 (4): 336 – 346.*
14. *WHO (2009). Diarrhoeal Diseases, http://www.who.int/vaccine/research/diseases/diarrhoeal/en/index6.html ; accessed 29/01/2020.*
15. *Wu, M. Z., Wu, W., & Wang, P. (2006). Prediction for Incidence of Hemorrhagic Fever With Renal Syndrome With Back Propagation Artificial Neural Network Model, China Journal of Vector Biology & Control, 17: 223 – 226.*
16. *Yan, L., Wang, H., Zhang, X., Li, M. Y., & He, J. (2017). Impact of Meteorological Factors on the Incidence of Bacillary Dysentery in Beijing, China: A Time Series Analysis (1970 – 2012), PLoS ONE, 12 (8): 1 – 13.*
17. *Yan, W., Xu, Y., Yang, X., & Zhou, Y. (2010). A Hybrid Model for Short-Term Bacillary Dysentery Prediction in Yichang City, China, Japan Journal of Infectious Diseases, 63: 264 – 270.*