NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696 Website: ijiert.org
VOLUME 7, ISSUE 10, Oct.-2020

ARIMA FORECASTING OF THE PREVALENCE OF ANEMIA AMONG PREGNANT WOMEN IN BAHRAIN

DR. SMARTSON P. NYONI
ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe

MR. THABANI NYONI
Department of Economics, University of Zimbabwe, Harare, Zimbabwe

ABSTRACT
Using annual time series data on the prevalence of anemia among pregnant women in Bahrain from 1990 – 2018, the study seeks to make forecasts for the period 2017 – 2025. The study applies the Box-Jenkins ARIMA methodology. The diagnostic ADF tests show that the Z series under consideration is an I (0) variable. Based on the AIC, the study presents an AR (4) process or the ARIMA (4, 0, 0) model as the optimal model. The diagnostic tests further indicate that the presented model is stable and its residuals are not serially correlated. The study established that the prevalence of anemia among pregnant women in Bahrain is likely to increase from the estimated 24.4% in 2017 to almost 26.1% by 2025. The study basically recommends that the government of the Kingdom of Bahrain should intensify its national flour fortification program and free provision of universal healthcare services including antenatal care programs in order to reserve the predicted trends in the prevalence of anemia among pregnant women in the country.

INTRODUCTION
Anemia is a common nutritional disorder, affecting 1.6 billion people globally, which constitutes approximately 25% of the world population (McLean et al., 2009). During pregnancy, anemia is very common, especially in developing countries such Bahrain and is primarily related to the expansion of plasma volume without normal expansion of maternal hemoglobin (Hb) mass. It can also be caused by iron deficiency (Cunningham et al., 2001; Ramakrishnan, 2001). A number of factors affect the occurrence of iron deficiency anemia during pregnancy among which poor nutrition, multigravida and multiparity, close birth spacing and infection (Beard, 2000; Esmat et al., 2010). During pregnancy, approximately 840-1210mg of iron is needed to avoid anemia (7). Anemia during pregnancy is still a major public health challenge in the country (Al-Dallal & Hussain, 2011; Merza et al., 2014). The main goal of this study is to predict the prevalence of anemia among pregnant women in Bahrain over the period 2017 – 2025.

LITERATURE REVIEW
In a cross-sectional study, Merza et al. (2014) evaluated the prevalence and risk factors of iron deficiency anemia among pregnant women in Bahrain. 366 pregnant women were included in the study during June 2012. The pregnant women were recruited during their antenatal visit. The personal characteristics, pregnancy and dietary information were documented. In addition, hemoglobin and serum ferritin levels were determined. The results of the study indicated that the prevalence of anemia in the included sample was 26.2% and that lower educational level and close birth space (less or equal to 2 years) were the main risk factors. Similarly, in a descriptive, retrospective study; Al-Alawi & Sarhan (2014), examined the prevalence of anemia in the country, however; not in pregnant women but among children aged 9-months. The study also investigated the correlation between hemogloblinopathies and anemia in mothers during pregnancy and anemia in infants. The authors established that anemia among infants is decreasing in the Kingdom of Bahrain. No study has forecasted the prevalence of anemia. This paper is the first of its kind in the Kingdom of Bahrain.

METHODODOLOGY
3.1 The Box – Jenkins (1970) Methodology
The first step towards model selection is to difference the series in order to achieve stationarity. Once this process is over, the researcher will then examine the correlogram in order to decide on the appropriate orders

of the AR and MA components. It is important to highlight the fact that this procedure (of choosing the AR and MA components) is biased towards the use of personal judgement because there are no clear – cut rules on how to decide on the appropriate AR and MA components. Therefore, experience plays a pivotal role in this regard. The next step is the estimation of the tentative model, after which diagnostic testing shall follow. Diagnostic checking is usually done by generating the set of residuals and testing whether they satisfy the characteristics of a white noise process. If not, there would be need for model re – specification and repetition of the same process; this time from the second stage. The process may go on and on until an appropriate model is identified (Nyoni, 2018c). This approach will be used to analyze, Z, the series under consideration.

3.2 The Applied Box – Jenkins ARIMA Model Specification

If the sequence $\Delta^d Z_t$ satisfies an ARMA (p, q) process; then the sequence of Z_t also satisfies the ARIMA (p, d, q) process such that:

$$\Delta^d Z_t = \sum_{i=1}^{p} \beta_i \Delta^d L^i Z_t + \sum_{i=1}^{q} \alpha_i L^i \mu_t + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where Δ is the difference operator, vector $\beta \in \mathbb{R}^p$ and $\alpha \in \mathbb{R}^q$.

3.3 Data Collection

This study is based on annual observations (that is, from 1990 – 2018) on the prevalence of anemia among pregnant women, that is, the percentage of pregnant women whose hemoglobin level is less than 110 grams per liter at sea level [denoted as Z] in Bahrain. Out-of-sample forecasts will cover the period 2017 – 2025. All the data was collected from the World Bank online database.

3.4 Diagnostic Tests & Model Evaluation

3.4.1 The ADF Test in Levels

Table 1: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
Z	-4.641072	0.0011	-3.724070	@1%	Stationary
			-2.986225	@5%	Stationary
			-2.632604	@10%	Stationary

Table 1 shows that the series under consideration is stationary in levels.

3.4.2 Evaluation of ARIMA models (without a constant)

Table 2: Evaluation of ARIMA Models (without a constant)

Model	AIC	U	ME	RMSE	MAPE
ARIMA (2, 0, 2)	-22.55456	0.15417	1.6949	8.9117	3.9927
ARIMA (1, 0, 0)	83.63678	0.98968	0.91052	8.9553	6.1
ARIMA (2, 0, 0)	-17.31526	0.18132	1.7042	8.9119	4.0239
ARIMA (3, 0, 0)	-23.59648	0.16014	1.6926	8.9117	3.9897
ARIMA (4, 0, 0)	**-27.70837**	0.14248	1.6865	8.9116	3.9733
ARIMA (5, 0, 0)	-26.67576	0.14083	1.6852	8.9116	3.9619

A model with a lower AIC value is better than the one with a higher AIC value (Nyoni, 2018b) Similarly, the U statistic can be used to find a better model in the sense that it must lie between 0 and 1, of which the closer it is to 0, the better the forecast method (Nyoni, 2018a). In this research paper, only the AIC is used to select the optimal model. Therefore, the ARIMA (4, 0, 0) model, which is also called the AR (4) model; is finally chosen.

3.5 Residual & Stability Tests

3.5.1 Correlogram of the Residuals of the ARIMA (4, 0, 0) Model

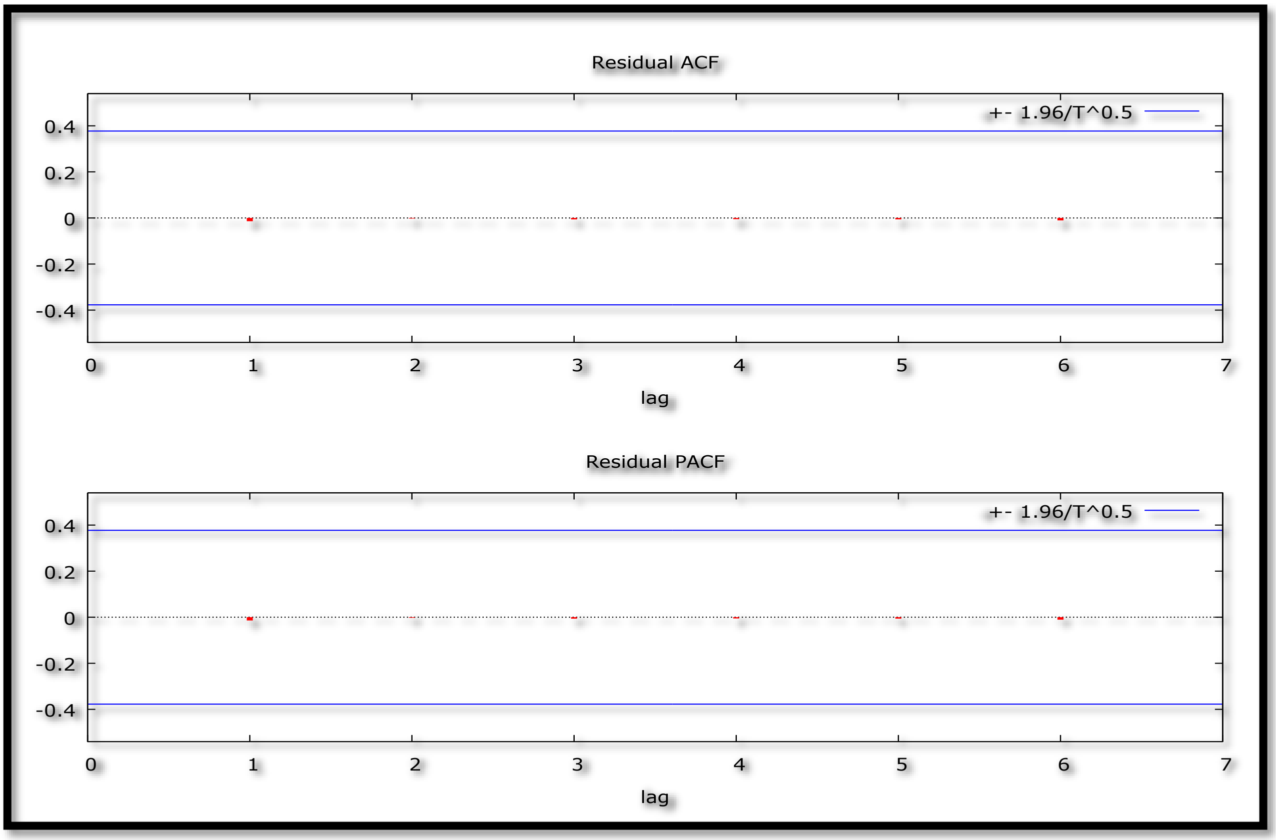

Figure 1: Correlogram of the Residuals

Figure 1 indicates that the estimated optimal ARIMA (4, 0, 0) model is adequate since ACF and PACF lags are quite short and within the bands.

3.5.2 Stability Test of the ARIMA (4, 0, 0) Model

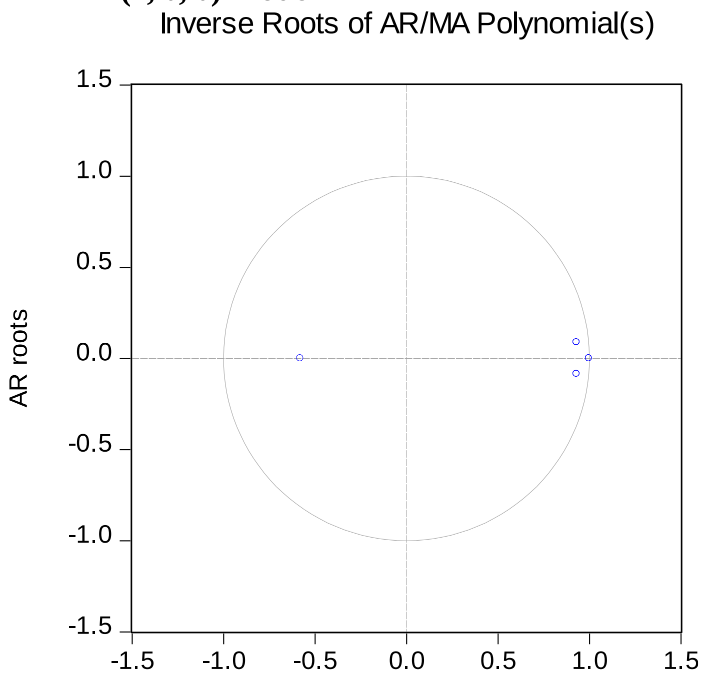

Figure 2: Inverse Roots

Since all the AR roots lie inside the unit circle, it implies that the estimated ARIMA process is (covariance) stationary; thus confirming that the ARIMA (4, 0, 0) model is really stable and suitable for forecasting the prevalence of anemia in pregnant women in Bahrain.

FINDINGS OF THE STUDY

4.1 Results Presentation

Table 3: Main Results

ARIMA (4, 0, 0) Model:

The chosen optimal model, the ARIMA (4, 0, 0) model can be expressed as follows:

$$Z = 2.24482Z_{t-1} - 1.05917Z_{t-2} - 0.642032Z_{t-3} + 0.456290Z_{t-4} \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

Variable	Coefficient	Standard Error	z	p-value
β_1	2.24482	0.176938	12.69	0.0000***
β_2	-1.05917	0.466851	-2.269	0.0233**
β_3	-0.642032	0.467233	-1.374	0.1694
β_4	0.456290	0.17569	2.593	0.0095***

Table 3 shows the main results of the ARIMA (4, 0, 0) model.

Forecast Graph

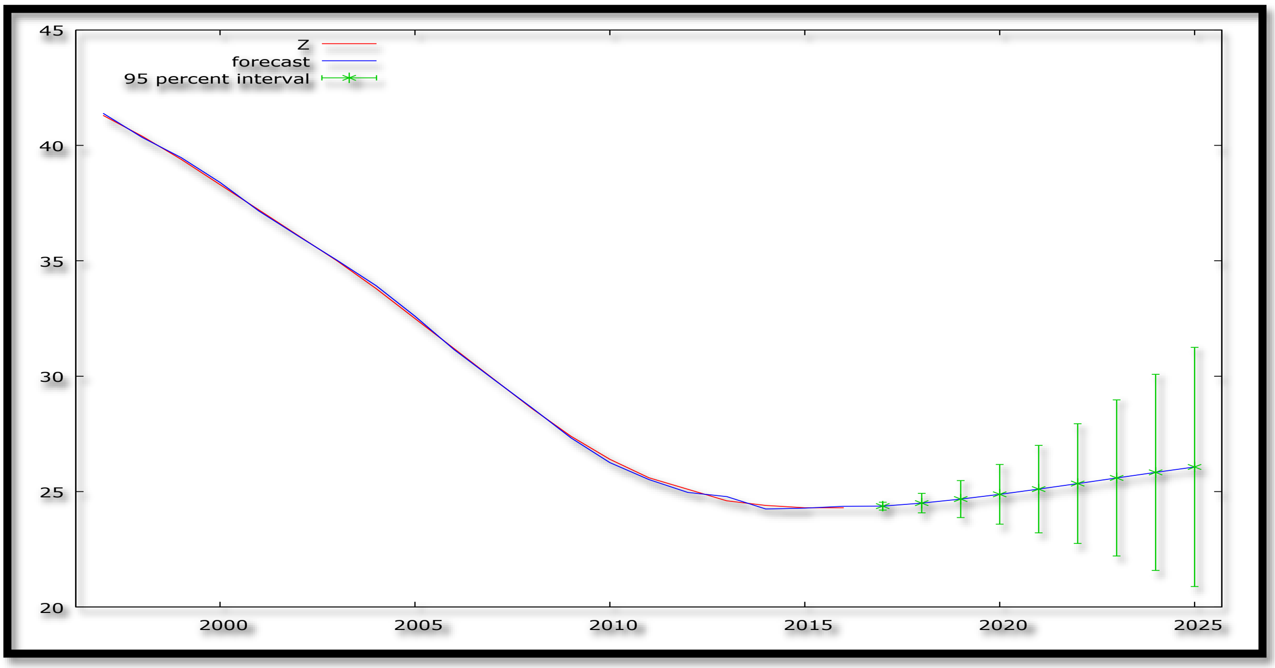

Figure 3: Forecast Graph – In & Out-of-Sample Forecasts

Figure 3 shows the in-and-out-of-sample forecasts of the series, Z. The out-of-sample forecasts cover the period 2017 – 2025.

Predicted Z– Out-of-Sample Forecasts Only

Table 4: Predicted Z

Year	Predicted Z	Standard Error	95% Confidence Interval
2017	24.3704	0.0874505	(24.1990, 24.5418)
2018	24.5014	0.214908	(24.0802, 24.9226)
2019	24.6752	0.409059	(23.8734, 25.4769)
2020	24.8815	0.659453	(23.5890, 26.1740)
2021	25.1084	0.966338	(23.2144, 27.0024)
2022	25.3476	1.32318	(22.7542, 27.9410)
2023	25.5911	1.72559	(22.2090, 28.9731)
2024	25.8326	2.16746	(21.5844, 30.0807)
2025	26.0669	2.64334	(20.8860, 31.2477)

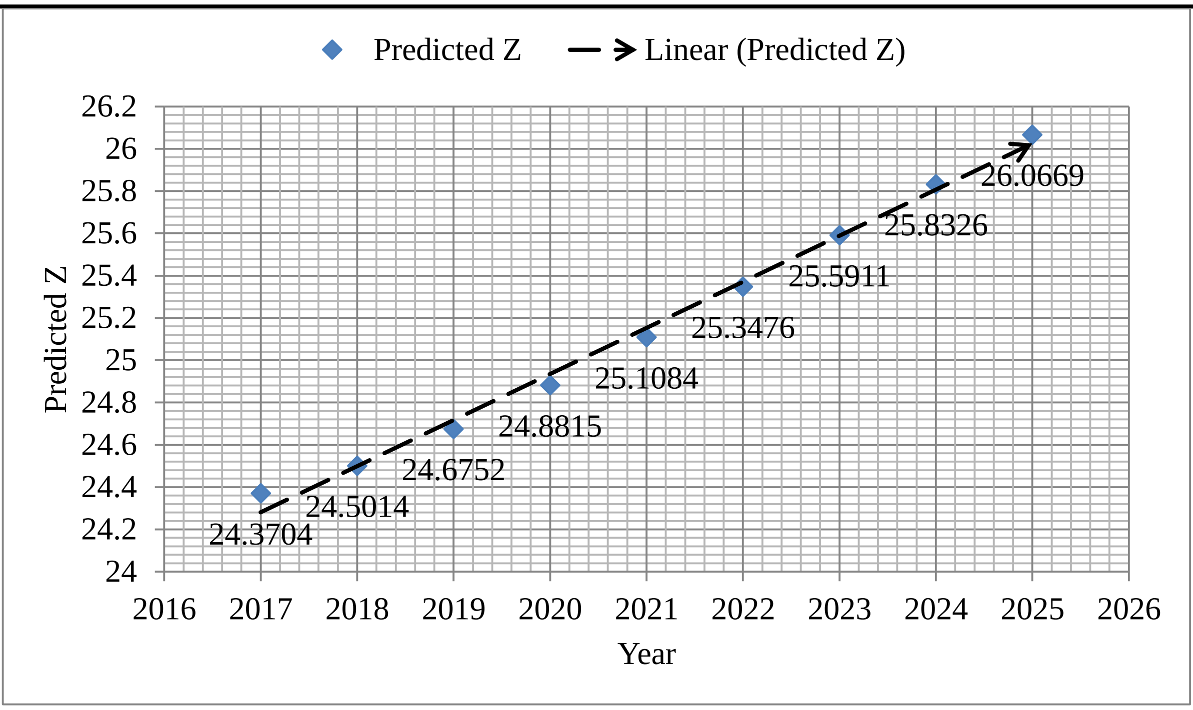

Figure 4: Graphical Analysis of Out-of-Sample Forecasts

Table 4 and figure 4 show the out-of-sample forecasts only. The prevalence of anemia in pregnant women in Bahrain is projected to increase from the estimated 24.4% to approximately 26.1% by 2025.

CONCLUSION

The study shows that the ARIMA (4, 0, 0) model is not only stable but also the most suitable model to forecast the prevalence of anemia in pregnant women in Bahrain over the period 2017 – 2025. The model predicts an increase in the prevalence of anemia among pregnant women in Bahrain. This points to the fact that anemia among pregnant women in Bahrain is far from being eradicated in the country. The study recommends that the government of the Kingdom of Bahrain should intensify the national flour fortification program and free provision of universal healthcare services including antenatal care programs, especially in rural areas and among non-Bahraini pregnant women; where significant groups of households are economically disadvantaged. Furthermore, there is need for establishment of more women friendly clinics for education, screening and treatment of anemia, HIV, TB, and other predisposing conditions.

REFERENCES

1) Al-Alawi, M., & Sarhan, N. (2014). Prevalence of Anemia Among Nine-month-old Infants Attending Primary Care in Bahrain, Journal of Bahrain Medicine & Social Science, 25 (1): 1 – 4.
2) Al-Dallal, Z. S., & Hussain, K. M. (2011). Impact of the National Flour Fortification Program on the Prevalence of Iron Deficiency and Anemia Among Women at Reproductive Age in the Kingdom of Bahrain, Ministry of Bahrain, Kingdom of Bahrain.
3) Beard, J. L. (2000). Effectiveness and Strategies of Iron Supplementation During Pregnancy, American Journal of Clinical Nutrition, 71 (5): 1288 – 1294.
4) Cunningham, F. G., et al. (2001). Obstetrics, McGraw Hill, New York.
5) Esmat, B., et al. (2010). Prevalence of Iron Deficiency Anemia Among Iranian Pregnant Women: A Systematic Review and Meta Analysis, Journal of Reproductive Infertility, 11 (1): 17 – 24.
6) McLean, E., et al. (2009). Worldwide Prevalence of Anemia, Public Health & Nutrition, 12 (4): 444 – 454.
7) Merza, R., et al. (2014). The Prevalence and Factors Associated with Iron Deficiency Anemia in Anemic Pregnant Women, Bahrain Medical Bulletin, 36 (3): 1 – 9.
8) Nyoni, T (2018b). Modeling and Forecasting Inflation in Kenya: Recent Insights from ARIMA and GARCH analysis, Dimorian Review, 5 (6): 16 – 40.

9) Nyoni, T. (2018a). Modeling and Forecasting Naira/USD Exchange Rate in Nigeria: A Box-Jenkins ARIMA Approach, MPRA Paper No. 88622, University Library of Munich, Munich, Germany.
10) Nyoni, T. (2018c). Box – Jenkins ARIMA Approach to Predicting net FDI inflows in Zimbabwe, MPRA Paper No. 87737, University Library of Munich, Munich, Germany.
11) Ramakrishnan, U. (2001). Functional Consequences of Nutritional Anemia During Pregnancy and Early Childhood, Nutritional Anemia, pp: 43 – 68.