Proceedings of Online International Conference on Advances in Technology, Social Sciences and Humanities
Organized by Novateur Publications, Pune, Maharashtra, India
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN: 2581-4230, Website: journalnx.com, July 11th and 12th 2020.

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

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ABSTRACT
Anemia, a disease caused by a reduction in the hemoglobin levels in the blood, has become a more serious public health problem in Jordan, especially among pregnant women. Using annual time series data on the prevalence of anemia among pregnant women in Jordan from 1990 – 2018, the study attempts to make forecasts for the period 2017 – 2025. The research applies the Box-Jenkins ARIMA methodology. The diagnostic ADF tests show that, AJ the series under consideration is an I (2) variable. Based on the AIC, the study presents the ARIMA (0, 2, 2) model as the best model. The diagnostic tests further show that the presented model is indeed stable and its residuals are not serially correlated and are also normally distributed. The results of the study indicate that the prevalence of anemia among pregnant women in Jordan will rise sharply over the period 2017 – 2025, from about 38% to almost 48.7%. The study, amongst other recommendations, encourages the government of Jordan to intensify its support to pregnant women; especially through the routine supplementations with iron and folate.

1.0INTRODUCTION
Anemia, a condition where the number of red blood cells (RBCs) or the oxygen carrying-capacity of RBCs is insufficient to meet the physiological needs (WHO, 2011); is one of the world's leading causes of hemorrhage and disability (WHO, 2001) and is therefore, one of the most serious global public health problems (Al-Mehaisen et al., 2011). Anemia affects 1.6 billion people worldwide, which corresponds to 24.8% of the total world population (WHO, 2011). In fact, 52% of pregnant women in developing countries are anemic compared to 23% in developed countries (WHO, 2001). In Jordan, the prevalence of anemia among pregnant women has increased over the past decade, from 26% in 2002 to 34% in 2012 (Al-Mehaisen et al., 2011). The negative impact of anemia affects both mother and fetus (Lieberman et al., 1987 & 1988; Klebanoff et al., 1991; Viteri, 1994; Broek, 1998; Lone et al., 2004a; Lone et al., 2004b; Marchant et al., 2004; Lee et al., 2006; Zhang et al., 2009). Anemia in pregnancy is one of the predisposing factors for preterm delivery (Lieberman et al., 1987 & 1988; Godfrey et al., 1991; Marti et al., 2001; Lone et al., 2004a), low birthweight (Lieberman et al., 1987 & 1988; Klebanoff et al., 1991; Godfrey et al., 1991;

ISSN: 2581-4230, Website: journalnx.com, July 11th and 12th 2020.

Viteri, 1994; Broek, 1998; Marti et al., 2001; Brabin et al., 2001; Lone et al., 2004b; Marchant et al., 2004; Lee et al., 2006), still-birth and neonatal death (Lone et al., 2004b; Lee et al., 2006) as well as maternal death (Thangaleela & Vijayalakshmi, 1994; Sukrat & Sirichotiyakul, 2006). Because anemia is the most frequent maternal complication of pregnancy (Godfrey et al., 1991; Al-Mehaisen et al., 2011; Anchang-Kimbi et al., 2017), antenatal care should be concerned about its future prevalence and trends. Therefore, the main goal of this paper is to predict the prevalence of anemia among pregnant women in Jordan over the period 2017 – 2025. Anemia in pregnancy is serious problem in Jordan (Abdo et al., 2019) and therefore requires comprehensive understanding of its current and future prevalence. Hence, the need for this study.

2.0 LITERATURE REVIEW

In a cross-sectional study, Al-Mehaisen et al. (2011) estimated the prevalence and the determinants of anemia among pregnant women in rural Jordan. A cohort of 700 pregnant women from a National Health Service Hospital and 10 health centres completed a questionnaire. The study established that 34.7% of the women were anemic. Mohammad et al. (2012) conducted a cross-sectional study on 1030 pregnant women in the age of 16-40 years for the assessment of their hemoglobin status. The study found out that the prevalence of anemia in pregnancy was approximately 56.7%. In a randomized controlled trial, Abujilban et al. (2018) evaluated the effectiveness of a health information package in Jordanian anemic pregnant women's knowledge regarding anemia, compliance with iron supplementation and hemoglobin level. The results of the study indicated that the health information package program was effective. More recently, Abdo et al. (2019) assessed the prevalence of anemia in Jordan for both sexes at the national level. The research established the prevalence of anemia in pregnant females was approximately 27.4%. While anemia has been widely studied in Jordan, no study has attempted to forecast its prevalence among pregnant women. This paper will bridge this information gap.

3.0 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 the AJ series under consideration.

3.2 The Applied Box – Jenkins ARIMA Model Specification

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

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

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 AJ] in Jordan. 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
AJ	-1.509386	0.5118	-3.737853	@1%	Non-stationary
			-2.991878	@5%	Non-stationary
			-2.635542	@10%	Non-stationary

Table 1 shows that AJ is not stationary in levels.

3.4.2 The ADF Test (at First Differences)

Table 2: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ΔAJ	-0.526990	0.8698	-3.724070	@1%	Non-stationary
			-2.986225	@5%	Non-stationary
			-2.632604	@10%	Non-stationary

Tables 2 indicates that AJ is not an I (1) variable.

3.4.3 The ADF Test (at Second Differences)

Table 3: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
Δ^2AJ	-6.357842	0.0000	-3.737853	@1%	Stationary
			-2.991878	@5%	Stationary
			-2.635542	@10%	Stationary

Table 3 indicates that AJ is an I (2) variable.

3.4.4 Evaluation of ARIMA models (with a constant)

Table 4: Evaluation of ARIMA Models (with a constant)

Model	AIC	U	ME	RMSE	MAPE
ARIMA (1, 2, 1)	-39.26459	0.17551	-0.00031646	0.093878	0.25704
ARIMA (2, 2, 2)	-39.75987	0.15896	0.0004677	0.085228	0.23826
ARIMA (1, 2, 0)	-40.25328	0.18036	-0.00085199	0.095836	0.26352
ARIMA (2, 2, 0)	-39.80956	0.17286	0.0005029	0.092822	0.25242
ARIMA (0, 2, 1)	-39.43812	0.18373	-0.00093342	0.097465	0.26567
ARIMA (0, 2, 2)	**-42.40051**	0.16282	0.0015881	0.08753	0.23152

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 (0, 2, 2) model is finally chosen.

3.5 Residual & Stability Tests

3.5.1 Correlogram of the Residuals of the ARIMA (0, 2, 2) Model

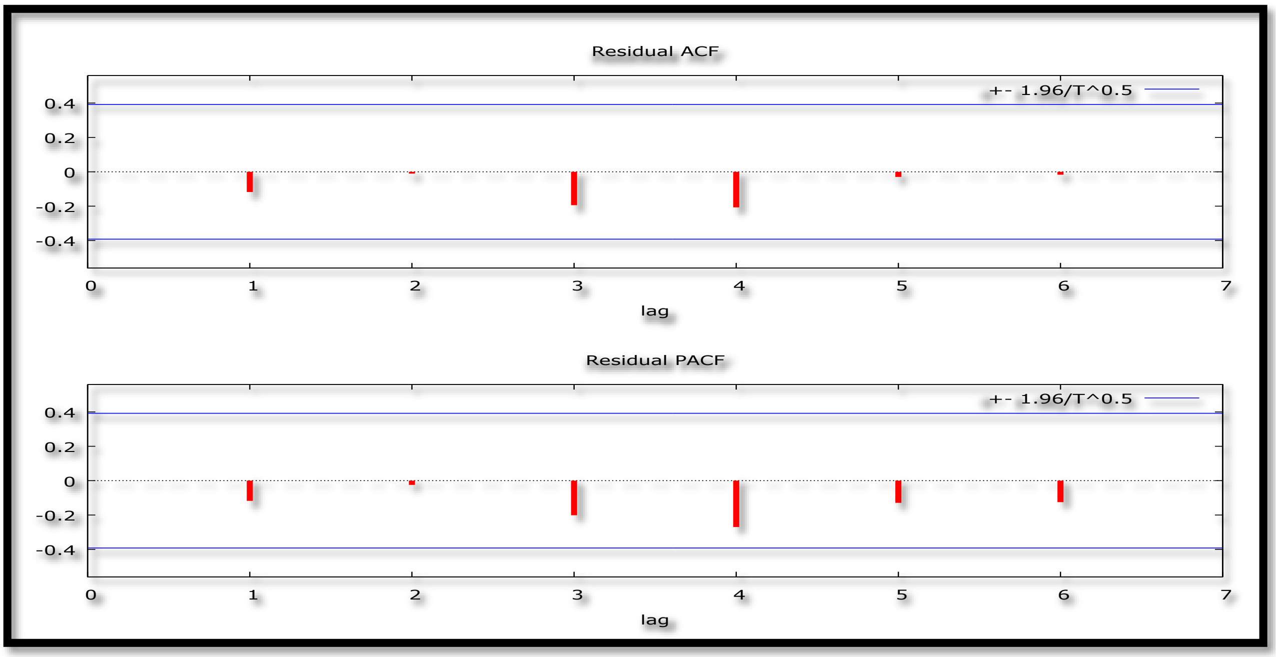

Figure 1: Correlogram of the Residuals

Figure 1 indicates that the estimated optimal model is adequate since ACF and PACF lags are quite short and within the bands. This indicates that the "no autocorrelation" assumption is not violated in this study.

3.5.2 Stability Test of the ARIMA (0, 2, 2) Model

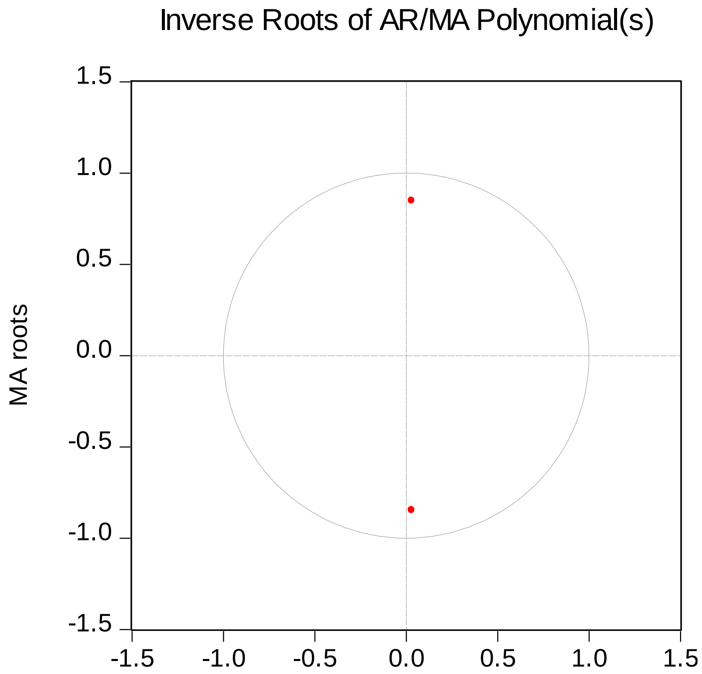

Figure 2: Inverse Roots

Since both MA roots lie inside the unit circle, it implies that the estimated ARIMA process is (covariance) stationary; thus confirming that the ARIMA (0, 2, 2) model is stable.

3.5.3 Normality Test of the Residuals of the ARIMA (0, 2, 2) Model

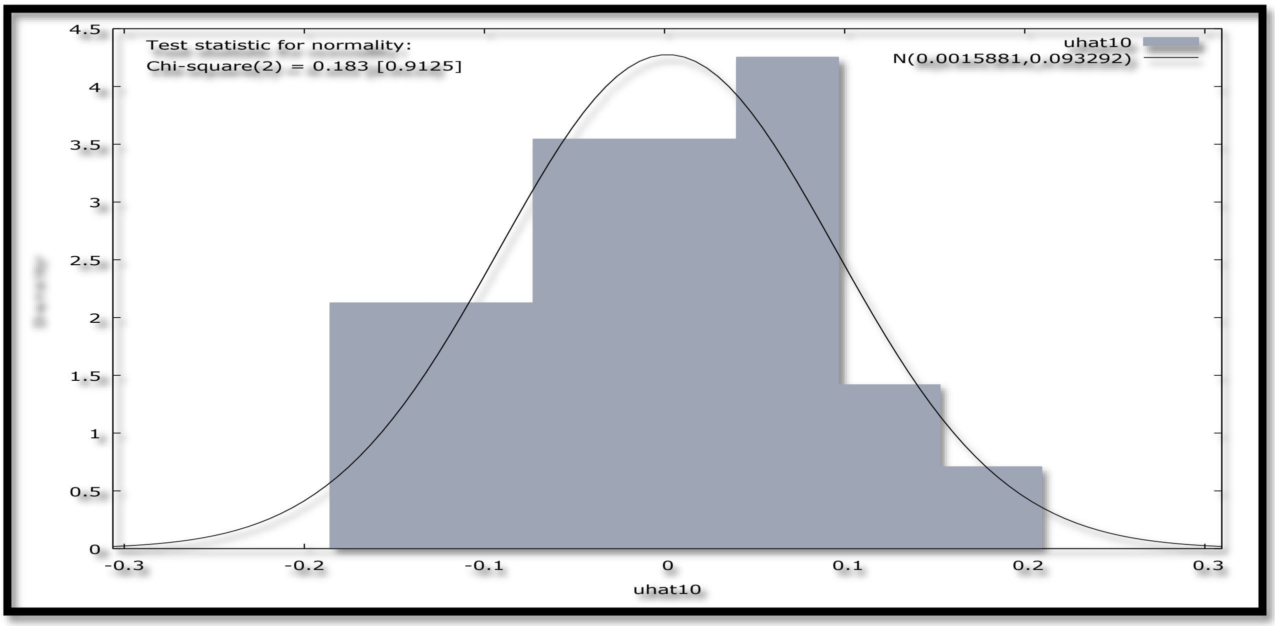

Figure 3: Normality Test

ISSN: 2581-4230, Website: journalnx.com, July 11th and 12th 2020.

Since the probability value of the chi-square statistic is insignificant, we reject the null hypothesis and conclude that the residuals of the ARIMA (0, 2, 2) model are normally distributed.

4.0 FINDINGS OF THE STUDY

4.1 Results Presentation

Table 5: Main Results

ARIMA (0, 2, 2) Model:				
The chosen optimal model, the ARIMA (0, 2, 2) model can be expressed as follows: $\Delta^2 AJ_t = 0.0672706 - 0.0730475\mu_{t-1} + 0.649561\mu_{t-2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$				
Variable	Coefficient	Standard Error	z	p-value
constant	0.0672706	0.0255562	2.632	0.0085***
β_1	-0.0730475	0.186394	-0.3919	0.6951
β_2	0.649561	0.206270	3.149	0.0016***

Table 5 shows the main results of the ARIMA (0, 2, 2) model.

Forecast Graph

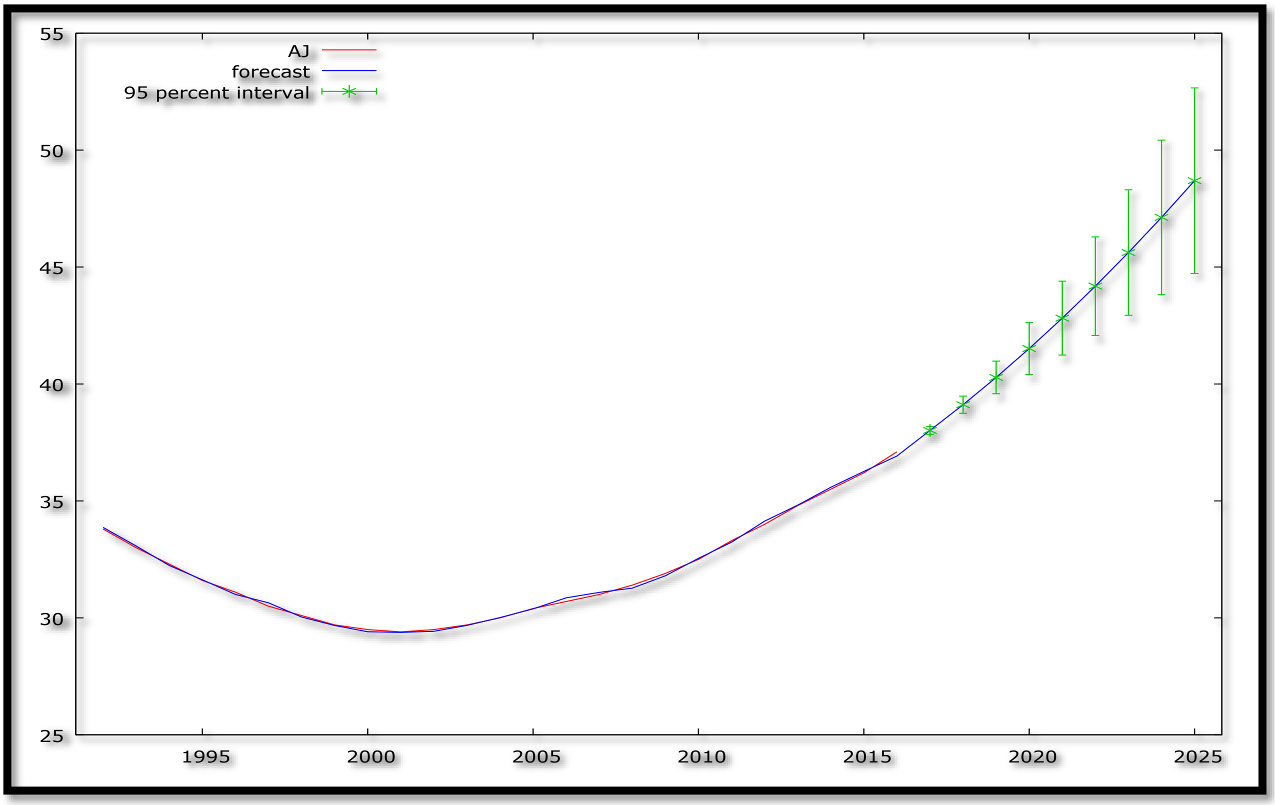

Figure 4: Forecast Graph – In & Out-of-Sample Forecasts

Figure 4 shows the in-and-out-of-sample forecasts of the AJ series. The out-of-sample forecasts cover the period 2017 – 2025.

Predicted AJ– Out-of-Sample Forecasts Only

Table 6: Predicted AJ

Year	Predicted AJ	Standard Error	95% Confidence Interval
2017	38.0145	0.0863877	(37.8452, 38.1838)
2018	39.1139	0.187546	(38.7463, 39.4815)
2019	40.2805	0.356054	(39.5827, 40.9784)
2020	41.5145	0.565121	(40.4069, 42.6221)
2021	42.8157	0.806245	(41.2355, 44.3959)
2022	44.1842	1.07512	(42.0770, 46.2914)
2023	45.6199	1.36894	(42.9368, 48.3030)
2024	47.1229	1.68567	(43.8191, 50.4268)
2025	48.6932	2.02372	(44.7268, 52.6597)

Table 6 shows the out-of-sample forecasts only. The prevalence of anemia in Jordan among women is expected to rise from the estimated 38% in 2017 to approximately 48.7% by 2025. The results of this study are consistent with the scientific observation made by Al-Mehaisen et al. (2011).

5.0 CONCLUSION

The study shows that the ARIMA (0, 2, 2) model is not only stable but also the most suitable model to forecast the prevalence of anemia among women in Jordan over the period 2017 – 2025. The model predicts a significant increase in the prevalence of anemia among pregnant women in Jordan. The study encourages the government of Jordan to intensify its support to pregnant women, especially through the routine supplementations with iron and folate. The government should also increase patient knowledge (Abujilban et al., 2018) about anemia and induce positive attitude towards the disease in order to control anemia in pregnancy in the country. Additionally, there is need for the establishment of women friendly clinics throughout the country so that more women are screened not only for anemia but also for HIV, TB, cervical cancer, breast cancer and other gynecological problems. In this regard, it is important for the government of Jordan to actually increase resource allocation to maternal and child health services. This could potentially reverse the predicted upwards trajectory in the prevalence of anemia.

REFERENCES

[1] Abdo, N., et al. (2019). The Prevalence and Determinants of Anemia in Jordan, East Mediterranean Health Journal, 25 (5): 341 – 349.

[2] Abujilban, S., Hatamleh, R., & Al-Shuqerat, S. (2018). The Impact of a Planned Health Educational Program on the Compliance and Knowledge of Jordanian Pregnant Women With Anemia, Women & Health, pp: 1 – 14.

[3] Al-Mehaisen, L., et al. (2011). Maternal Anemia in Rural Jordan: Room for Improvement, Anemia, pp: 1 – 8.

[4] Anchang-Kimbi, J. K., et al. (2017). Profile of Red Blood Cell Morphologies and Causes of Anemia Among Pregnant Women at First Clinic Visit in the Mount Cameroon Area: A Prospective Cross-sectional Study, BMC Research Notes, 10 (1): 645 – 659.

[5] Brabin, B. J., et al. (2001). An Analysis of Anemia and Pregnancy-related Martenal Mortality, Journal of Nutrition, 131 (2): 604 – 614.

[6] Broek, N. (1998). Anemia in Pregnancy in Developing Countries, British Journal of Obstetrics and Gynecology, 105 (4): 385 – 390.

[7] Godfrey, K. M., et al. (1991). The Effect of Maternal Anemia and Iron Deficiency on the Ratio of Fetal Weight to Placental Weight, British Journal of Obstetrics and Gynecology, 98 (9): 886 – 891.

[8] Klebanoff, M. A., et al. (1991). Anemia and Spontaneous Preterm Birth, Anemia Journal of Obstetrics and Gynecology, 164 (1): 59 – 63.

[9] Lee, H. S., et al. (2006). Iron Status and its Association With Pregnancy Outcomes in Korean Pregnant Women, European Journal of Clinical Nutrition, 60 (9): 1130 – 1135.

[10] Lieberman, E., et al. (1987). Risk Factors Accounting for Racial Differences in the Rate of Premature Birth, The New England Journal of Medicine, 317 (12): 743 – 748.

[11] Lieberman, E., et al. (1988). Association of Maternal Hematocrit With Premature Labor, American Journal of Obstetrics and Gynecology, 159 (1): 107 – 114.

[12] Lone, F. W., Qureshi, R. N., & Emanuel, F. (2004a). Maternal Anemia and its Impact on Perinatal Outcome, Tropical Medicine and International Health, 9 (4): 486 – 490.

[13] Lone, F. W., Qureshi, R. N., & Emmanuel, F. (2004b). Martenal Anemia and its Impact on Perinatal Outcome in a Tertiary Care Hospital in Pakistan, Eastern Mediterranean Health Journal, 10 (6): 801 – 807.

[14] Marchant, T., et al. (2004). Anemia in Pregnancy and Infant Mortality in Tanzania, Tropical Medicine and International Health, 9 (2): 262 – 266.

[15] Marti, A., et al. (2001). Association Between Prematurity and Maternal Anemia in Venezuelan Pregnant Women During Third Trimester at Labor, Nutrition, 51 (1): 44 – 48.

[16] Mohammad, A., Ibrahim, S., & Ibrahim, A. I. (2012). Prevalence of Anemia Among Jordanian Pregnant Women and Effect of Early Pregnancy on Alkaline Phosphatase Activity, Jordan Journal of Biological Sciences, 5 (1): 65 – 70.

[17] Nyoni, T (2018b). Modeling and Forecasting Inflation in Kenya: Recent Insights from ARIMA and GARCH analysis, Dimorian Review, 5 (6): 16 – 40.

[18] 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.
[19] Nyoni, T. (2018c). Box – Jenkins ARIMA Approach to Predicting net FDI inflows in Zimbabwe, MPRA Paper No. 87737, University Library of Munich, Munich, Germany.
[20] Sukrat, B., & Sirichotiyakul, S. (2006). The Prevalence and Causes of Anemia During Pregnancy in Maharaj Nakorn Chiang Mai Hospital, Journal of the Medical Association of Thailand, 89: 142 – 146.
[21] Thangaleela, T., & Vijayalakshmi, S. (1994). Prevalence of Anemia in Pregnancy, Indian Journal of Nutrition and Dietetics, 31: 26 – 32.
[22] Viteri, F. E. (1994). The Consequences of Iron Deficiency and Anemia in Pregnancy on Maternal Health, the Foetus and the Infant, SCN News, 11: 14 – 18.
[23] WHO (2001). Iron Deficiency Anemia, WHO, Geneva.
[24] WHO (2011). Hemoglobin Concentrations for the Diagnosis of Anemia and Assessment of Severity, WHO, Geneva.
[25] Zhang, Q., et al. (2009). Maternal Anemia and Preterm Birth: A Prospective Cohort Study, International Jurnal of Epidemiology, 38 (5): 1380 – 1389.