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

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ABSTRACT:

Using annual time series data on the prevalence of anemia among pregnant women in Nigeria from 1990 – 2018, the study endeavors to make forecasts for the period 2017 – 2025. The study applies the Box-Jenkins ARIMA methodology. The diagnostic ADF tests show that, Y, the series under consideration is an I (2) variable. Based on the AIC, the study presents the ARIMA (0, 2, 1) model as the best model. The diagnostic tests further reveal that the presented model is quite 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 Nigeria is likely to decline from 57.5% in 2017 to approximately 54.1% by 2025. This clearly shows that anemia among pregnant women in the country will remain a big challenge even within the next five years. In order to address this challenge, there is need for the federal government of Nigeria to increase its commitment towards iron supplementation during pregnancy, especially for women of low economic status.

1.0 INTRODUCTION:

Anemia in pregnancy, a commonest complication worldwide, is a leading cause of maternal and perinatal morbidity and mortality especially in developing countries. It is a medical condition that is usually preventable through public health interventions, which are often feasible and cost-effective (Ogu & Ikimalo, 2018). Anemia in pregnancy is defined as hemoglobin concentration less than 11g/dl. More than 50% of pregnant women in the world have hemoglobin level indicative of anemia (WHO, 2015). The prevalence of anemia in Nigeria ranges from 76% in Abeokuta (Idowu et al., 2005), 67.7 in Enugu (Iloabachie & Meniru, 1990), 56.1% in Bayelsa (Oboro et al., 2002) to 51.4% in Ibadan (Aimakhu & Olayemi, 2003). Accounting for 75-95% of cases of anemia in pregnancy, iron deficiency is the most common cause of anemia in pregnancy (Halimi et al., 2011). The high physiological requirement for iron in pregnancy is difficult to meet with most diets; this is so especially in developing countries such as Nigeria where food requirement is a problem (Ogu & Ikimalo, 2018). The main purpose of this research is to predict the prevalence of anemia among pregnant women in Nigeria over the period 2017 – 2025.

2.0 RELATED STUDIES:

Nwizu et al. (2011) studied the prevalence of anemia at booking and underlying factors in a teaching hospital in Northern Nigeria. The packed red cell volume (PCV) and red cell morphology of 300 pregnant women was determined using the capillary technique and the blood film. Using an interviewer administered questionnaire, additional information on socio-demographic characteristics, obstetric and past medical history was obtained. The results of the study indicate that the high prevalence of anemia in pregnancy among the study participants was related to low educational and economic status. Consistently, Ogu & Ikimalo (2018) sought to ascertain the prevalence of anemia in pregnancy, the impact of hematinics supplementation on maternal anemia prevalence, and the effect of maternal anemia on fetal outcomes at the University of Port Harcourt Teaching Hospital, in South-South Nigeria. The study was a prospective study of 430 pregnant women attending the antenatal clinic at the University of Port Harcourt Teaching Hospital. Participants were consecutive patients with singleton pregnancies booking for antenatal care who gave consent to be recruited for the study. Participants were enrolled at their booking antenatal visit and monitored through pregnancy till delivery. Hemoglobin concentration was used to assess the level of anemia. The study established that anemia in pregnancy was still a huge problem in Nigeria and that the incidence of low birth weight babies and preterm deliveries in women with anemia in pregnancy was statistically different from that of parturients with normal hemoglobin levels. There is a dearth in literature in Nigeria when it comes to studies forecasting the prevalence of anemia. It is this information gap that this paper will fill with regards to the anemia among pregnant women in the country.

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, Y, the series under consideration.

3.2 The Applied Box – Jenkins ARIMA Model Specification

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

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

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 Y] in Nigeria. 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
Y	5.870596	1.0000	-3.711457	@1%	Non-stationary
			-2.981038	@5%	Non-stationary
			-2.629906	@10%	Non-stationary

Table 1 shows that Y 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
ΔY	-1.552208	0.4907	-3.737853	@1%	Non-stationary
			-2.991878	@5%	Non-stationary
			-2.635542	@10%	Non-stationary

Table 2 shows that Y also not stationary even in first differences.

3.4.3 The ADF Test (at Second Differences)

Table 3: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
Δ^2Y	-8.369731	0.0000	-3.737853	@1%	Stationary
			-2.991878	@5%	Stationary
			-2.635542	@10%	Stationary

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

3.4.8 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)	-73.48994	0.2521	-0.0026121	0.047893	0.068564
ARIMA (2, 2, 2)	-70.61802	0.24664	-0.0021095	0.046827	0.065459
ARIMA (1, 2, 0)	-73.63011	0.26242	-0.001628	0.049601	0.072293
ARIMA (2, 2, 0)	-74.19398	0.24861	-0.0024363	0.047238	0.066224
ARIMA (0, 2, 1)	**-74.88395**	0.2544	-0.0030165	0.048324	0.06587
ARIMA (0, 2, 2)	-73.82215	0.25081	-0.0021216	0.047617	0.068983
ARIMA (3, 2, 0)	-72.19666	0.24857	-0.002453	0.047236	0.066162

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, 1) model is finally chosen.

3.5 Residual & Stability Tests

3.5.1 Correlogram of the Residuals of the ARIMA (0, 2, 1) Model

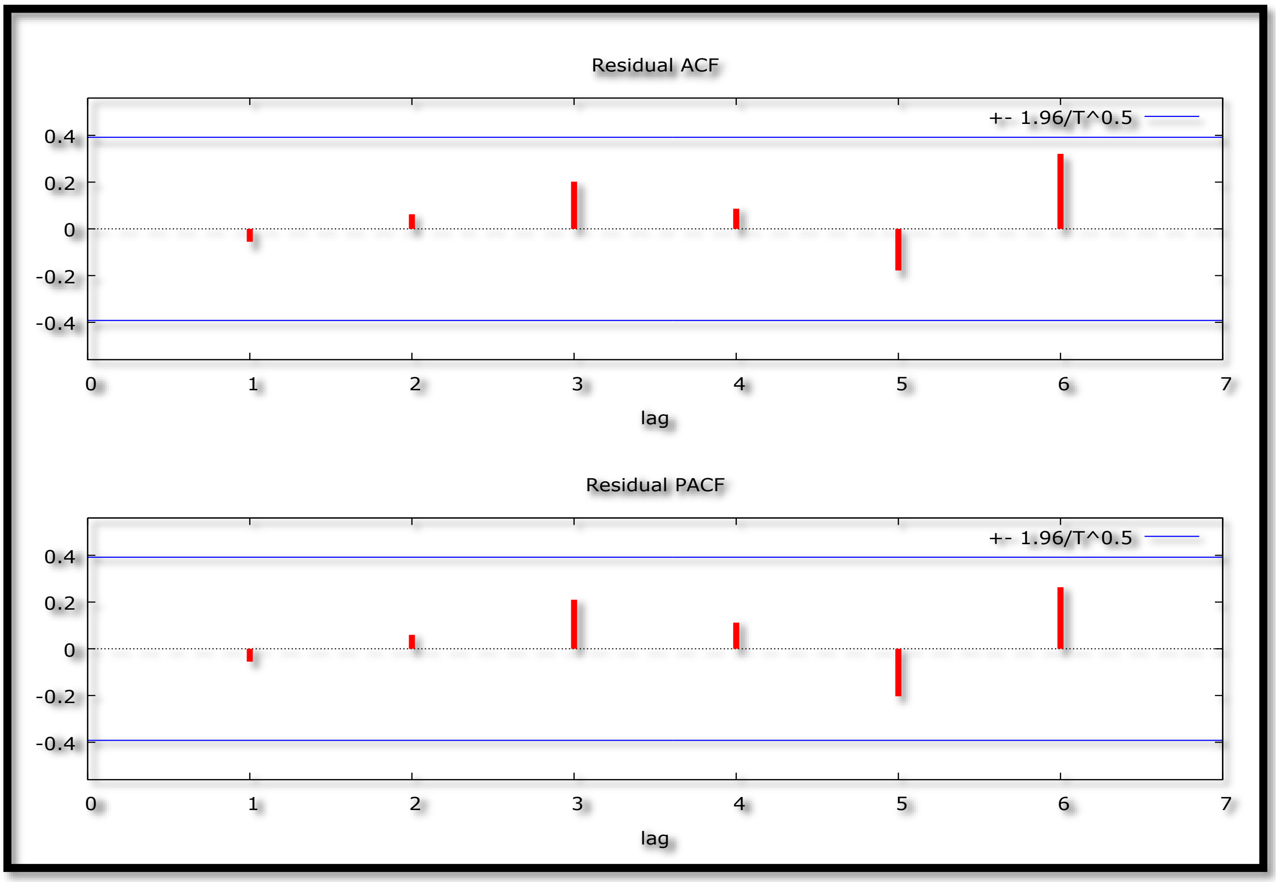

Figure 1: Correlogram of the Residuals

Figure 1 indicates that the estimated optimal ARIMA (0, 2, 1) model is adequate since ACF and PACF lags are quite short and within the bands. This implies that the "no autocorrelation" assumption is not violated in this paper.

3.5.2 Stability Test of the ARIMA (0, 2, 1) Model

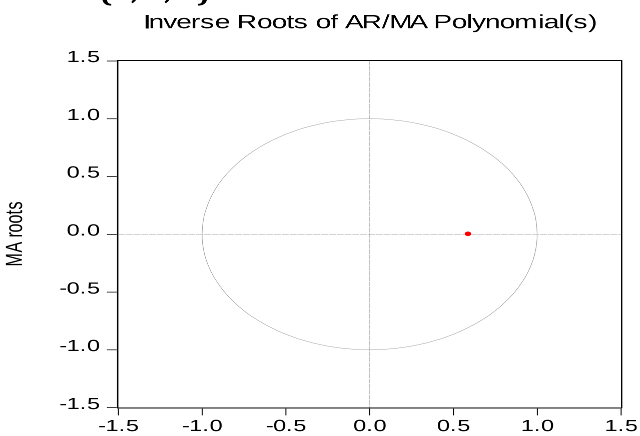

Figure 2: Inverse Roots

Since the MA root lies inside the unit circle, it implies that the estimated ARIMA process is (covariance) stationary; thus confirming that the ARIMA (0, 2, 1) model is stable.

3.5.3 Normality Test of the Residuals of the ARIMA (0, 2, 1) Model

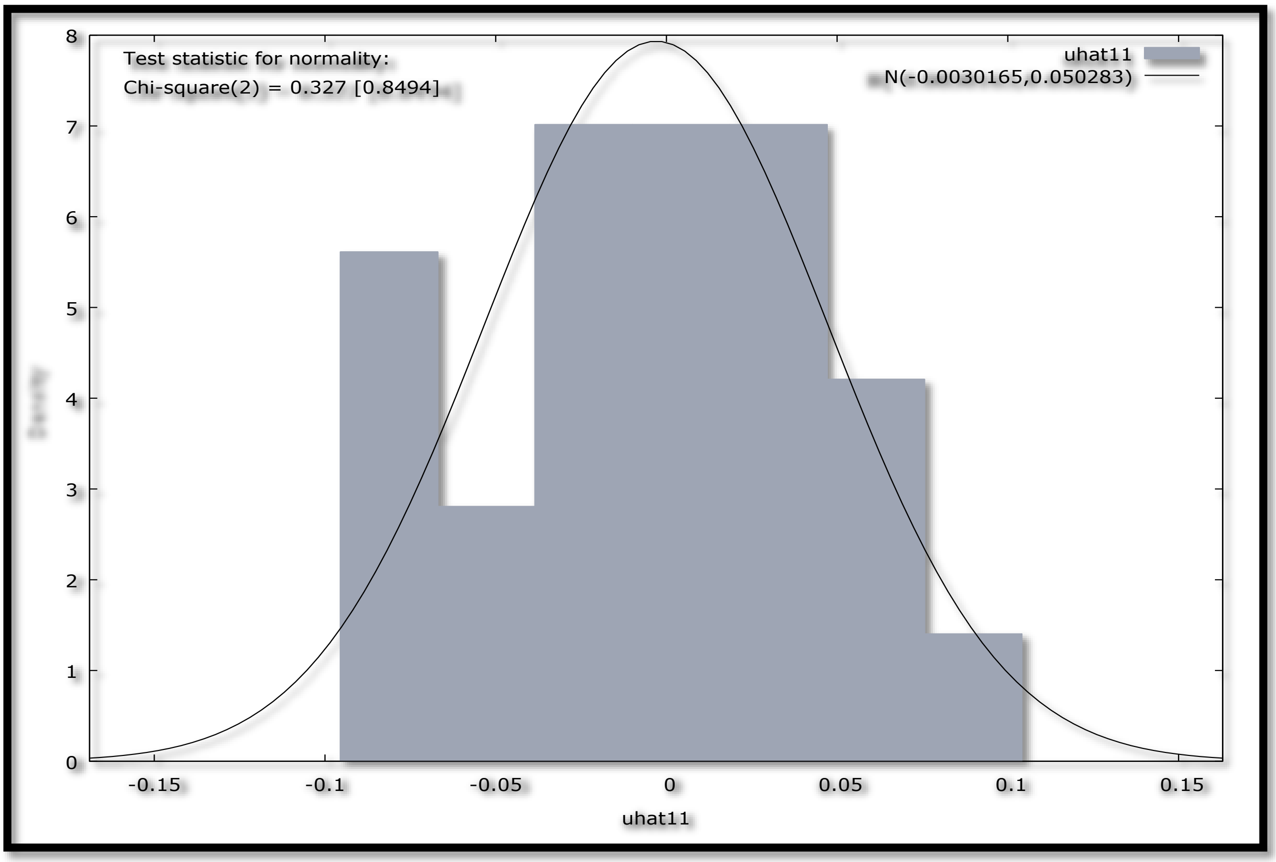

Figure 3: Normality Test

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, 1) model are normally distributed.

4.0 FINDINGS OF THE STUDY:

4.1 Results Presentation

Table 5: Main Results

ARIMA (0, 2, 1) Model:				
The chosen optimal model, the ARIMA (0, 2, 1) model can be expressed as follows: $\Delta^2 Y_t = -0.0187732 - 0.568983\mu_{t-1}$ … . . … . . [2]				
Variable	Coefficient	Standard Error	z	p-value
constant	-0.0187732	0.00433528	-4.33	0.0000***
α_1	-0.568983	0.172322	-3.302	0.001***

Table 5 shows the main results of the ARIMA (0, 2, 1) model.

Forecast Graph

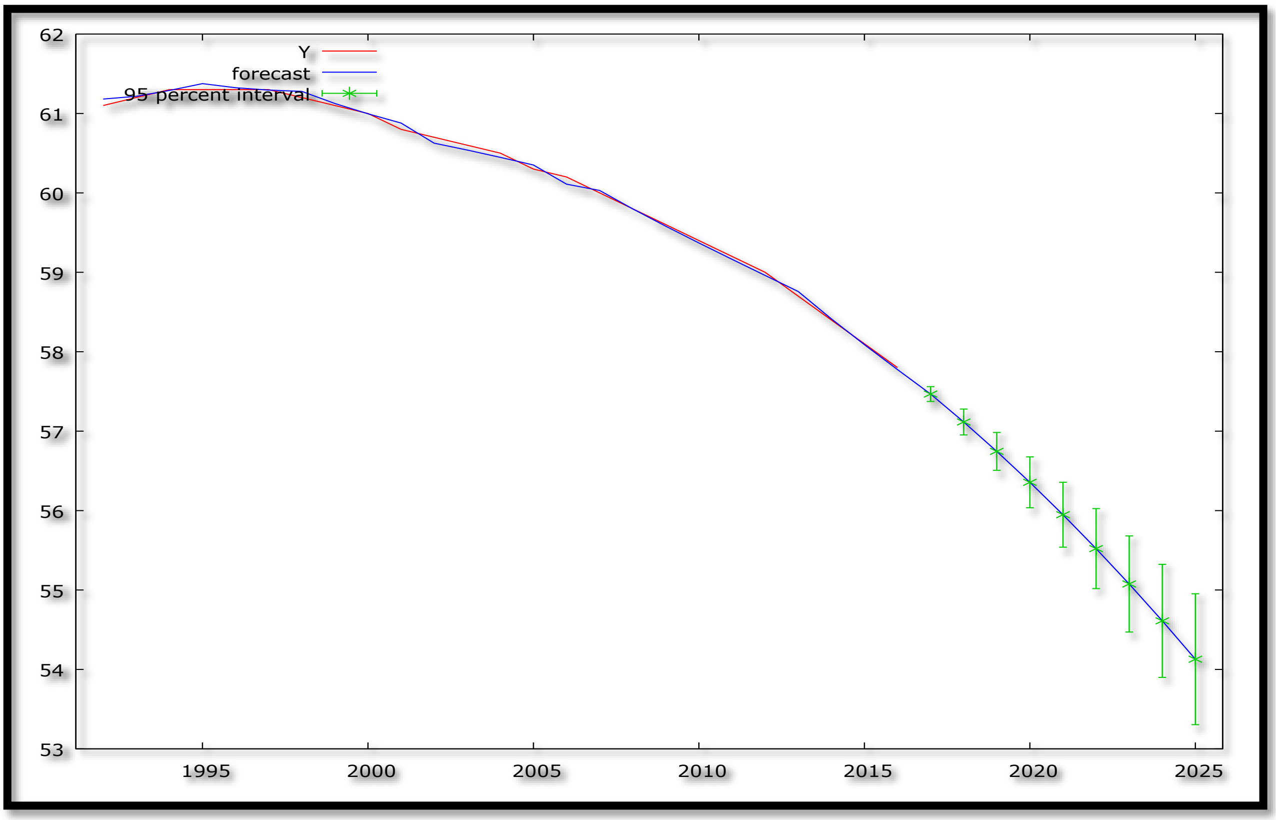

Figure 4: Forecast Graph – In & Out-of-Sample Forecasts

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

Predicted Y– Out-of-Sample Forecasts Only

Table 6: Predicted Y

Year	Predicted Y	Standard Error	95% Confidence Interval
2017	57.4672	0.0476229	(57.3738, 57.5605)
2018	57.1156	0.0831400	(56.9526, 57.2786)
2019	56.7452	0.121555	(56.5070, 56.9835)
2020	56.3561	0.163403	(56.0358, 56.6764)
2021	55.9482	0.208639	(55.5393, 56.3571)
2022	55.5215	0.257112	(55.0176, 56.0255)
2023	55.0761	0.308662	(54.4711, 55.6810)
2024	54.6118	0.363140	(53.9001, 55.3236)
2025	54.1288	0.420410	(53.3049, 54.9528)

Table 6 shows the out-of-sample forecasts only. Despite the fact that anemia in pregnancy still causes significant maternal morbidity and mortality in Nigeria (Nwizu et al., 2011), the prevalence of anemia in Nigeria among pregnant women is projected to decline from about 57.5% in 2017 to almost 54.1% in around 2025.

5.0 CONCLUSION:

The study shows that the ARIMA (0, 2, 1) model is not only stable but also the most suitable model to forecast the prevalence of anemia in Nigeria among pregnant women over the period 2017 to 2025. The model predicts a commendable decrease in the prevalence of anemia among pregnant women in the country. However, the prevalence of anemia in Nigeria among pregnant women, remains unacceptably high. The forecasts of this study point to the need for iron supplementation during pregnancy for reproductive women in the country. Additionally, the government of Nigeria ought to establish women-friendly clinics around the country for anemia screening of all reproductive women (pregnant and non-pregnant). Furthermore, there is need for strengthening TB/HIV treatment programme collaborations to ensure that all HIV positive mothers are initiated on ART and regular screening.

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