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

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

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

Abstract:

The prevalence of anemia in Indian pregnant women is amongst the highest in the world. Using annual time series data on the prevalence of anemia among pregnant women in India from 1990 – 2018, the study endeavors to make forecasts for the period 2017 – 2025. The study applies the Box-Jenkins ARIMA technique. The diagnostic ADF tests show that, X, the series under consideration is an I (2) variable. Based on the AIC, the study presents the ARIMA (1, 2, 0) model as the best model. The diagnostic tests further show that the presented model is really stable and its residuals are not serially correlated and are also normally distributed. The results of the study indicate that the prevalence of anemia in India among pregnant women will decrease by only 1% over the out-of-sample period. Indeed, anemia in pregnant women will remain a serious challenge in India over the period 2017 – 2025 and even beyond. There is need for continued iron supplementation during pregnancy for reproductive women in the country.

1.0INTRODUCTION

Anemia is a condition where the red blood cell number or their oxygen-carrying capacity is insufficient to meet physiological needs, and is conventionally taken as a hemoglobin (Hb) value that is less than two standard deviation (SD) below the median value for healthy matched population by age, sex, attitude, smoking, and pregnancy status (Stevens et al., 2013). Anemia in pregnancy is defined as Hb values less than 11gm/dl (CDC, 1989; WHO, 2001). Any patient with a Bb of less than 11gm/dl to 11.5gm/dl at the start of pregnancy is treated as anemic. The reason is that as the pregnancy progresses, the blood is (naturally) diluted and the woman will eventually become anemic (Chowdhury et al., 2014). Approximately 20% of pregnant women in the world suffer anemia, and most of the cases are iron deficiency, folic acid deficiency, or both (Kozuma, 2009). The prevalence of anemia in developed and developing countries in pregnant women is 14% and 51%, respectively; and 65-75% in India. Prevalence of anemia in all the groups is higher in India as compared to other developing countries (Kalaivani, 2009). Martenal anemia contributes to 18% of perinatal mortality and 20% of maternal mortality in South Asian countries including India

(Rahman et al., 2016). The main objective of this study is to predict the prevalence of anemia among pregnant women in India over the period 2017 – 2025.

2.0 LITERATURE REVIEW

In a review article, Sabina et al. (2015) analyzed anemia in pregnancy amongst Indian women. In the paper, the authors basically averred that since iron and folic acid, in amounts necessary for the fetus are transported to the fetus, the mother is likely to develop iron deficiency anemia as well as folic acid deficiency anemia. Tomar et al. (2017) analyzed the epidemiology and determinants of anemia in pregnancy in a rural area in India. All pregnant women visiting the Obstetrics and Gynaecology Out-patients Department at Index Medical College Hospital, from 1 June 2015 and 31 December 2015 were examined by recording predesigned and structured history of pregnant women with total hemoglobin concentration. Hemoglobin estimation was done using Sahli's method. The study established that the prevalence of anemia among the pregnant women under consideration was approximately 82.9%. In another review article, Tandon et al. (2018) studied the management of iron deficiency anemia in pregnancy in India and finally suggested the use of an algorithm for diagnosis and treatment of iron deficiency anemia 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, X, the series under consideration.

3.2 The Applied Box – Jenkins ARIMA Model Specification

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

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

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 X] in India. 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
X	-1.129581	0.6867	-3.737853	@1%	Non-stationary
			-2.991878	@5%	Non-stationary
			-2.635542	@10%	Non-stationary

Table 1 shows that X 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
ΔX	-1.704805	0.4162	-3.737853	@1%	Non-stationary
			-2.991878	@5%	Non-stationary
			-2.635542	@10%	Non-stationary

According to table 2, X 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
$\Delta^2 X$	-8.633803	0.0000	-3.737853	@1%	Stationary
			-2.991878	@5%	Stationary
			-2.635542	@10%	Stationary

Tables 3 indicates that X is an I (2) variable.

3.4.4 Evaluation of ARIMA models (without a constant)

Table 4: Evaluation of ARIMA Models (without a constant)

Model	AIC	U	ME	RMSE	MAPE
ARIMA (1, 2, 1)	-57.7055	0.36665	-0.013236	0.068079	0.11131
ARIMA (2, 2, 2)	-55.10276	0.35718	-0.011286	0.066203	0.10514
ARIMA (1, 2, 0)	**-59.37753**	0.3695	-0.014552	0.068515	0.1099
ARIMA (2, 2, 0)	-57.81949	0.36573	-0.01219	0.067924	0.11126
ARIMA (0, 2, 1)	-56.53769	0.39164	-0.015812	0.07224	0.12063
ARIMA (0, 2, 2)	-56.68375	0.37428	-0.010857	0.069328	0.11345

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 (1, 2, 0) model is finally chosen.

3.5 Residual & Stability Tests

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

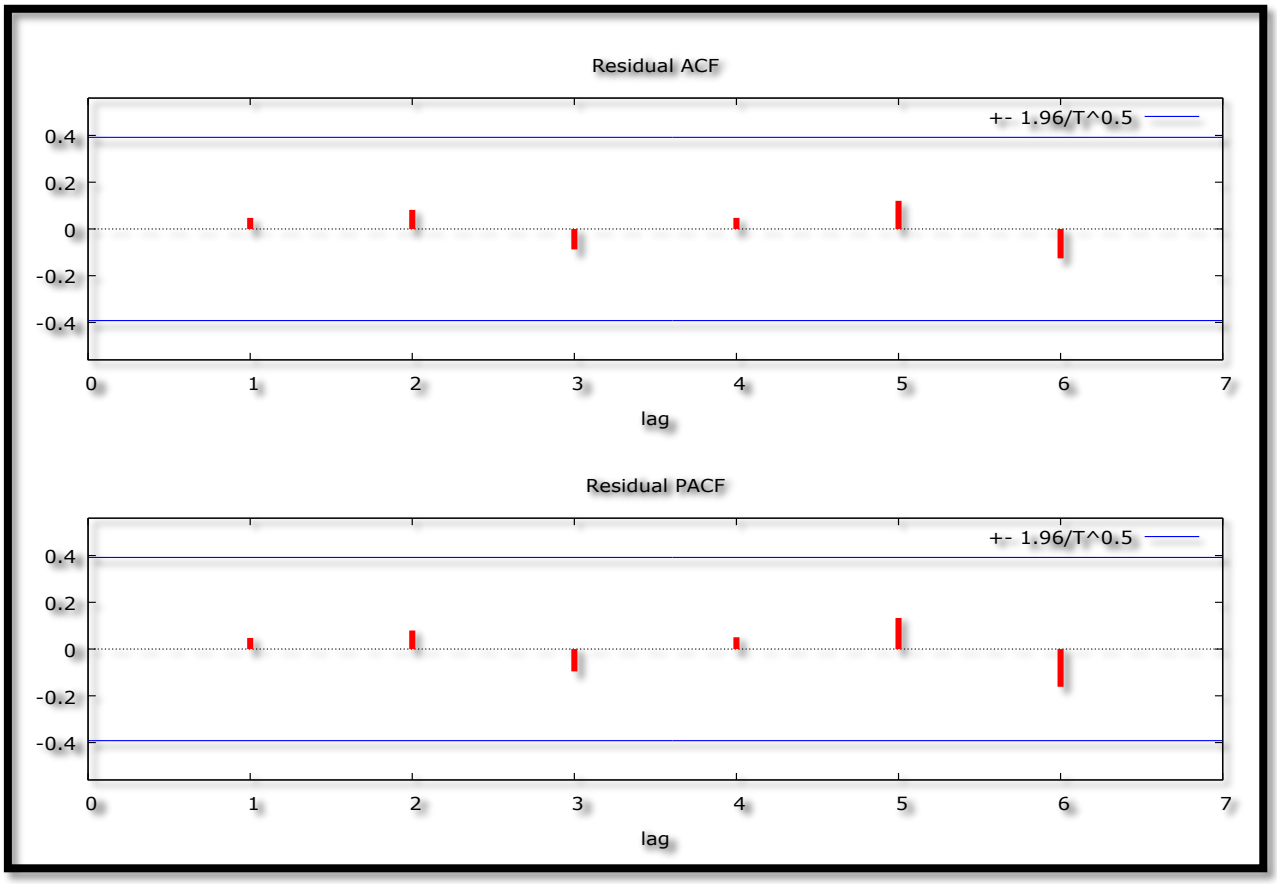

Figure 1: Correlogram of the Residuals

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

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

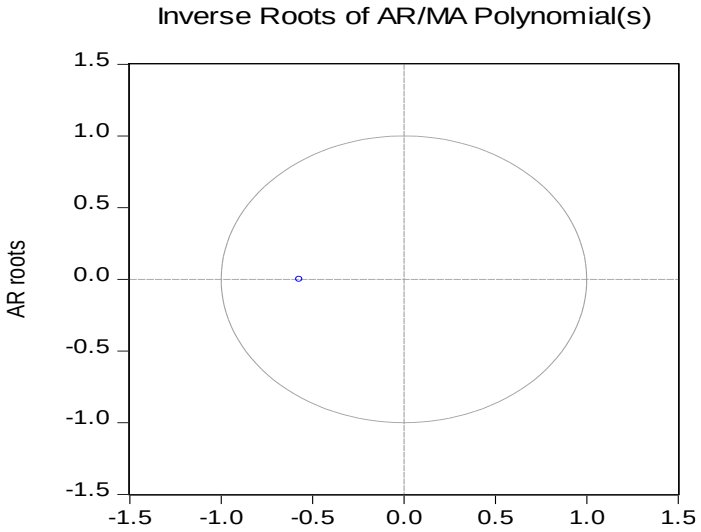

Figure 2: Inverse Roots

Since all the AR root lies inside the unit circle, it means that the estimated ARIMA process is (covariance) stationary; thus confirming that the ARIMA (1, 2, 0) model is really stable and suitable for forecasting annual number of people practicing open defecation in Lesotho.

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

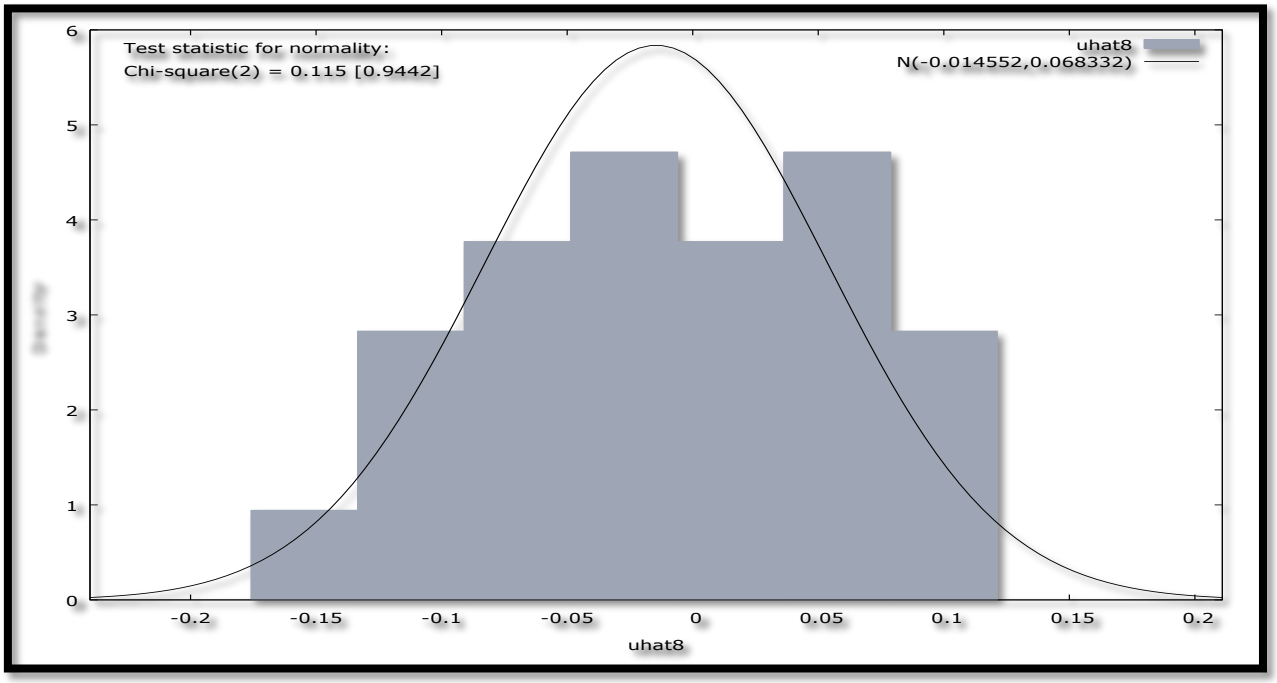

Figure 3: Normality Test

Since the probability value of the chi-square statistic is insignificant, we reject the null hypothesis and conclude that the residuals of the ARIMA (1, 2, 0) model are normally distributed.

4.0 FINDINGS OF THE STUDY

4.1 Results Presentation

Table 5: Main Results

ARIMA (1, 2, 0) Model:

The chosen optimal model, the ARIMA (1, 2, 0) model can be expressed as follows:

$$\Delta^2 X_t = -0.546007\Delta^2 X_{t-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

Variable	Coefficient	Standard Error	z	p-value
β_1	-0.546007	0.174643	-3.126	0.0018***

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

Forecast Graph

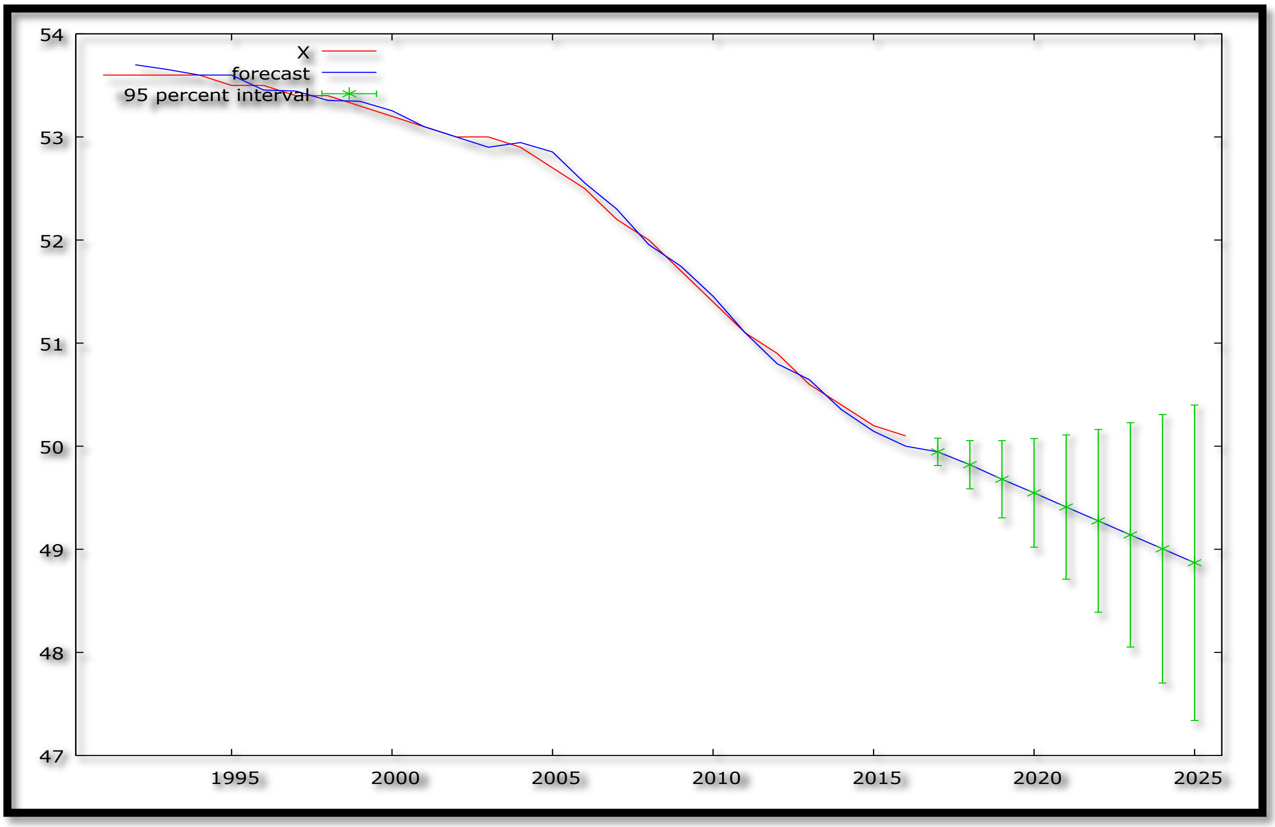

Figure 4: Forecast Graph – In & Out-of-Sample Forecasts

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

Predicted X– Out-of-Sample Forecasts Only

Table 6: Predicted X

Year	Predicted X	Standard Error	95% Confidence Interval
2017	49.9454	0.0676391	(49.8128, 50.0780)
2018	49.8206	0.119361	(49.5867, 50.0546)
2019	49.6795	0.191085	(49.3050, 50.0541)
2020	49.5474	0.268822	(49.0205, 50.0742)
2021	49.4103	0.357029	(48.7106, 50.1101)
2022	49.2760	0.452219	(48.3896, 50.1623)
2023	49.1401	0.555105	(48.0521, 50.2281)
2024	49.0051	0.664539	(47.7026, 50.3076)
2025	48.8696	0.780461	(47.3399, 50.3993)

Table 6 shows the out-of-sample forecasts only. The prevalence of anemia in India among pregnant women is forecasted to decrease slightly from the estimated 49.9% in 2017 to nearly 48.9% by 2025. Anemia in pregnant women in the country is persistant and will remain high over the years (Tomar et al., 2017; Tandon et al., 2018).

5.0 CONCLUSION

The paper shows that the ARIMA (1, 2, 0) model is not only stable but also the most suitable model to forecast the prevalence of anemia in India among pregnant women over the period 2017 – 2025. The model predicts a small decrease (approximately 1%) in the annual prevalence of anemia among women in the country. The predictions of this study point to the need for iron supplementation during pregnancy for reproductive women in India. Furthermore, public awareness programs such as the "National Anemia Awareness and Treatment Day" (Tandon et al., 2018) ought to be prioritized in the country. Furthermore, the Indian government ought to also strengthen HIV/TB program collaboration in order to win in the fight against anemia in pregnancy.

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