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

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ABSTRACT:

Anemia in pregnancy is a serious public health problem resulting in high maternal morbidity and mortality especially in developing countries such as Ethiopia. Using annual time series data on the prevalence of anemia among pregnant women in Ethiopia from 1990 – 2018, the study attempts to make forecasts for the period 2017 – 2025. The study applied the Box-Jenkins ARIMA methodology. The diagnostic ADF tests show that, AB, the series under consideration is an I (2) variable. Based on the AIC, the study presents the ARIMA (1, 2, 0) model as the optimal model. The diagnostic tests further indicate that the presented model is quite stable and its residuals are not serially correlated and are also normally distributed. The results of the study show that the prevalence of anemia among pregnant women in Ethiopia will rise over the out-of-sample period. The study, amongst other recommendations, encourages the government of Ethiopia to expand coverage of its support to pregnant women, particularly through the routine supplementations with iron and folate. Furthermore, reproductive women should be educated about anemia in pregnancy.

INTRODUCTION:

Anemia is defined as hemoglobin concentration which is less than 11g/dL (WHO, 2014). Even if anemia is a worldwide public health problem affecting numerous people in all age groups, particularly the burden of the problem is higher among pregnant women (Akhtar & Hassan, 2012), especially those who live in developing countries such as Ethiopia. In fact, 1.62 billion people in the world are anemic, of these, 56 million anemia cases are found in women (Balarajan et al., 2011). Worldwide, anemia contributes to at least 115000 maternal deaths and 591000 prenatal deaths per year (Salhan et al., 2012). In Africa, at least 51.7% of pregnant women are anemic (WHO, 2008). In Ethiopia, with an overall prevalence of approximately 62.7% (WHO, 2011; Gebre & Mulugeta, 2015; Ayano & Amentie, 2018); anemia remains a major public health problem, which causes maternal and fetal severe consequences (Berhe et al., 2019). The main purpose of this study is to predict the prevalence of anemia among pregnant women in Ethiopia over the period 2017 – 2025. This study is important in the sense that public health policy makers will use the findings to design appropriate interventions to reduce the high burden of the disease, now, as well as in future.

LITERATURE REVIEW:

In a systematic review and meta-analysis, Kassa et al. (2017) analyzed the prevalence and determinants of anemia in Ethiopia and found out that about one-third of pregnant women in the country were anemic. These results have also been confirmed by Serbesa & Iffa (2018) whose study assessed the knowledge, attitude and practice of pregnant women with regard to prevention of iron deficiency anemia in public hospitals of Harar, Eastern Ethiopia. Kassa et al. (2017) also found out that Malaria infections and gravidity were shown to be some of the main factors causing anemia in the country. In an institutional based cross-sectional study, Zekarias et al. (2017) examined the prevalence and determinants of anemia among pregnant women attending antenatal care (ANC) in Mizan Tepi University Teaching Hospital, South West Ethiopia; from April 3 to May 3 2017. Bivariate and multivariate logistic regression was applied. The study established that the overall prevalence of anemia was 23.5%. In a recent hospital-based cross-sectional study, Berhe et al. (2019) determined the prevalence and associated factors of anemia in Adigrat General Hospital. A multivariate logistic regression was applied. The results of the study indicate that the prevalence of anemia among pregnant women under the study was 7.9%. No forecasting studies have been done in the country with regards to predicting anemia in pregnancy. This paper will be the first of its kind in Ethiopia.

METHODODOLOGY:

3.1 The Box – Jenkins (1970) Methodology:

The first step towards model selection is to difference the series in order to achieve stationary. 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 judgment 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, AB, the series under consideration.

3.2 The Applied Box – Jenkins ARIMA Model Specification:

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

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

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 AB] in Ethiopia. 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
AB	-1.553893	0.4899	-3.737853	@1%	Non-stationary
			-2.991878	@5%	Non-stationary
			-2.635542	@10%	Non-stationary

Table 1 shows that AB 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
ΔAB	-1.181634	0.6658	-3.724070	@1%	Non-stationary
			-2.986225	@5%	Non-stationary
			-2.632604	@10%	Non-stationary

Table 2 shows that AB 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^2AB	-6.968621	0.0000	-3.737853	@1%	Stationary
			-2.991878	@5%	Stationary
			-2.635542	@10%	Stationary

Table 3 indicates that AB 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)	-47.80291	0.4788	0.024176	0.082308	0.14566
ARIMA (1, 2, 0)	-49.71115	0.47985	0.025118	0.08247	0.14331
ARIMA (2, 2, 0)	-47.86316	0.47806	0.023196	0.082197	0.14701
ARIMA (0, 2, 1)	-49.17551	0.48541	0.026031	0.083421	0.14558

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 eventually chosen.

3.5 Residual & Stability Tests:

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

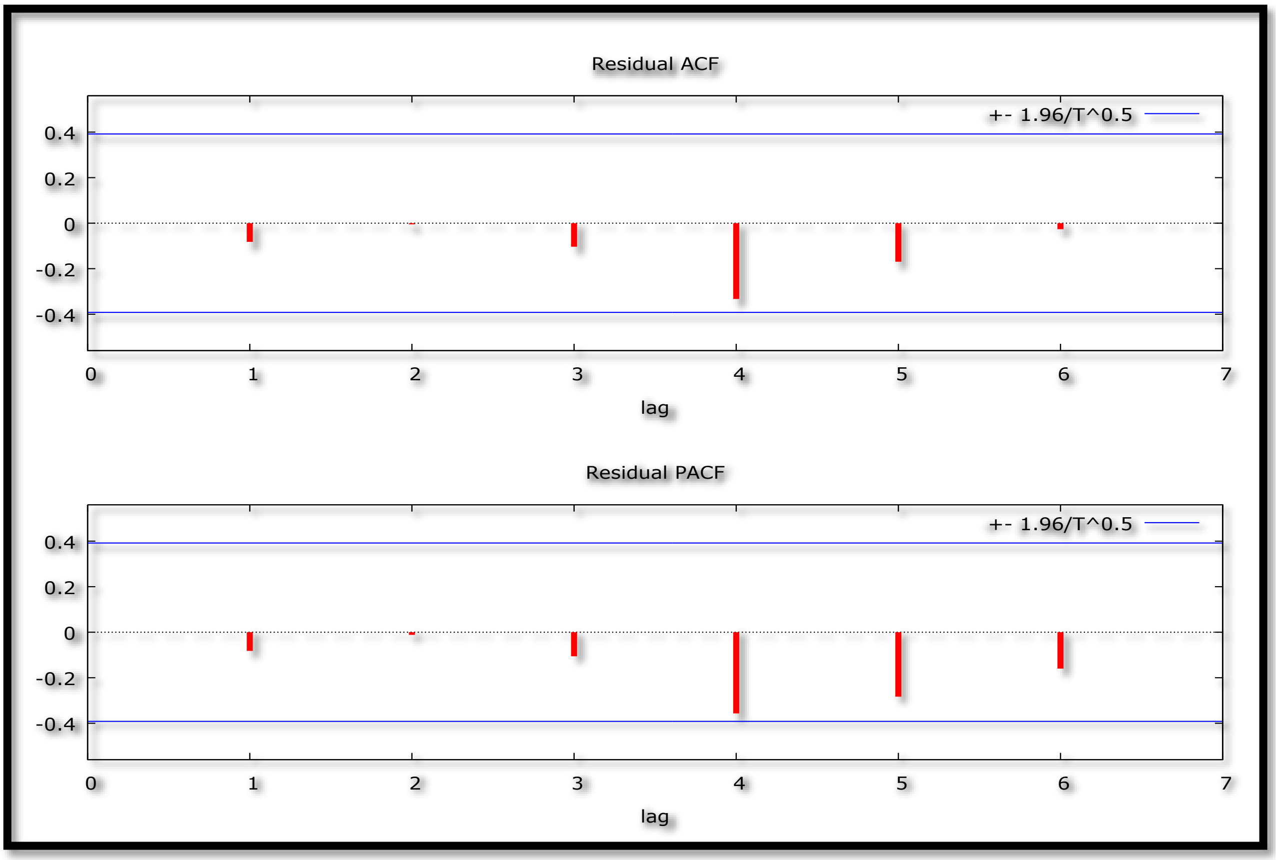

Figure 1: Correlogram of the Residuals

Figure 1 indicates that the estimated optimal ARIMA (1, 2, 0) model is adequate since ACF and PACF lags are quite short and within the bands.

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

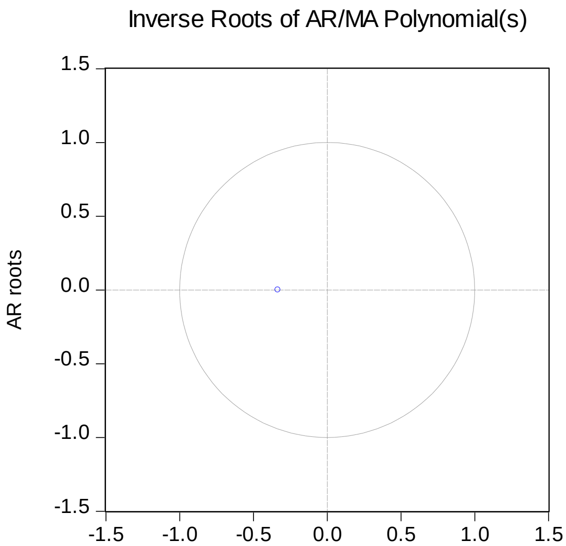

Figure 2: Inverse Roots

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

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

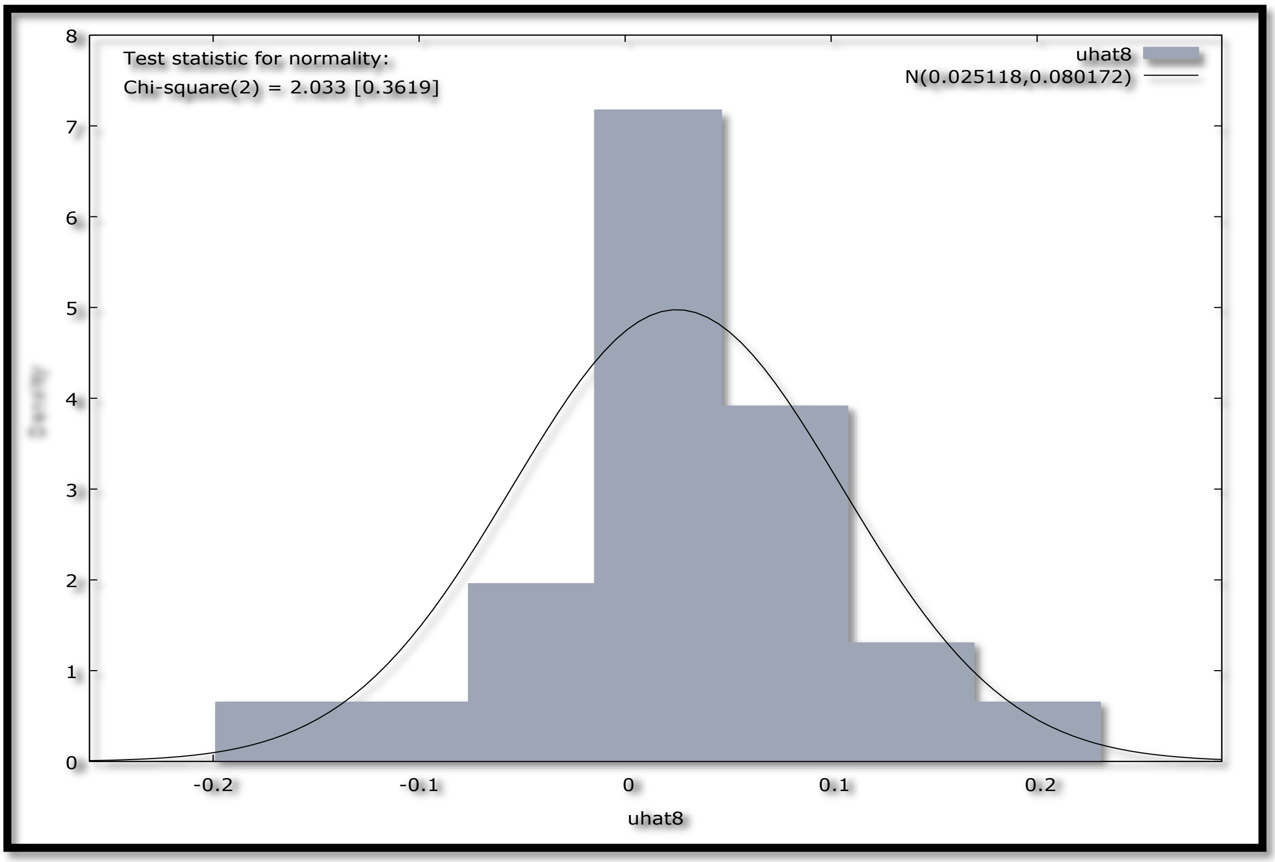

Figure 3: Normality Test

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.

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: $\Delta^2 AB_t = -0.319869\Delta^2 AB_{t-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$				
Variable	Coefficient	Standard Error	z	p-value
β_1	-0.319869	0.194384	-1.646	0.0999*

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

Forecast Graph

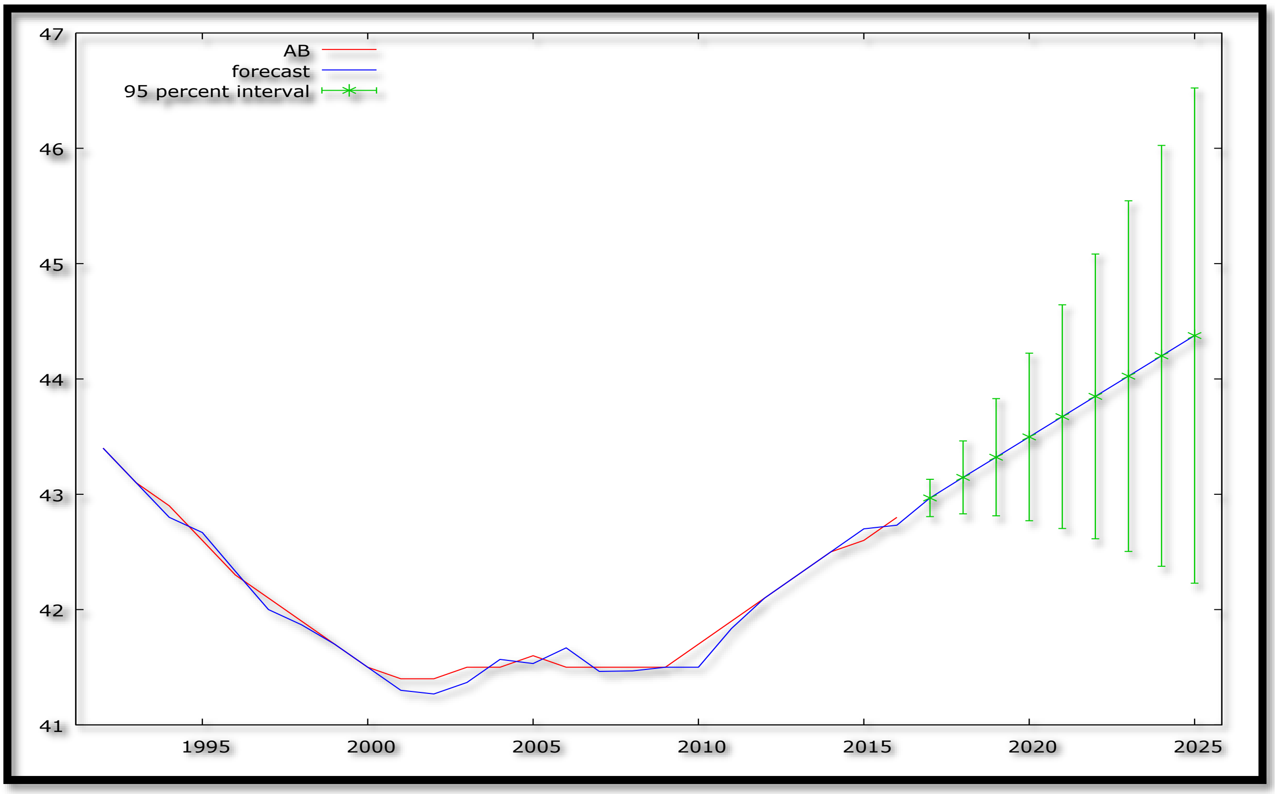

Figure 4: Forecast Graph – In & Out-of-Sample Forecasts

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

Predicted AB– Out-of-Sample Forecasts Only

Table 6: Predicted AB

Year	Predicted AB	Standard Error	95% Confidence Interval
2017	42.9680	0.0824700	(42.8064, 43.1297)
2018	43.1463	0.161246	(42.8302, 43.4623)
2019	43.3212	0.259317	(42.8130, 43.8295)
2020	43.4972	0.370711	(42.7707, 44.2238)
2021	43.6729	0.494728	(42.7033, 44.6426)
2022	43.8487	0.629982	(42.6140, 45.0835)
2023	44.0245	0.775669	(42.5042, 45.5448)
2024	44.2002	0.931073	(42.3754, 46.0251)
2025	44.3760	1.09563	(42.2286, 46.5234)

Table 6 shows the out-of-sample forecasts only. The prevalence of anemia in pregnant women in Ethiopia is forecasted to slightly rise from the estimated 43% to about 44.4% by 2025. These results suggest that anemia in pregnancy in Ethiopia remains a challenge for public health policy makers (Berhe et al., 2019).

CONCLUSION:

The study shows that the ARIMA (1, 2, 0) model is not only stable but also the most suitable model to forecast the prevalence of anemia among pregnant women in Ethiopia over the period 2017 – 2025. The presented model hints of a possible sharp rise in the prevalence of anemia in the country's pregnant women. The study encourages the government of Ethiopia to intensify its support to pregnant women through the routine supplementations with iron and folate. This may reverse the predicted trend. Additionally, the government of Ethiopia should strengthen HIV/TB programme collaboration as well as establish women friendly clinics to screen and educate women in the reproductive age group. Moreso, reproductive women should be educated about anemia in pregnancy.

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