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# ARIMA FORECASTING OF THE PREVALENCE OF ANEMIA AMONG PREGNANT WOMEN IN GHANA

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**ABSTRACT:**

**Anemia is the most common hematological disorder; that can occur in women. In pregnancy, anemia is usually a result of iron deficiency and sometimes a result of folic acid deficiency, amongst other causes. Using annual time series data on the prevalence of anemia among pregnant women in Ghana 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 the AG 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. Furthermore, the diagnostic tests reveal 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 women in Ghana is likely to continue to decline over the out-of-sample period. Amongst other policy prescriptions, the study recommends iron supplementation during pregnancy for reproductive women in the country.**

**INTRODUCTION:**

Anemia in pregnancy is a major public health problem around the globe, especially in developing countries (McLean et al., 2009). About 2 billion people are anemic worldwide (WHO, 2001). In fact, Africa has the highest prevalence of anemia in pregnancy (McLean et al., 2009). Ghana is among the countries in Africa with a high prevalence of anemia in pregnancy (GSS, 2015). Anemia in pregnancy is defined as hemoglobin concentration less than 11g/dl (WHO, 2015). Anemia in pregnancy is associated with adverse maternal and neonatal health outcomes such as miscarriages, stillbirths, intrauterine growth restriction, perinatal anemia and maternal mortality (Chumak & Grjibovski, 2010; Mirzaie et al., 2010; Zerfu & Ayele, 2013; New & Wirth, 2015). There are many causes of anemia in pregnancy, but the most common ones are iron and folate deficiencies (Look et al., 2006; Zerfu & Ayele, 2013). In the case of Ghana, the causes of anemia in pregnant women are iron and folate deficiencies as well as intestinal parasitic infections, malaria, HIV infections, and hemogloblinopathies such as sickle cell anemia and beta-thalasaemias (Vochem et al., 1998; Apea-Kubi et al., 2004; Ouma et al., 2007; Engmann et al., 2008; Baidoo et al., 2010; Tay et al., 2013; Volker et al., 2017). Well known obstetric causes of anemia in pregnancy include teenage pregnancies, pregnancy among elderly women, very low body mass index as well as more than five previous deliveries (grand multiparity) (Liabsuetrakul, 2011; Al-Farsi et al., 2011; GSS, 2015). The main aim of this study is to predict the prevalence of anemia among pregnant women in Ghana over the period 2017 – 2025.

## LITERATURE REVIEW:

In a prospective case control study, Geelhoed et al. (2006) examined determinants of severe anemia in rural Ghana. General linear modeling was applied. The results of the study indicated that multiple pregnancy, urinary tract infections, less than 4 ANC visits as well as body mass index were the main factors contributing to anemia in pregnancy in rural Ghana. In a cross-sectional study, Anlaakuu & Anto (2017), identified factors associated with anemia among pregnant women receiving antenatal care at the Sunyani Municipal Hospital in Ghana between May and June 2015. Bivariate and multivariate analyses were carried out to determine factors associated with anemia. The study established that Malaria infection, fish/snails intake and gestational age at first ANC visit were significantly associated with anemia. In retrospective analysis of ANC records of pregnant women, Nonterah et al. (2019) determined the prevalence and maternal factors associated with anemia in pregnancy at first ANC visits in rural Ghana. The study was carried out in the Navrongo War Memorial Hospital, a secondary referral facility in the Kassena-Nankana district in rural Northern Ghana. A logistic regression model was applied. The study found out that the burden of anemia was still very high in rural Ghana and that the main factors associated with anemia in pregnancy were grand multiparity, booking during the 3rd trimester as well as mothers who were underweight. No even a single study has attempted to forecast the prevalence of anemia in pregnancy in the country. It is research gap that this study intends to fill.

## 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 AG series under consideration.

### 3.2 The Applied Box – Jenkins ARIMA Model Specification:

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

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

where $\Delta$ 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 AG] in Ghana. 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 |
|---|---|---|---|---|---|
| AG | -1.584129 | 0.4750 | -3.737853 | @1% | Non-stationary |
| | | | -2.991878 | @5% | Non-stationary |
| | | | -2.635542 | @10% | Non-stationary |

Table 1 shows that AG 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 |
|---|---|---|---|---|---|
| ΔAG | -0.680047 | 0.8343 | -3.724070 | @1% | Non-stationary |
| | | | -2.986225 | @5% | Non-stationary |
| | | | -2.632604 | @10% | Non-stationary |

From table 2, AG is also not stationary even after taking first differences.

### 3.4.3 The ADF Test (at Second Differences):

Table 3: with intercept

| Variable | ADF Statistic | Probability | Critical Values | | Conclusion |
|---|---|---|---|---|---|
| $\Delta^2$AG | -5.150894 | 0.0004 | -3.737853 | @1% | Stationary |
| | | | -2.991878 | @5% | Stationary |
| | | | -2.635542 | @10% | Stationary |

As shown in table 3, AG 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) | -54.43264 | 0.2138 | -0.00002 | 0.06936 | 0.092325 |
| ARIMA (1, 2, 0) | **-55.92534** | 0.21576 | 0.00015144 | 0.070098 | 0.093621 |
| ARIMA (2, 2, 0) | -55.30499 | 0.20964 | -0.00037162 | 0.06802 | 0.08958 |
| ARIMA (0, 2, 1) | -55.75602 | 0.21638 | 0.00012499 | 0.070351 | 0.095142 |
| ARIMA (0, 2, 2) | -55.89688 | 0.20648 | -0.0005989 | 0.067088 | 0.087632 |

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 selected.

### 3.5 Residual & Stability Tests:

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

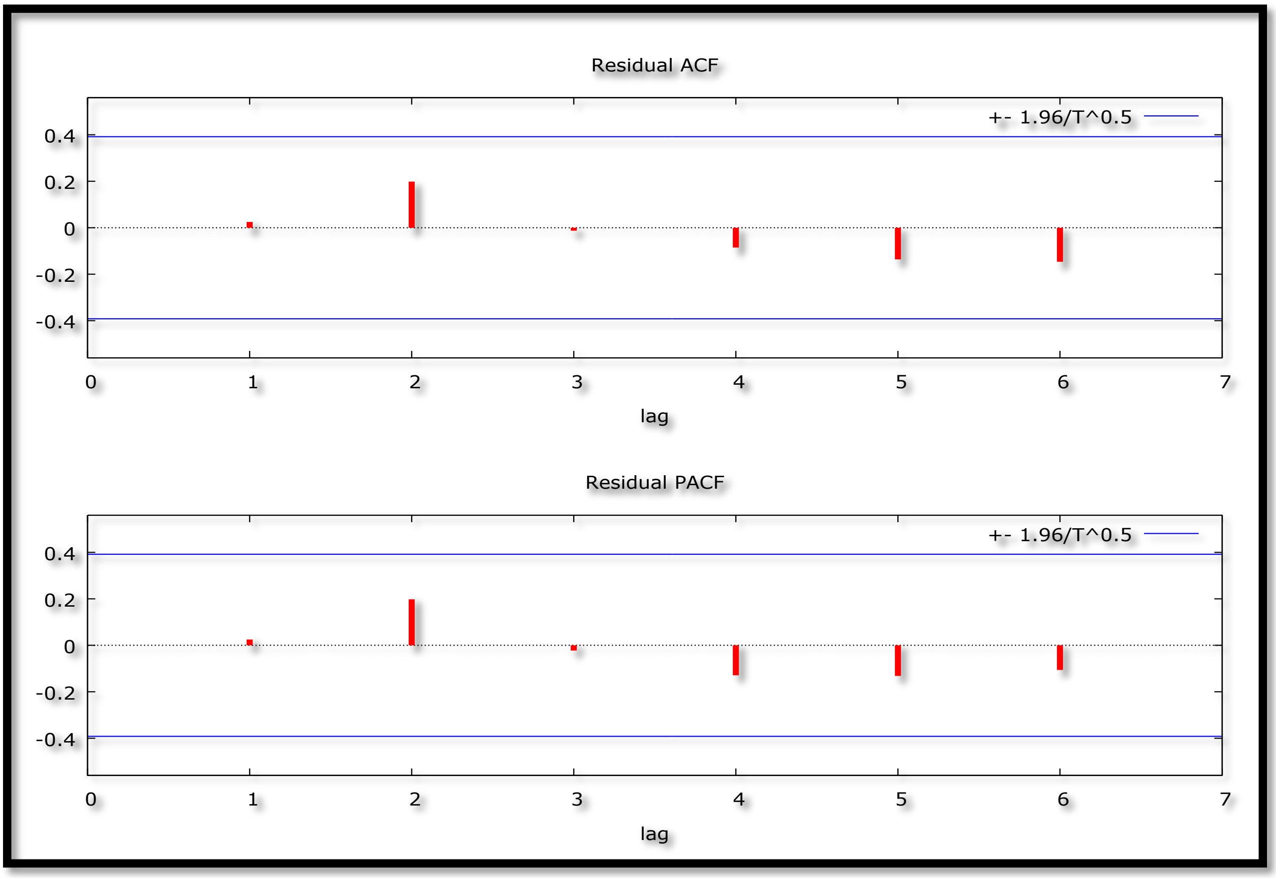


Figure 1: Correlogram of the Residuals

Figure 1 shows that the estimated optimal 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:

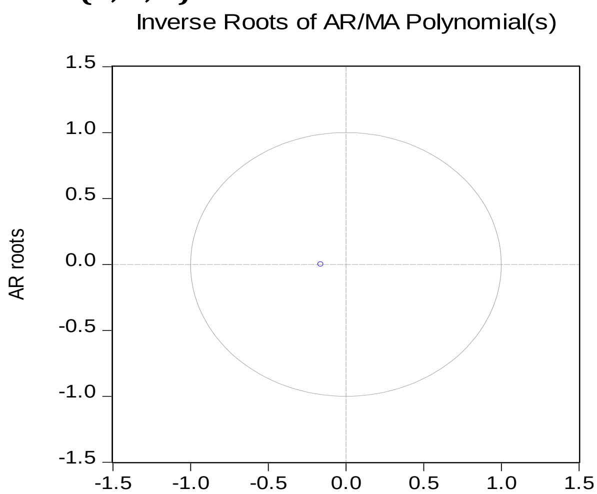


Figure 2: Inverse Roots

Because all 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

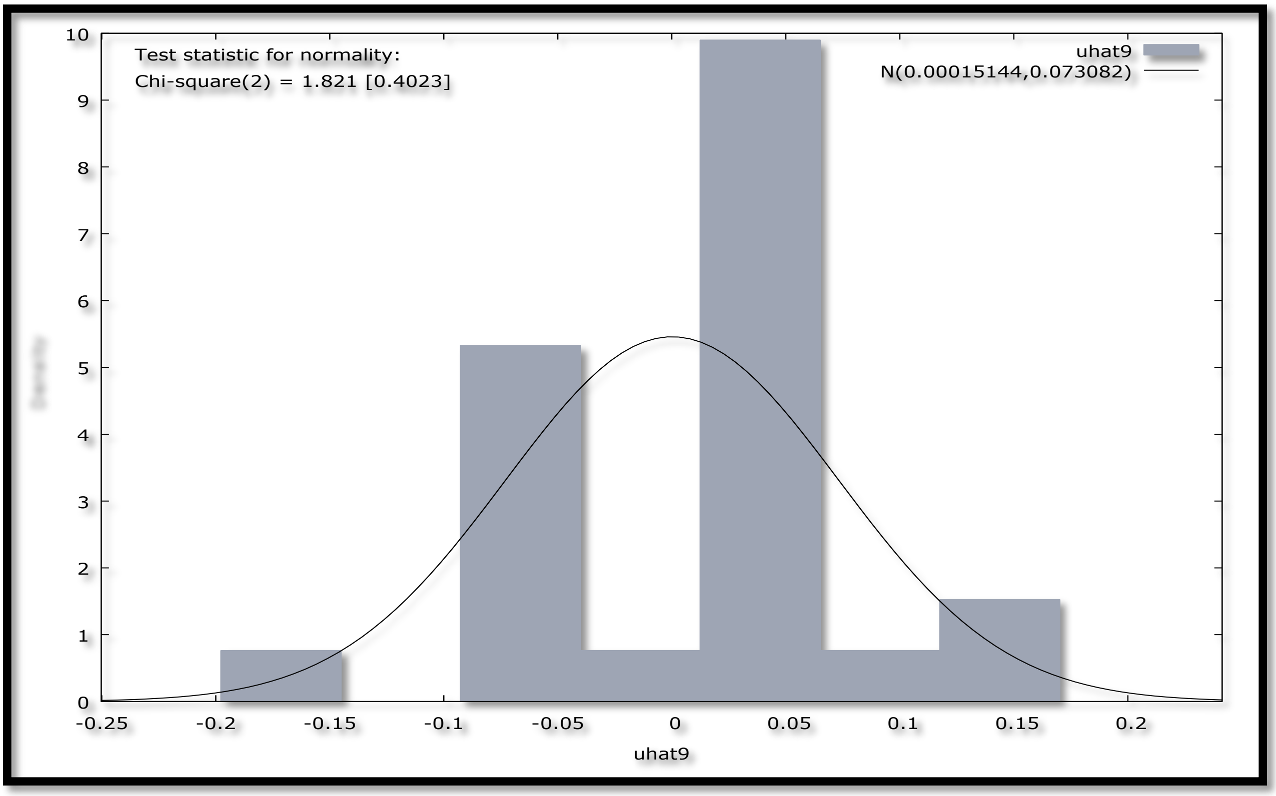


Figure 3: Normality Test

Given that 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:

$$\Delta^2 AG_t = -0.0247926 - 0.152704\Delta^2 AG_{t-1} \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

| Variable | Coefficient | Standard Error | z | p-value |
|---|---|---|---|---|
| constant | -0.0247926 | 0.0122471 | -2.024 | 0.0429** |
| $\beta_1$ | -0.152704 | 0.211729 | -0.7212 | 0.4708 |

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

**Forecast Graph**

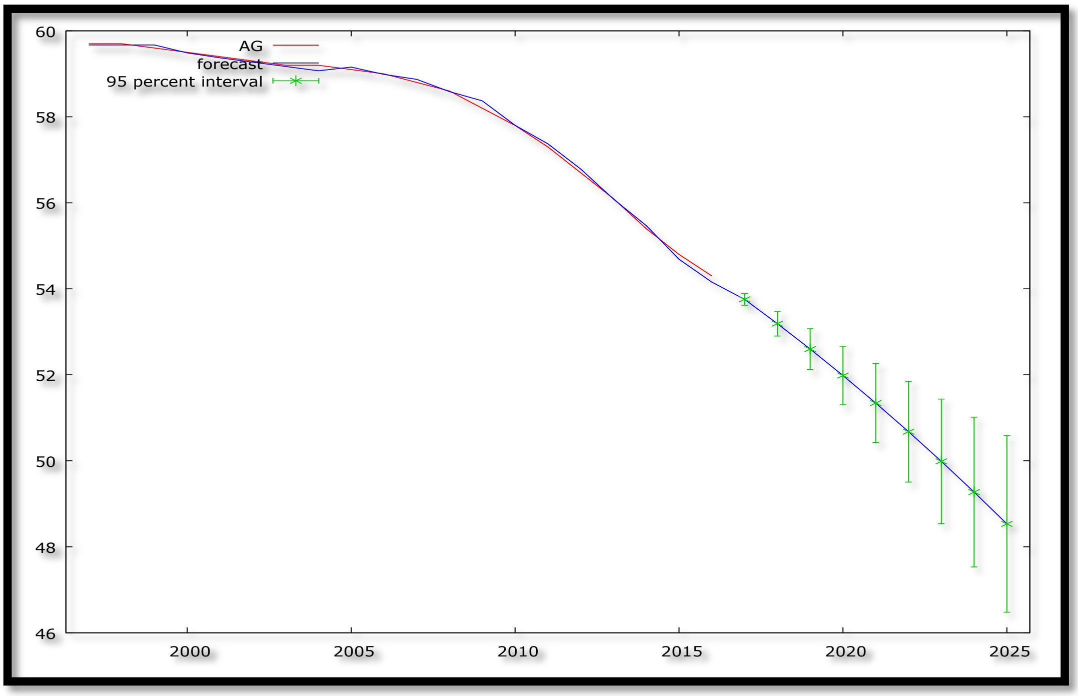


Figure 4: Forecast Graph – In & Out-of-Sample Forecasts

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

**Predicted AG– Out-of-Sample Forecasts Only**

Table 6: Predicted AG

| Year | Predicted AG | Standard Error | 95% Confidence Interval |
|---|---|---|---|
| 2017 | 53.7562 | 0.0700941 | (53.6188, 53.8935) |
| 2018 | 53.1904 | 0.147239 | (52.9018, 53.4790) |
| 2019 | 52.5995 | 0.240776 | (52.1275, 53.0714) |
| 2020 | 51.9838 | 0.348019 | (51.3017, 52.6659) |
| 2021 | 51.3433 | 0.467464 | (50.4270, 52.2595) |
| 2022 | 50.6780 | 0.597981 | (49.5060, 51.8500) |
| 2023 | 49.9879 | 0.738708 | (48.5401, 51.4357) |
| 2024 | 49.2730 | 0.888955 | (47.5307, 51.0153) |
| 2025 | 48.5334 | 1.04816 | (46.4790, 50.5877) |

Table 6 and figure 4 show the out-of-sample forecasts only. The prevalence of anemia in Ghana is predicted to continue on a downwards trend from about 54% in 2017 to almost 49% by 2025. However, the burden of anemia in pregnancy is still very high in Ghana (Anlaakuu & Anto, 2017; Nonterah et al., 2019).

**CONCLUSION:**

The paper shows that the ARIMA (1, 2, 0) model is not only stable but also the most suitable model to make predictions of the prevalence of anemia among pregnant women in Ghana over the period 2017 – 2025. The model predicts a commendable decrease in the prevalence of anemia among pregnant women in the country. Unfortunately, the prevalence of anemia in Ghana among pregnant women, remains unacceptably high. The forecasts of this research point to the need for iron supplementation during pregnancy for reproductive women in the country. The government of Ghana should also improve; especially early access to Antenatal Care (ANC) services and also expand coverage of malaria programs. There is also need for early diagnosis and treatment of HIV/TB in pregnancy through HIV/TB programme collaborations to reduce anemia incidence related to TB/HIV.

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