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ARIMA FORECASTING OF THE PREVALENCE OF ANEMIA IN CHILDREN IN THE GAMBIA

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Abstract:

Using annual time series data on the prevalence of anemia in children under 5 years of age in Yemen from 1990 – 2016, the study makes predictions for the period 2017 – 2025. The study applies the Box-Jenkins ARIMA methodology. The diagnostic ADF tests show that, AG, the series under consideration is an I (0) variable. Based on the AIC, the study presents an AR (3) process, the ARIMA (3, 0, 0) model as the optimal model. The diagnostic tests further prove that the presented model is stable and its residuals are not serially correlated. The results of the study indicate that the prevalence of anemia in children in The Gambia is projected to slightly rise over the out-of-sample period by approximately 1.2%. This implies that the prevalence of anemia in children under the age of five in The Gambia will remain very high.

Keywords: The prevalence of anemia, the Box-Jenkins ARIMA methodology,

1.0 INTRODUCTION

Globally, anemia can be found in more than 40% of children under five years of age (Stevens *et al*., 2013), primarily those living in rural households with low socioeconomic status and exposed to poor sanitation (Rohner *et al*., 2013; Engle-Stone *et al*., 2017). Anemia remains one of the most important health problems for children in African countries and The Gambia is not an exception (Bojang *et al*., 2010). Young children, especially those under the age of five, are highly susceptible to anemia (Allen *et al*., 2006; WHO, 2017). The current analysis suggests that although there are multiple factors contributing to anemia, anemia in Gambian children is mainly nutritionally-induced (NaNA-Gambia, 2019), particulary iron, vitamin A, folate and vitamin B12 deficiencies (WHO, 2017; Engle-Stone *et al*., 2017; Green & Mitra, 2017). Other causes of anemia in children in The Gambia, just like in any other African country, include; infections with *Plasmodium falciparum* (which mainly causes Malaria) and hemogloblinopathies (Weber *et al*., 1997; Bojang *et al*., 2010). More than 50% of Gambian children are anemic (hemoglobin less than 110 g/dL) (*ibid*). WHO classifies the population public health severity of anemia as high for prevalence rates of more than or equal to 40% (WHO, 2011). Anemia prevalence is higher in male children than in female children and in children living in rural areas compared to those living in urban areas (NaNA-Gambia, 2019). The main goal of this study is to forecast the prevalence of anemia in children under the age of 5 in The Gambia over the period 2017 – 2025.

2.0 LITERATURE REVIEW

Bojang *et al*. (2010) analyzed the possibility of preventing the recurrence of anemia in Gambian children following discharge from hospital. A randomized trial was carried out during the 2003 and 2004 malaria transmission seasons, with 1200 Gambia children with moderate or severe anemia. The study basically found out that mortality following discharge from hospital was low among children who received sulfadoxine-pyrimethamine (SP) or placebo. Recently, Petry *et al*. (2019) assessed the prevalence of under-and over-nutrition, anemia, iron deficiency (ID), iron deficiency anemia (IDA), vitamin A deficiency (VAD) and urinary iodine concentration (UIC). Multivariate analysis was employed to assess risk factors of anemia. The study established that among children aged 6 – 59 months, the prevalence of anemia was 50.4%. No study has attempted modeling and forecasting the prevalence of anemia in children under the age of five in the country. While Petry *et al*. (2019) analyzed the prevalence of anemia in children aged 6 – 59 months, leaving behind those aged 0 – 5 months. This study will take into account all children under the age of five. This piece of work will be the first of its kind in The Gambia and is expected to go a long way in accelerating the reduction of anemia prevalence 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, AG, the 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:

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

where Δ is the difference operator, vector $\beta \in R^p$ and $\alpha \in R^q$.

3.3 DATA COLLECTION

This study is based on annual observations (that is, from 1990 – 2016) on the prevalence of anemia in children under the age of 5 in The Gambia [denoted as AG]. Prevalence of anemia in children under 5 years of age in The Gambia, implies, the percentage of children under the age of 5 whose hemoglobin level is less than 110 grams per liter at sea level. Out-of-sample forecasts will cover the period 2016 – 2025. All the data was gathered 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	-2.639950	0.0992	-3.737853	@1%	Non-stationary
			-2.991878	@5%	Non-stationary
			-2.635542	@10%	Stationary

Table 1 shows that AG is stationary in levels.

3.4.2 EVALUATION OF ARIMA MODELS (WITH A CONSTANT)

Model	AIC	U	ME	RMSE	MAPE
ARIMA (1, 0, 0)	39.00466	0.99959	-0.16751	0.96144	0.61967
ARIMA (2, 0, 0)	-28.22345	0.26343	0.15949	0.94102	0.32428
ARIMA (3, 0, 0)	**-30.19218**	0.24648	0.16322	0.9363	0.30986
ARIMA (4, 0, 0)	-28.28184	0.24621	0.16189	0.93347	0.30972
ARIMA (5, 0, 0)	-26.30528	0.2463	0.16126	0.93254	0.30942

Table 2: Evaluation of ARIMA Models (with a constant)

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 (3, 0, 0) model, well-known as the AR (3) model; is finally chosen.

3.5 RESIDUAL TESTS

3.5.1 CORRELOGRAM OF THE RESIDUALS OF THE ARIMA (3, 0, 0) MODEL

Figure 1: Correlogram of the Residuals

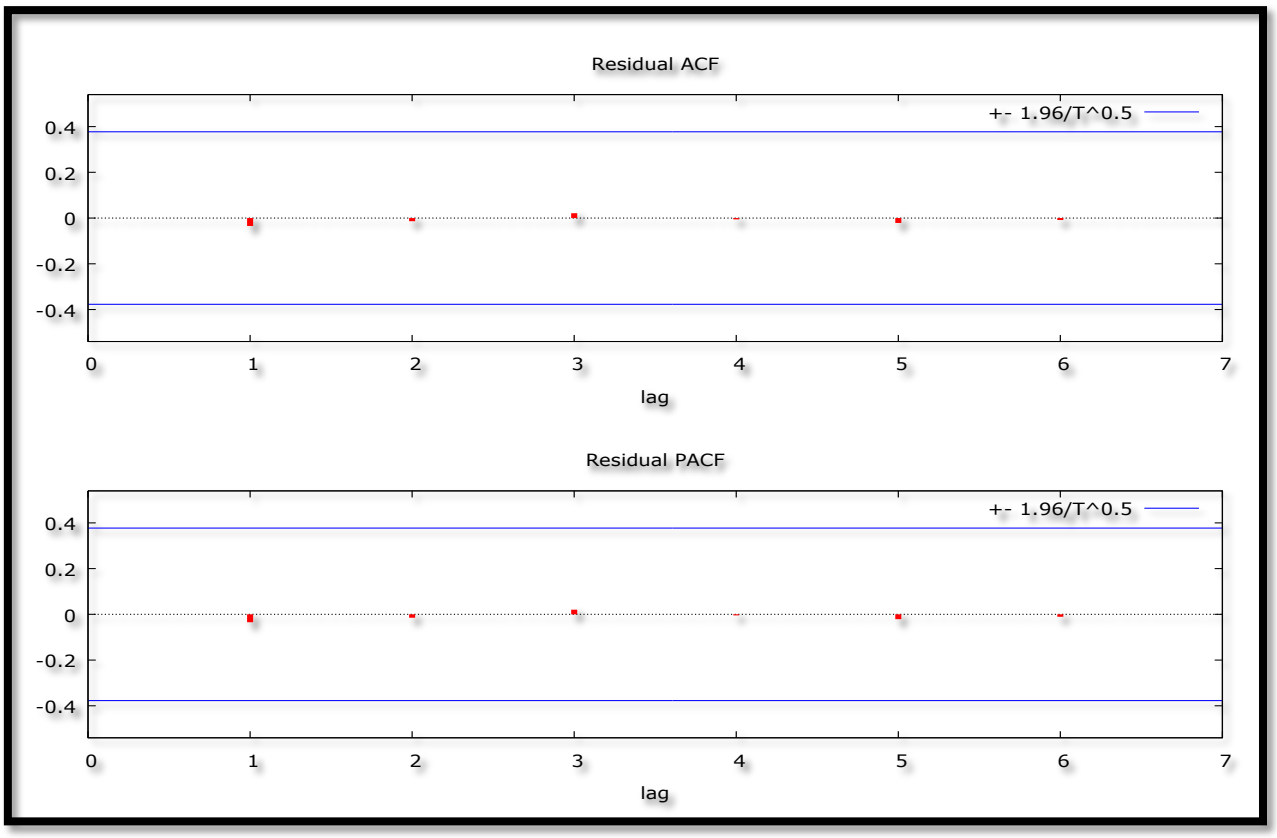

Figure 1 shows that the estimated optimal model is adequate since ACF and PACF lags are quite short and within the bands.

4.0 FINDINGS OF THE STUDY

4.1 RESULTS PRESENTATION[1]

Table 3: Main Results

ARIMA (3, 0, 0) Model:

The chosen optimal model, the ARIMA (3, 0, 0) model can be expressed as follows:

$$AG_t = 79.8613 + 1.58704AG_{t-1} - 0.225663AG_{t-2} - 0.376704AG_{t-3} \dots\dots\dots\dots\dots\dots\dots\dots [2]$$

Variable	Coefficient	Standard Error	z	p-value
constant	79.8613	0.0954311	836.8	0.0000***
β_1	1.58704	0.185956	8.535	0.0000***
β_2	-0.225663	0.364289	-0.6195	0.5356
β_3	-0.376704	0.183625	-2.051	0.0402**

Table 3 shows the main results of the ARIMA (3, 0, 0) model.

[1] *The *, ** and *** imply statistical significance at 10%, 5% and 1% levels of significance; respectively.*

Forecast Graph

Figure 2: Forecast Graph – In & Out-of-Sample Forecasts

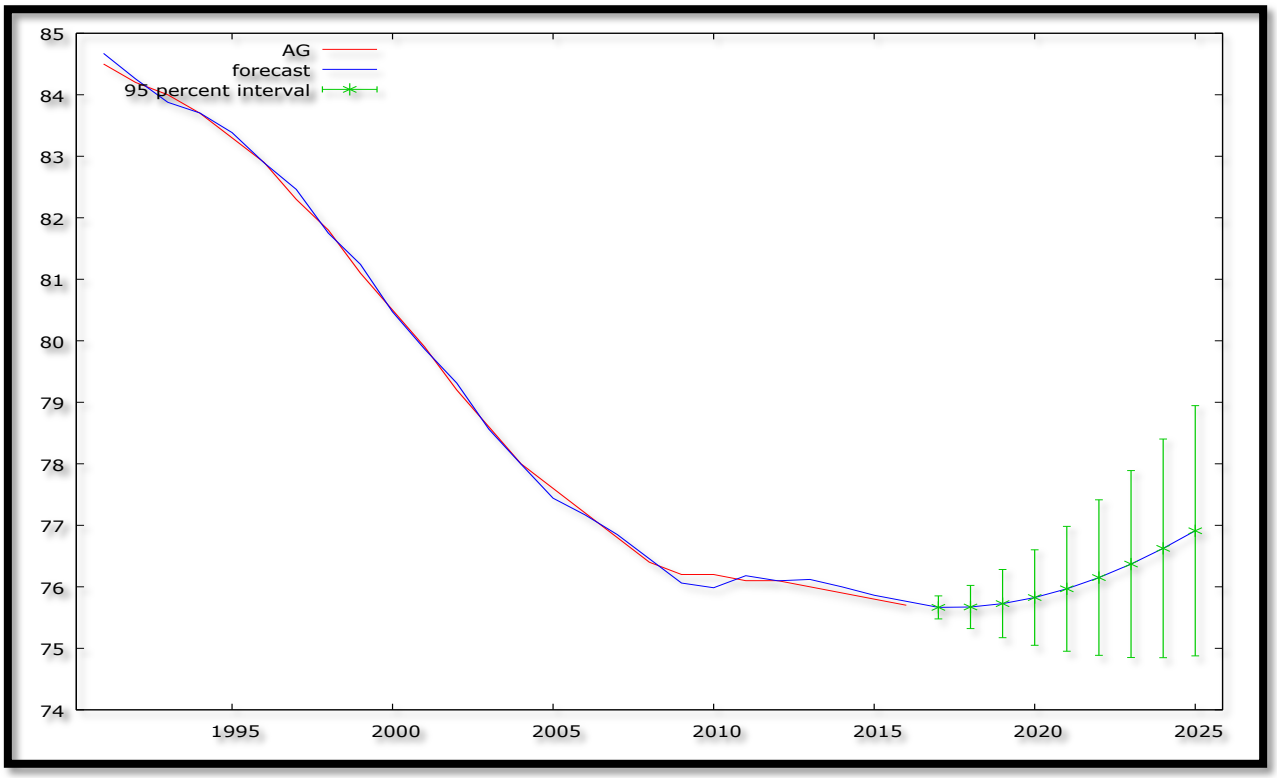

Figure 2 shows the in-and-out-of-sample forecasts of the AG series. The out-of-sample forecasts cover the period 2017 – 2025.

Predicted AG– Out-of-Sample Forecasts Only

Table 4: Predicted AG

Year	Predicted AG	Standard Error	95% Confidence Interval
2017	75.6659	0.0954901	(75.4787, 75.8530)
2018	75.6719	0.179122	(75.3208, 76.0230)
2019	75.7269	0.282895	(75.1724, 76.2814)
2020	75.8256	0.396161	(75.0492, 76.6021)
2021	75.9677	0.517938	(74.9525, 76.9828)
2022	76.1501	0.645019	(74.8859, 77.4143)
2023	76.3703	0.775404	(74.8506, 77.8901)
2024	76.6252	0.907011	(74.8475, 78.4029)

Table 4 shows the out-of-sample forecasts only. The prevalence of anemia in children in The Gambia is projected to slightly increase over the out-of-sample period.

5.0 CONCLUSION

The study shows that the ARIMA (3, 0, 0) model is not only stable but also the most suitable model to forecast the prevalence of anemia in children in The Gambia over the period 201 – 2025. The model predicts an increase in the prevalence of anemia in the country, from 75.7% in 2017 to about 76.9% by 2025. This points to the notion that anemia in Gambian children is far from being eradicated in the country. The study recommends that the government of The Gambia should intensify nutritional supplementation and food fortification programmes, especially in rural areas where significant groups of households are economically disadvantaged. In this regard, the government should provide technical and financial support, especially for small to medium enterprises for the rural populace in order to reduce poverty. Furthermore, there is need for strengthening TB and HIV treatment programs to reduce anemia related to HIV/TB.

REFERENCES

1. Allen, L. *et al*. (2006). Guidelines on Food Fortification with Micronutrients, *WHO*, Geneva.
2. Bojang, K. A., *et al*. (2010). Prevention of Recurrence of Anemia in Gambian Children Following Discharge From Hospital, *PLoS ONE*, pp: 1 – 11.
3. Engle-Stone, R. *et al*. (2017). Predictors of Anemia in School Children: Biomarkers Reflecting Inflammation and Nutritional Determinants of Anemia (BRINDA) Project, *AJCN*, 106: 402 – 415.
4. Green, R., & Mitra, A. D. (2017). Megaloblastic Anemias: Nutritional and Other Causes, *Medicine*, 89 (7): 1 – 9.
5. NaNA-Gambia (2019). Gambia National Micronutrient Survey 2018, *NaNA-Gambia*, Banjul.
6. 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.
7. Nyoni, T. (2018b). Modeling and Forecasting Inflation in Kenya: Recent Insights from ARIMA and GARCH analysis, *Dimorian Review*, 5 (6): 16 – 40.
8. Nyoni, T. (2018c). Box – Jenkins ARIMA Approach to Predicting net FDI inflows in Zimbabwe, MPRA Paper No. 87737, *University Library of Munich*, Munich, Germany.
9. Petry, N. *et al*. (2019). Micronutrient Deficiencies, Nutritional Status and the Determinants of Anemia in Children 0 – 59 Months of Age and Non-pregnant Women of Reproductive Age in The Gambia, *Nutrients*, 11 (2275): 1 – 20.
10. Rohner, F., *et al*. (2013). Infant and Young Children Feeding Practices in Urban Philippines and Their Associations With Stunting, Anemia, and Deficiencies of Iron and Vitamin A, *Food & Nutrition Bulletin*, 34: 17 – 34.
11. Stevens, G. A. *et al*. (2013). Global, Regional, and National Trends in Hemoglobin Concentration and Prevalence of Total and Severe Anemia in Children and Pregnant and Non-pregnant Women for 1995 – 2011: A Systematic Analysis of Population Representative Data, *Lancet Global Health*, pp: 1 – 9.
12. Weber, M. W. *et al*. (1997). Pallor as a Clinical Sign of Severe Anemia in Children: An Investigation in the Gambia, *Bulletin of the World Health Organization*, 75 (1): 113 – 118.
13. WHO (2011). Hemoglobin Concentrations for the Diagnosis of Anemia and Assessment of Severity, *WHO*, Geneva.
14. WHO (2017). Nutritional Anemias: Tools for Effective Prevention and Control, *WHO*, Geneva.