NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 6, ISSUE 1, Jan. -2020

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

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ABSTRACT:

Using annual time series data on the prevalence of anemia among pregnant women in Malaysia from 1990 – 2018, the study endeavors to make forecasts for the period 2017 – 2025. The study applies the Box-Jenkins ARIMA approach. The diagnostic ADF tests show that, W, the series under consideration is an I (2) variable. Based on the AIC, the study presents the ARIMA (1, 2, 1) model as the best model. The diagnostic tests further reveal that the presented model is basically stable, since 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 Malaysia will rise over the period 2017 – 2025, from about 38.1% in 2017 to approximately 49.6% by around 2025. The study generally calls for the need for the Malaysian government to expand on its nutritional supplementation policy in the female population as well as improving its antenatal care health system.

1.0 INTRODUCTION:

Anemia in pregnancy constitutes a major public health problem in developing countries (Brabin et al., 2001) and Malaysia is not an exception (Haniff et al., 2007). Actually, in Malaysia, anemia in pregnant women still constitutes a major and challenging health problem (Milman, 2015). In Malaysia, at least 2 million women of reproductive age have anemia (McLean et al., 2009) and at least 88% of the anemia is associated with iron deficiency (Milman, 2015). Women of reproductive age have monthly menstrual blood and thereby iron losses, during approximately 40 years and in addition women in Malaysia may have 3-4 pregnancies and child deliveries, which causes further cause iron losses due to iron depletion during pregnancy (when no supplementary iron is taken) and iron losses due to bleeding at delivery. This is the main cause for iron deficiency anemia in women in Malaysia (Foo et al., 2004). Anemia in pregnancy is one of the main causes of maternal mortality (Brabin et al., 2001) and is also associated with a number of adverse perinatal outcomes (WHO, 1992; Scholl & Reilly, 2000; Allen, 2000). The main goal of this research is to predict the prevalence of anemia among pregnant women in Malaysia over the period 2017 – 2025.

2.0 LITERATURE REVIEW:

In a cross-sectional study, Hannif et al. (2007) investigated the prevalence, magnitude and epidemiology of anemia in Malaysia. Multistage stratified random sampling technique was used and 59 Ministry of Health (MOH) primary care clinic were selected and the final dataset of the study consisted of 1072 antenatal mothers from 56 clinics. The study indicated that the overall prevalence of anemia in this population was 35% and that the majority of anemia was of the mild type. In a recent Malaysian study, Milman (2015) studied iron deficiency and anemia in pregnant women. The methodological approach of the study was hinged on a literature survey on publications and guidelines on the frequency of iron deficiency and iron deficiency anemia in Malaysia compared with Western countries. The study established that prevalence of anemia in women of reproductive age is 30% and in pregnant women 40% and that, in general, anemia in pregnant women still constitute a major and challenging health problem in the country. No study has forecasted the prevalence of anemia among pregnant women in Malaysia. It is this information gap that this piece of work seeks to fill.

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, W, the series under consideration.

3.2 The Applied Box – Jenkins ARIMA Model Specification

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

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

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 W] in Malaysia. 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
W	-1.738638	0.4006	-3.724070	@1%	Non-stationary
			-2.986225	@5%	Non-stationary
			-2.632604	@10%	Non-stationary

Table 1 shows that W is not an I (0) variable.

3.4.2 The ADF Test (at First Differences)

Table 2: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ΔW	2.497684	0.9999	-3.724070	@1%	Non-stationary
			-2.986225	@5%	Non-stationary
			-2.632604	@10%	Non-stationary

Table 2 indicates that W is also 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^2W	-3.848951	0.0078	-3.737853	@1%	Stationary
			-2.991878	@5%	Stationary
			-2.635542	@10%	Stationary

Tables 3 implies that W 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)	**-47.66528**	0.1507	0.023798	0.083353	0.18006
ARIMA (2, 2, 2)	-45.54486	0.14616	0.022685	0.080835	0.17605
ARIMA (1, 2, 0)	-42.30641	0.17566	0.038491	0.09583	0.22302
ARIMA (2, 2, 0)	-47.52041	0.15156	0.023046	0.08402	0.19761

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, 1) model is finally chosen.

3.5 Residual Tests

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

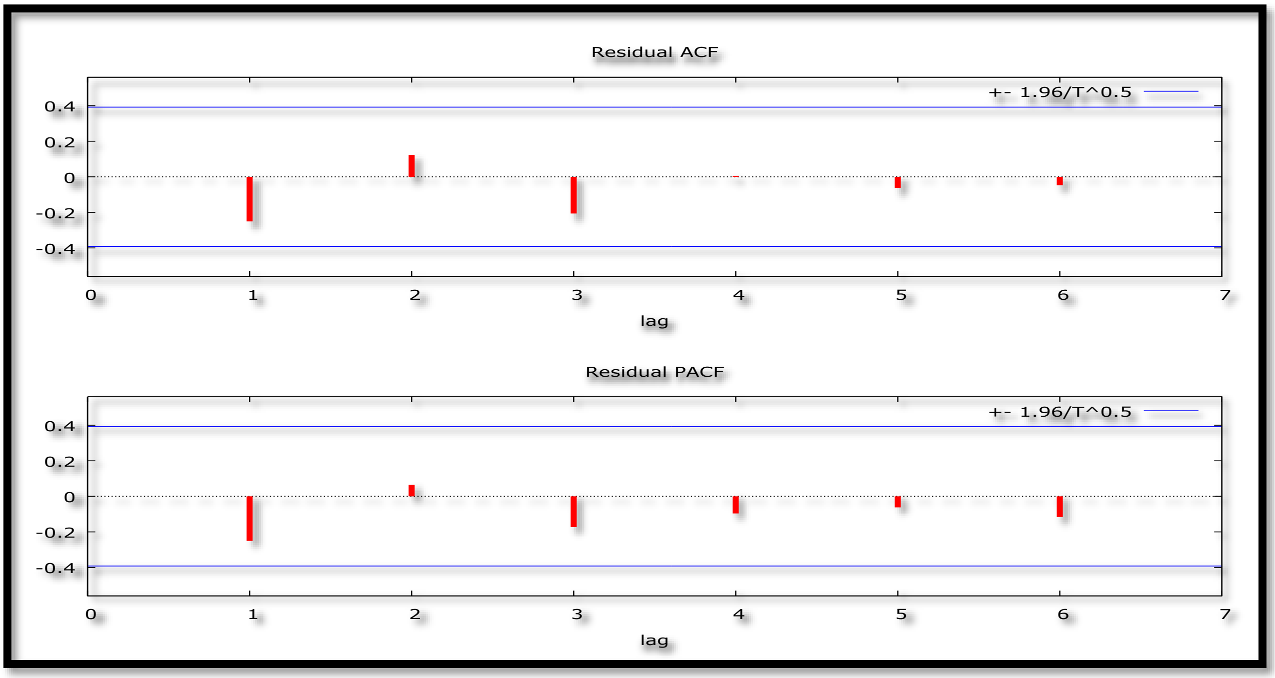

Figure 1: Correlogram of the Residuals

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

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

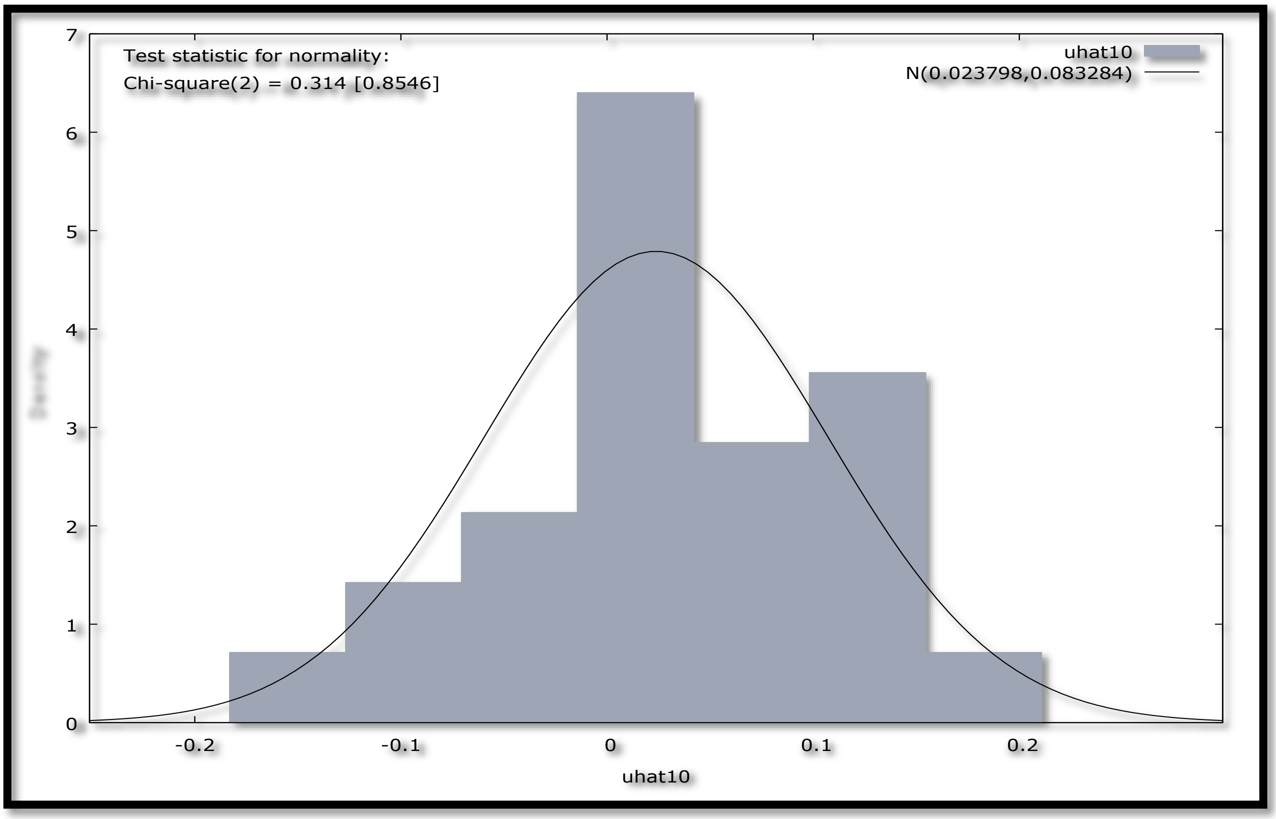

Figure 2: Normality Test

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, 1) model are normally distributed.

4.0 FINDINGS OF THE STUDY:

4.1 Results Presentation

Table 5: Main Results

ARIMA (1, 2, 1) Model:				
The chosen optimal model, the ARIMA (1, 2, 1) model can be expressed as follows: $\Delta^2 W_t = 0.97268\Delta^2 W_{t-1} - 0.764467\mu_{t-1} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \dots \dots . . \dots . . [2]$				
Variable	Coefficient	Standard Error	z	p-value
β_1	0.97268	0.11013	8.832	0.0000***
α_1	-0.764467	0.2789	-2.741	0.0061***

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

Forecast Graph

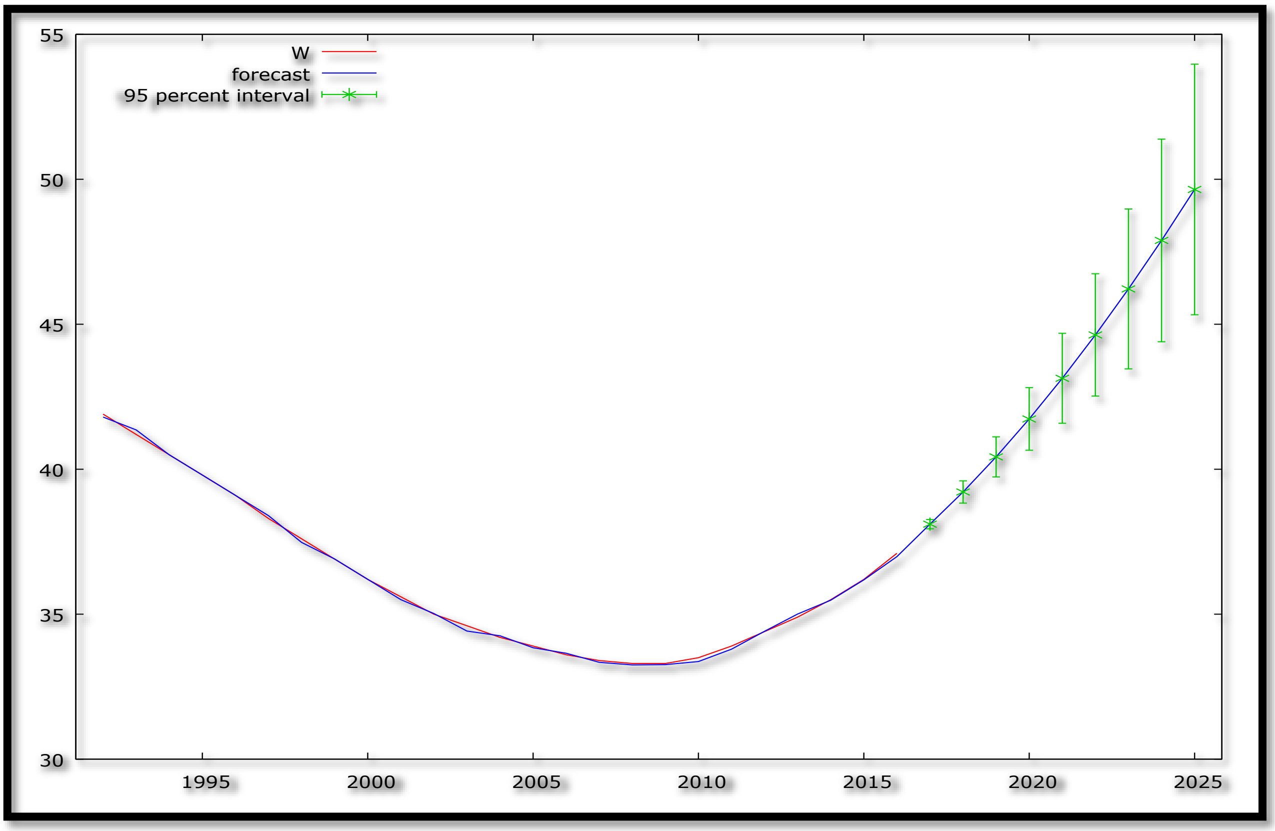

Figure 3 The *, ** and *** imply statistical significance at 10%, 5% and 1% levels of significance; respectively.: Forecast Graph – In & Out-of-Sample Forecasts

Figure 3 shows the in-and-out-of-sample forecasts of the series, W. The out-of-sample forecasts cover the period 2017 – 2025.

Predicted W– Out-of-Sample Forecasts Only

Table 6: Predicted W

Year	Predicted W	Standard Error	95% Confidence Interval
2017	38.1062	0.0809614	(37.9476, 38.2649)
2018	39.2158	0.196258	(38.8312, 39.6005)
2019	40.4260	0.352652	(39.7348, 41.1171)
2020	41.7339	0.550843	(40.6542, 42.8135)
2021	43.1368	0.791835	(41.5849, 44.6888)
2022	44.6324	1.07672	(42.5220, 46.7427)
2023	46.2178	1.40657	(43.4610, 48.9747)
2024	47.8908	1.78240	(44.3974, 51.3843)
2025	49.6490	2.20516	(45.3269, 53.9710)

Table 6 apparently shows the out-of-sample forecasts only. The prevalence of anemia in Malaysia among pregnant women is projected to resurge from the estimated 38.1% in 2017 to approximately 49.6% by 2025. Indeed, anemia among pregnant women in Malaysia remains a major public health challenge (Milman, 2015).

5.0 CONCLUSION:

The study shows that the ARIMA (1, 2, 1) model is not only stable but also the most suitable model to forecast the prevalence of anemia among pregnant women in Malaysia over the period 2017 to 2025. The model predicts resurgence in the prevalence of anemia in Malaysian pregnant women. In order to possibly reverse the predictions of this paper, the research recommends that the government of Malaysia should expand and intensify its focus on promoting an effective nutritional supplementation policy in the female population as well as directing resources to the antenatal care health system. Furthermore, the government of Malaysia should also ensure that there is regular screening of pregnant mothers during ANC visits. Last but not least, strengthening of HIV/TB program collaborations should be a priority in this regard, in order to ensure early diagnosis and treatment of HIV and TB in pregnant women in the country.

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