International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048
Volume 7, Issue 8, pp 207-211, August-2023
https://doi.org/10.47001/IRJIET/2023.708027

Utilizing Empirical Evidence Obtained from the ARIMA Model to Track SDG-3 Progress and Review Neonatal Healthcare Policies in Barbados

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***Abstract* - The 3rd sustainable development goal (SDG-3) focuses on promotion of good health for all at every stage of life. Target 3.2 aims to reduce neonatal mortality to at least 12 deaths per 1000 live births by the end of 2030. Tracking progress towards the achievement of this target is key to inform decisions, planning and allocation of resources to the maternal and child health (MNCH) program. This paper uses annual time series data on neonatal mortality rate (NMR) for Barbados from 1968 to 2019 to predict future trends of NMR over the period 2020 to 2030. Unit root tests have shown that the series under consideration is an I (2) variable. The optimal model based on AIC is the ARIMA (3,2,2) model. The ARIMA model projections have shownthat neonatal mortality will remain below 12 deaths per 1000 live births throughout the out of sample period. Therefore, authorities should address causes of deaths among neonates to keep neonatal deaths under control.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

Barbados is a Caribbean country which prioritizes equitable, efficient and accessible health care system within the context of its national development (Barbados, 2008). The prevalence of overweight, obesity and chronic non-communicable diseases is increasing for the general population (Barbados, 2008). A total fertility rate of 1.6 births per woman and neonatal mortality rate (NMR) of 10 per 1000 live births were reported in 2010(Barbados, 2012, World Bank, 2010). This shows that the country is doing well in controlling neonatal mortality and improving child survival. In this study we proposed the popular econometric model, the Box-Jenkins ARIMA methodology to model and forecast future trends of neonatal mortality rate for Barbados as it is appropriate for modeling linear data (Nyoni, 2018; Box & Jenkins, 1970). The results are expected to inform policy, decision making and allocation of resources towards maternal and child health programs. This early surveillance tool will help to detect abnormal trends of NMR and stimulate timeous implementation of neonatal healthcare strategies.

II. LITERATURE REVIEW

Kassebaum (2021) investigated current rates, recent trends, and potential trajectories of child mortality for the next decade. The author presented the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019 findings for all-cause mortality and cause-specific mortality in children younger than 5 years of age, with multiple scenarios for child mortality in 2030 that include the consideration of potential effects of COVID-19, and a novel framework for quantifying optimal child survival. It was found that Global child mortality declined by almost half between 2000 and 2019, but progress remains slower in neonates and 65 (32%) of 204 countries, mostly in sub-Saharan Africa and south Asia, are not on track to meet either SDG 3.2 target by 2030. The effect of a new maternity unit on maternal outcomes in rural Haiti was investigated by McDonald *et al*. (2021) who applied an interrupted time series analysis on data collected between July 2016 and October 2019 including 20 months before the opening of the maternity unit and 20 months after. The authors examined maternal neonatal outcomes such as physiological (vaginal) births, caesarean birth, postpartum hemorrhage (PPH), maternal deaths, stillbirths and undesirable outcomes (eclampsia, PPH, perineal laceration, postpartum infection, maternal death or stillbirth).It was found that the new maternity unit led to an upward trend in caesarean births yet an overall reduction in all undesirable maternal and neonatal outcomes. Schuurmans *et al.* (2021) estimated the prevalence of maternal death, stillbirth and low birthweight in women with (pre-) eclampsia and complicated pregnancies or deliveries in Centre de Références des Urgences Obstétricales, an obstetric emergency hospital in Port-au-Prince, Haiti, and examined the main risk factors for these adverse pregnancy outcomes. It was found out that there were 204 (0.6%) maternal deaths (648 per 100 000 women giving birth), 1962 (7.9%) stillbirths and 11 008 (44.1%) low birth weight neonates and

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10 991 (34.9%) were women with pre-eclampsia. Predictors of adverse pregnancy outcomes were not attending antenatal care (odds ratio (OR) 4.82; 95% confidence interval (CI) 3.55–6.55) and low birthweight (OR 1.40; 95% CI 1.05–1.86) for women with complicated pregnancies. Raymondville*et al*. (2020) examined the barriers and facilitators influencing facility-based childbirth in rural Haiti by conducting a mixed method study with a convergent design. The study concluded that pregnant women in rural Haiti must overcome substantial structural barriers and forfeit valued support from traditional birth attendants when they pursue facility-based childbirths.

III. METHODOLOGY

The Box – Jenkins Approach

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, 2018). The Box – Jenkins technique was proposed by Box & Jenkins (1970) and is widely used in many forecasting contexts.

Data Issues

This study is based on annual NMR in Barbados for the period 1968 to 2019. The out-of-sample forecast covers the period 2020 to 2030. All the data employed in this research paper was gathered from the World Bank online database.

Evaluation of ARIMA Models

Criteria Table

Table 1: Criteria Table

Model Selection Criteria Table			
Dependent Variable: DLOG(B, 2)			
Date: 01/22/22 Time: 12:29			
Sample: 1968 2019			
Included observations: 50			
Model	LogL	AIC*	BIC
(3,2)(0,0)	179.225259	-6.889010	-6.621327
(2,4)(0,0)	179.645210	-6.865808	-6.559885
(2,3)(0,0)	178.532403	-6.861296	-6.593613
(4,2)(0,0)	179.311729	-6.852469	-6.546545
(2,2)(0,0)	177.267032	-6.850681	-6.621239
(3,3)(0,0)	179.260984	-6.850439	-6.544516
(5,3)(0,0)	181.153715	-6.846149	-6.463744
(0,5)(0,0)	177.990644	-6.839626	-6.571943
(5,2)(0,0)	179.917520	-6.836701	-6.492537
(1,5)(0,0)	178.565993	-6.822640	-6.516716
(3,5)(0,0)	180.528492	-6.821140	-6.438735
(0,3)(0,0)	175.525559	-6.821022	-6.629820
(4,4)(0,0)	180.491078	-6.819643	-6.437239
(5,4)(0,0)	181.247191	-6.809888	-6.389243
(0,0)(0,0)	172.152610	-6.806104	-6.729623
(0,4)(0,0)	175.966662	-6.798666	-6.569224

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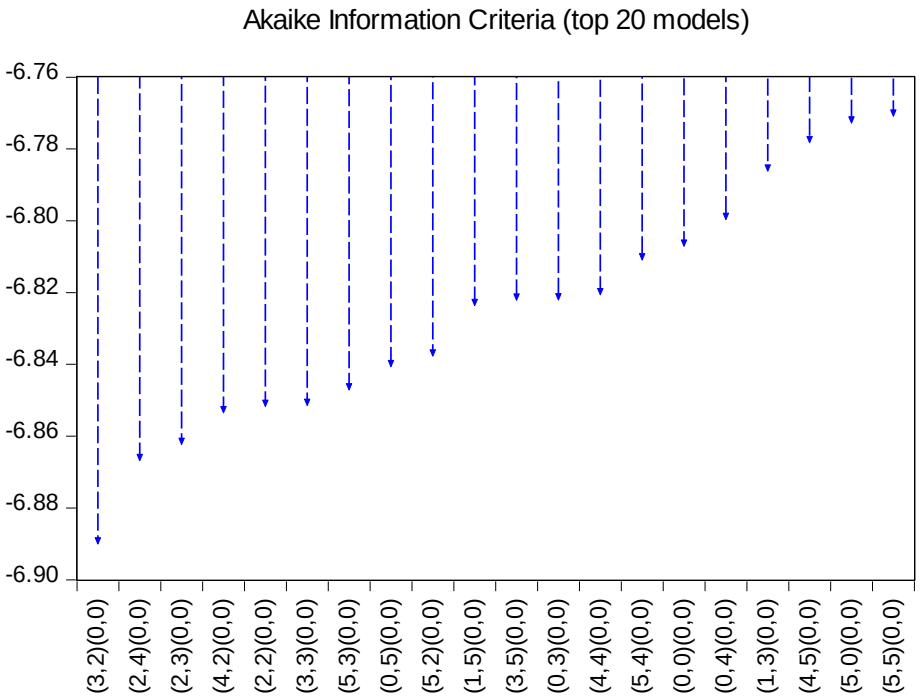
(1,3)(0,0)	175.629536	-6.785181	-6.555739
(4,5)(0,0)	180.431205	-6.777248	-6.356603
(5,0)(0,0)	176.294763	-6.771791	-6.504107
(5,5)(0,0)	181.247320	-6.769893	-6.311007

Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

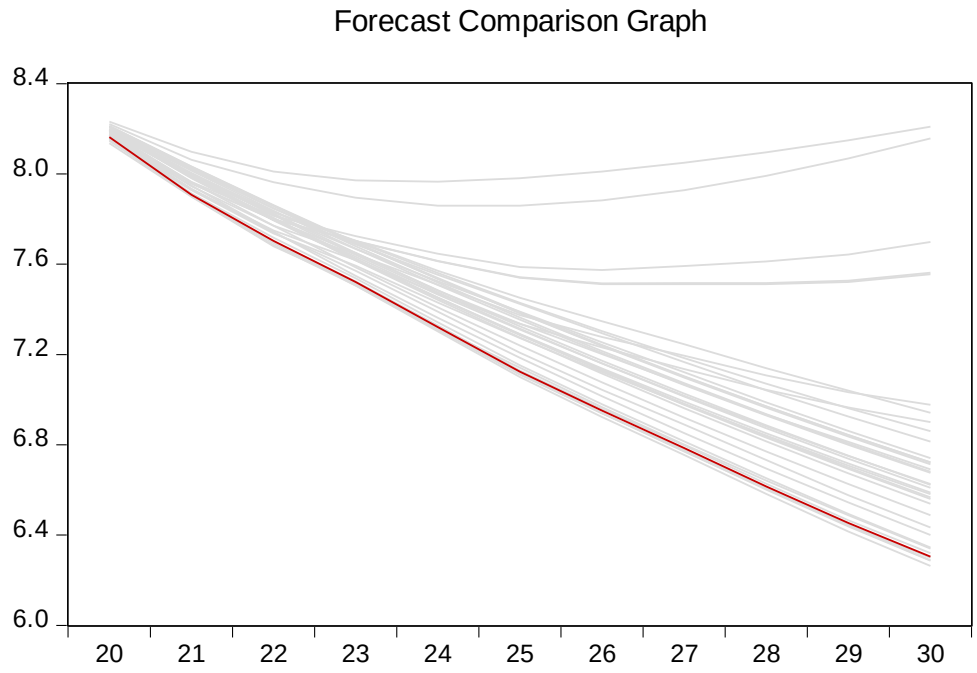


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Table 1 and Figure 1 indicate that the optimal model is the ARIMA (3, 2, 2) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (3, 2, 2) model.

IV. RESULTS

ARIMA (3,2,2) Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	8.16335487221782
2021	7.907765619705316
2022	7.70275161159506
2023	7.521194062087257
2024	7.320949680855084
2025	7.123504450223535
2026	6.950829375589248
2027	6.785542074517549
2028	6.615888727702774
2029	6.453916930688636
2030	6.304660128486599

Table 2 clearly indicates that there is likely to be a decline in NMR in the country over the period 2020 to 2030, ceteris paribus.

V. POLICY IMPLICATION & CONCLUSION

The launching of sustainable development goals in 2015 was meant to address various challenges that exist across the globe with the aim of improving the quality of life and living standards. SDG-3 was designed to address maternal and under five mortality which is a huge problem especially in low and middle income countries. Many countries have made significant progress towards achieving set targets by the end of 2030 including Barbados. The country, however is facing the emerging problem of a rise in chronic medical conditions like obesity, diabetes and hypertension which definitely impact negatively on pregnancy and neonatal outcomes. In this study we propose the popular Box-Jenkins econometric and statistical model to predict likely future trends of NMR for Barbados and the model projections suggest that neonatal mortality will remain below 12 deaths per 1000 live births throughout the forecast period. Therefore authorities in this country must address causes of neonatal deaths to keep neonatal mortality under control.

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Citation of this Article:

Dr. Smartson. P. NYONI, Thabani NYONI, "Utilizing Empirical Evidence Obtained from the ARIMA Model to Track SDG-3 Progress and Review Neonatal Healthcare Policies in Barbados" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 8, pp 207-211, August 2023. Article DOI https://doi.org/10.47001/IRJIET/2023.708027

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