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Designing and Implementing Effective Neonatal Healthcare Policies in Haiti Using Empirical Evidence from the ARIMA Model

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***Abstract* - Haiti is struggling to control neonatal mortality as a result of existing challenges such as poverty, inaccessible healthcare services, poor road infrastructure and shortage of medical staff. Neonatal healthcare solutions must address these problems at all levels of the health delivery system. Utilizing forecasts generated by the ARIMA model is expected to inform neonatal health policies and allocation of resources to the maternal and child health program in the country. This study uses annual time series data on neonatal mortality rate (NMR) for Haiti from 1960 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 (1) variable. The optimal model based on AIC is the ARIMA (4,1,2) model. The findings of this study suggest that neonatal mortality will gradually decrease from around 25 to approximately 17 deaths per 1000 live births by the end of 2030. Therefore, Haitian authorities should formulate appropriate neonatal policies that are meant to improve access to quality neonatal healthcare and ensure availability of medical staff &supplies. Neonatal healthcare program strategies should include regular refresher courses on basic & emergency essential newborn and obstetric care at all levels of the health delivery system.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

Haiti is a low-middle income country that shares the Caribbean Island Hispaniola with the Dominican Republic (MacDonald *et al*. 2021). The country is known for its high maternal mortality rates in the Americas (WHO, 2017; WHO, 2016). In 2015, the country reported 488 maternal deaths per 100 000 live births and a neonatal mortality rate (NMR) of 26 deaths per 1000 live births (UNICEF,2020; WHO, 2016). Being the poorest country in the Caribbean, its economy is heavily dependent on donor funding which then compromises health service delivery especially when donors withdraw their financial aid (Jacobs *et al*. 2016; Ramachandran *et al*. 2015). Over 50 percent of the Haitian population lives below the poverty datum line of below USD 2.41per day (World Bank, 2015). The situation in the country is made worse by lack of access to health services, poor road infrastructure and shortage of skilled medical staff (Schuurmans *et al*. 2021). The objective of this paper is to model and forecast NMR for Haiti using the Box-Jenkins ARIMA model which is appropriate for modelling linear time series data (Nyoni, 2018; Box & Jenkins, 1970). The findings of this study are expected to inform policy, planning and decision making so that appropriate & timeous neonatal interventions are implemented with the aim of reducing NMR to at least 12 per 1000 live birth by 2030.

II. LITERATURE REVIEW

Schuurmans *et al*.(2021)conducted a retrospective cohort study in Haiti to determine the prevalence of maternal death, stillbirth and low birth weight 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 identified the main risk factors for these adverse pregnancy outcomes. The study included pregnant women admitted to Centre de Référence des Urgences Obstétricales between 2013 and 2018 using hospital records. Risk factors investigated were age group, type of pregnancy (singleton, multiple), type of delivery and use of antenatal care services. The findings showed that of all admissions, 10 991 (34.9%) were women with (pre-) eclampsia and the main predictors of adverse pregnancy outcomes were not attending antenatal care, low birth weight and caesarian section in patients with complicated pregnancy. An interrupted time series analysis was done by MacDonald *et al.*(2021) to determine if the new maternity unit brought about improvements in maternal and neonatal outcomes using data collected between July 2016 and October 2019 including 20 months before the opening of the maternity unit and 20 months after. Authors examined maternal neonatal outcomes such as physiological (vaginal) births, caesarean birth, postpartum hemorrhage (PPH),

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maternal deaths, stillbirths and undesirable outcomes (eclampsia, PPH, perineal laceration, postpartum infection, maternal death or stillbirth). The results showed that the new maternity unit led to an upward trend in caesarean births yet an overall reduction in all undesirable maternal and neonatal outcomes. Raymondville *et al*. (2020) conducted a convergent, mixed methods study to assess barriers and facilitators to facility based childbirth at Hôpital Universitaire de Mirebalais (HUM) in Mirebalais, Haiti. Asecondary analyses of a prospective cohort of pregnant women seeking antenatal care at HUM was performed and quantitatively assessed predictors of not having a facility-based childbirth at HUM. The study also prospectively enrolled 30 pregnant women and interviewed them about their experiences delivering at home or at HUM. It was found that living further from the hospital, poverty and household hungerwere associated with not having a facility-based childbirth. Primigravid women were more likely to have a facility-based childbirth. Boulos *et al.*(2017) investigated the aetiology of severe bacterial infections in neonates. Researchers conducted a secondary retrospective analysis of a de-identified database from the Neonatal Intensive Care Unit (NICU) at Nos Petit Fre`res et Soeurs-St. Damien Hospital (NPFS-SDH). Records from 1292 neonates admitted to the NICU at NPFS-SDH in Port-au-Prince Haiti from 2013 to 2015 were reviewed. Sepsis accounted for 708 of 1292 (54.8%) of all admissions to the NICU. The most common organism cultured was Streptococcus agalactiae, followed by Klebsiella pneumoniae, Pseudomonas aeroginusa, Enterobacter aerogenes, Staphylococcus aureus and Proteus mirabillis.

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 Haiti for the period 1960 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 2: Criteria Table

Model Selection Criteria Table			
Dependent Variable: DLOG(H)			
Date: 01/22/22 Time: 14:25			
Sample: 1960 2019			
Included observations: 59			
Model	LogL	AIC*	BIC
(4,2)(0,0)	167.698639	-5.413513	-5.131813
(5,2)(0,0)	167.698738	-5.379618	-5.062706
(5,3)(0,0)	167.698631	-5.345716	-4.993591
(4,5)(0,0)	167.530741	-5.306127	-4.918789
(5,4)(0,0)	167.393891	-5.301488	-4.914150
(1,2)(0,0)	161.321133	-5.299021	-5.122959
(5,1)(0,0)	163.845126	-5.282886	-5.001186
(2,2)(0,0)	161.323542	-5.265205	-5.053930

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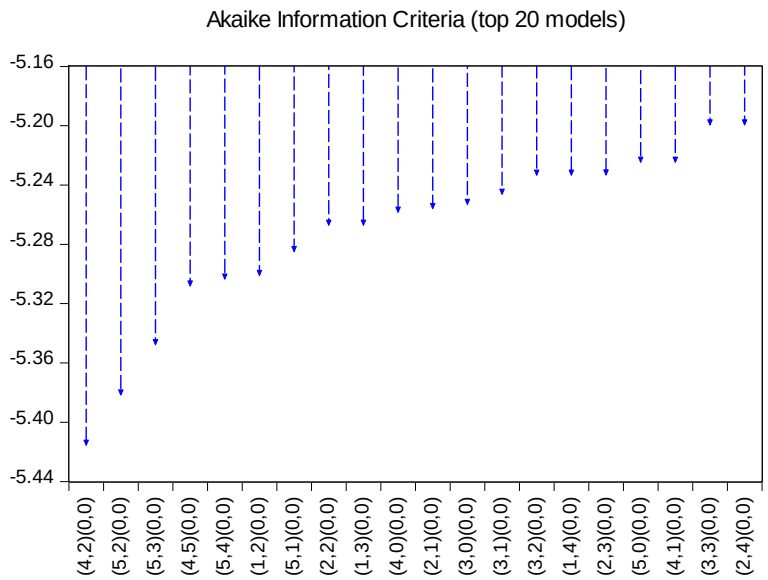
(1,3)(0,0)	161.323450	-5.265202	-5.053927
(4,0)(0,0)	161.065643	-5.256462	-5.045187
(2,1)(0,0)	159.990271	-5.253907	-5.077845
(3,0)(0,0)	159.905681	-5.251040	-5.074978
(3,1)(0,0)	160.703938	-5.244201	-5.032926
(3,2)(0,0)	161.327074	-5.231426	-4.984939
(1,4)(0,0)	161.325020	-5.231357	-4.984869
(2,3)(0,0)	161.322825	-5.231282	-4.984795
(5,0)(0,0)	161.068184	-5.222650	-4.976163
(4,1)(0,0)	161.067086	-5.222613	-4.976126
(3,3)(0,0)	161.326529	-5.197509	-4.915809
(2,4)(0,0)	161.326290	-5.197501	-4.915801

Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

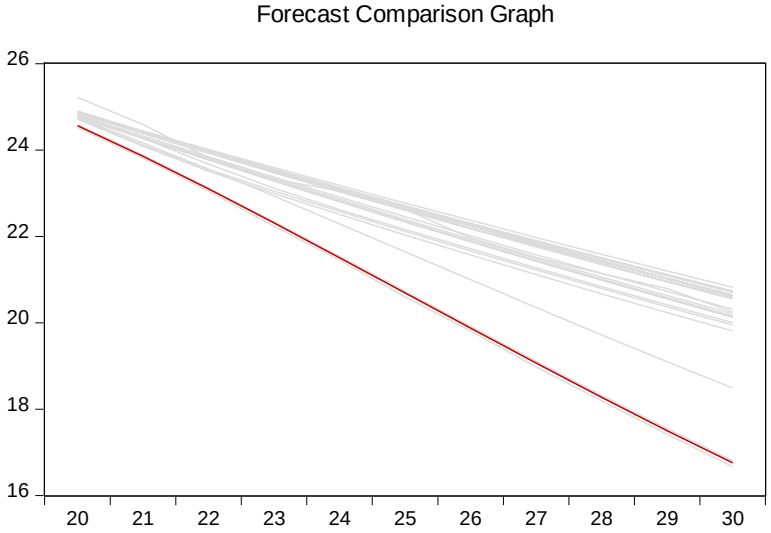


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Table 1 and Figure 1 indicate that the optimal model is the ARIMA (4,1,2) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (4,1,2) model.

IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 5: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	24.56342457260893
2021	23.85674903228602
2022	23.09887211982306
2023	22.31133400655879
2024	21.50640102215587
2025	20.69069354656433
2026	19.87408023267072
2027	19.06504530980298
2028	18.27144384644776
2029	17.50033440356917
2030	16.75777420338993

Table 2 clearly shows that neonatal mortality will gradually decrease from around 25 to approximately 17 deaths per 1000 live births by the end of 2030.

V. POLICY IMPLICATION & CONCLUSION

The achievement of set targets of sustainable development goals by low and middle income countries will remain a challenge given the continued existence of traditional problems such as poverty, hunger, political conflict and occurrence of natural disasters among other perennial problems. The success of maternal and child health programs in different countries is dependent on political commitment, adequate medical supplies, availability of adequate and trained medical staff, favorable working conditions and infrastructure which meets international health standards. In addition, health services should be accessible and affordable to all citizens regardless of political affiliation, ethnicity and color. This study proposed the Box-Jenkins ARIMA approach to model and forecast future trends of neonatal mortality for Haiti and the highlights from the forecast indicate that neonatal mortality will gradually decrease from around 25 to approximately 17 deaths per 1000 live births by the end of 2030. Therefore, the government of Haiti should formulate country specific neonatal policies that are meant to improve access to quality neonatal healthcare and ensure availability of medical staff and medical supplies. Neonatal healthcare program strategies should include regular refresher courses on basic & emergency essential newborn and obstetric care at all levels of the health delivery system.

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