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Using ARIMA Model Forecasts in the Formulation and Implementation of Appropriate Neonatal Healthcare Strategies in France

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***Abstract* - This study uses annual time series data on neonatal mortality rate (NMR) for France 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 (2) variable. The optimal model based on AIC is the ARIMA (0,2,3) model. The ARIMA model predictions indicate that neonatal mortality will slightly increase from 2.8 to around 3.5 deaths per 1000 live births by the end of 2030. Hence, this study encourages policy makers in France to identify and address local neonatal health challenges in order to keep neonatal mortality under control.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

Modelling techniques are essential surveillance tools that caninform policy and implementation of strategies in public health (Teutsch & Churchill, 2000). Several techniques have been applied in literature namely ARIMA, exponential smoothing, VAR, and machine learning methods. There are useful in time series prediction of disease incidences such as TB, HIV, Malaria and other health related problems (Zhao *et al*. 2020; Kaushik & Sahi, 2018; Mooney & Pejaver 2018;Fojnica *et al*. 2016). In this study we propose the Box-Jenkins ARIMA technique to model and predict future trends of neonatal mortality rate (NMR) for France. The ARIMA model is an appropriate technique for modelling linear time series data (Nyoni, 2018; Box-Jenkins, 1970). The model is simple to understand and can be easily applied in various settings like engineering, economics, agriculture and human medicine. The findings of this study are expected to highlight future trends of NMR and help to detect abnormal future trends of NMR early thereby informing neonatal policies to keep neonatal mortality under control in France.

II. LITERATURE REVIEW

Harpur *et al.* (2021) investigated trends in infant mortality rates (IMR) and stillbirth rates by socio-economic position (SEP) in Scotland, between 2000 and 2018, inclusive. Data for live births, infant deaths, and stillbirths between 2000 and 2018 were obtained from National Records of Scotland. Annual IMR and stillbirth rates were calculated and visualized for all of Scotland and when stratified by SEP. Negative binomial regression models were used to estimate the association between SEP and infant mortality and stillbirth events, and to assess for break points in trends over time. The study revealed that IMR fell from 5.7 to 3.2 deaths per 1000 live births between 2000 and 2018, with no change in trend identified. Stillbirth rates were relatively static between 2000 and 2008 but experienced accelerated reduction from 2009 onwards. When stratified by SEP, inequalities in IMR and stillbirth rates persisted throughout the study and were greatest amongst the sub-group of post-neonates.Regression analysis was employed by Jawad *et al.* (2021) to assess the association between conflict and maternal and child health globally.Data for 181 countries (2000–2019) from the Uppsala Conflict Data Program and World Bank were analyzed using panel regression models. The study findings showed that armed conflict is associated with substantial and persistent excess maternal and child deaths globally. Nath *et al.* (2020) examined the effect of extreme prematurity and early neonatal deaths on infant mortality rates in England. Authors used aggregate data on all live births, stillbirths and linked infant deaths in England in 2006–2016 from the Office for National Statistic. Infant mortality decreased from 4.78 deaths/1000 live births in 2006 to 3.54/1000 in 2014 (annual decrease of 0.15/1000) and increased to 3.67/1000 in 2016 (annual increase of 0.07/1000). This rise was driven by increases in deaths at 0–6 days of life. Wallace *et al.* (2020) investigated infant mortality among native-born children of immigrants in France for the period 2008–17. A nationally representative socio-demographic panel consisting of 296 400 births and 980 infant deaths for the period 2008–17 was used. Children of immigrants were defined as being born to at least one parent born abroad and their infant mortality was compared with that of children born to two parents born in France. Data was analyzed using multilevel logit

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models and the study results showed that there was a substantial amount of excess infant mortality among those children born to at least one parent from Eastern Europe, Northern Africa, Western Africa, Other Sub-Saharan Africa and the Americas, with variation among specific origin countries belonging to these groups. Zeitlin *et al. (*2020) investigated the patterns of stillbirth and neonatal mortality rates in Europe between 2004 and 2010. Data about live births, stillbirths and neonatal deaths by gestational age (GA) were collected using a common protocol by the Euro-Peristat project in 2004 and 2010. The study indicated that stillbirths and neonatal deaths declined at all gestational ages in countries with both high and low levels of mortality in 2004

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 France 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 1: Criteria Table

Model Selection Criteria Table			
Dependent Variable: DLOG(F, 2)			
Date: 01/22/22 Time: 13:49			
Sample: 1960 2019			
Included observations: 58			
Model	LogL	AIC*	BIC
(0,3)(0,0)	135.624641	-4.504298	-4.326674
(2,5)(0,0)	139.304640	-4.493263	-4.173540
(1,4)(0,0)	137.239605	-4.491021	-4.242347
(5,1)(0,0)	137.961314	-4.481425	-4.197226
(0,4)(0,0)	135.627314	-4.469907	-4.256758
(1,3)(0,0)	135.626389	-4.469875	-4.256726
(1,5)(0,0)	137.564264	-4.467733	-4.183534
(5,2)(0,0)	138.559348	-4.467564	-4.147840
(2,1)(0,0)	134.510258	-4.465871	-4.288247
(0,5)(0,0)	136.390698	-4.461748	-4.213074
(4,4)(0,0)	139.175748	-4.454336	-4.099087
(2,3)(0,0)	136.174572	-4.454296	-4.205621
(3,4)(0,0)	137.728242	-4.438905	-4.119181
(3,1)(0,0)	134.582170	-4.433868	-4.220719
(2,2)(0,0)	134.582149	-4.433867	-4.220718
(5,4)(0,0)	139.341270	-4.425561	-4.034787

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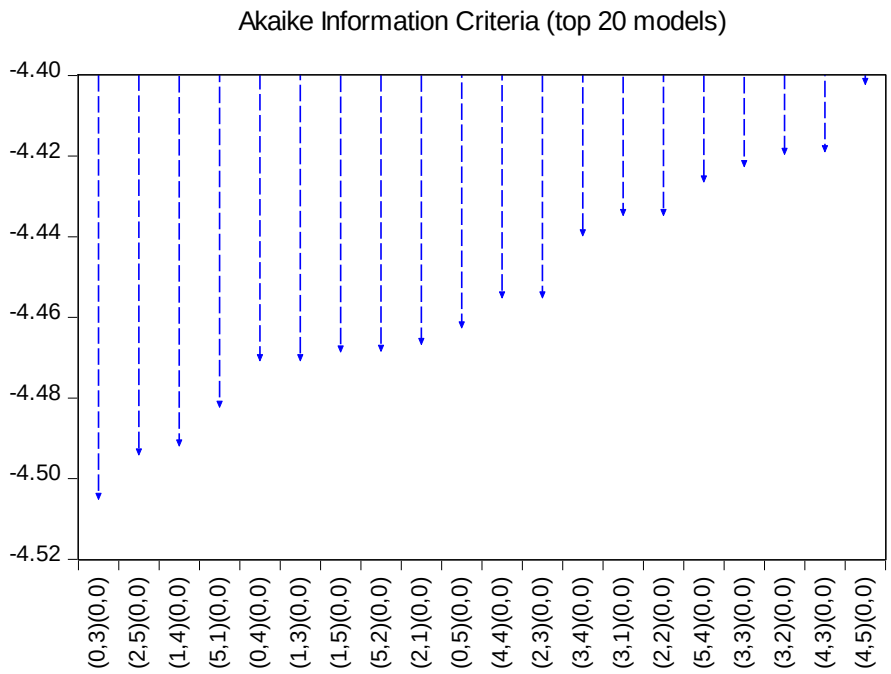
(3,3)(0,0)	136.230452	-4.421740	-4.137541
(3,2)(0,0)	135.143202	-4.418731	-4.170057
(4,3)(0,0)	137.124641	-4.418091	-4.098367
(4,5)(0,0)	138.639156	-4.401350	-4.010577

Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

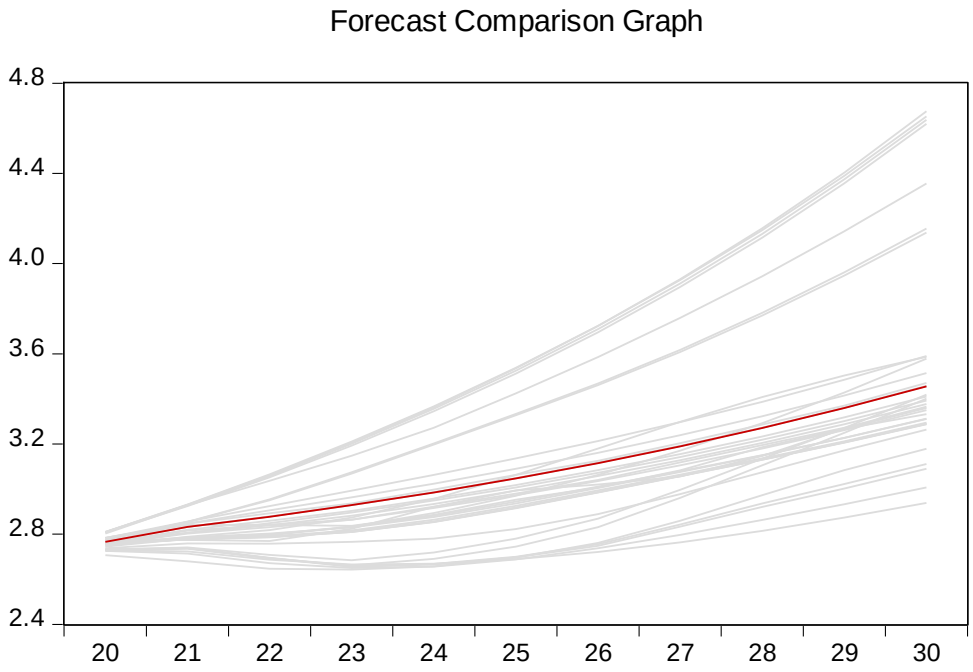


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Table 1 and Figure 1 indicate that the optimal model is the ARIMA (0,2,3) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (0,2,3) model.

IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	2.765418055440352
2021	2.83164681219458
2022	2.877472280423111
2023	2.928473403032674
2024	2.984897962879169
2025	3.047023230655511
2026	3.115158231968496
2027	3.1896463032043
2028	3.270867965714454
2029	3.35924415191136
2030	3.455239821423124

Table 2 clearly indicates that neonatal mortality will slightly increase from 2.8 to around 3.5 deaths per 1000 live births by the end of 2030.

V. POLICY IMPLICATION & CONCLUSION

Time series forecasting is a useful tool in surveillance of public health problems including neonatal mortality. ARIMA model, a popular statistical and econometric technique has been proven to produce accurate and reliable results in the analysis of linear time series data. This study utilizes this approach to predict future trends of NMR for France and the findings indicate thatneonatal mortality will slightly increase from 2.8 to around 3.5 deaths per 1000 live births by the end of 2030. Hence, this study encourages policy makers in France to identify and address local neonatal health challenges in order to keep neonatal mortality under control.

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