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Tracking Fiji's Future Progress towards Achieving Substantial Reduction of under Five Mortality By 2030 Using Holt's Linear Method

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***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for Fiji Islands from 1960 to 2020 to predict future trends of U5MR over the out of sample period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the applied model is stable in forecasting U5MR in Fiji Islands. The Holt's linear exponential smoothing model was applied in this study to forecast future trends of U5MR. The optimal values for the smoothing constants α and β are 0.9 and 0.1 respectively based on minimum MSE. The double exponential smoothing model projections suggest that U5MR will increase over the out of sample period. Therefore, we encourage health authorities in Fiji to urgently respond to the likely future increase in under five mortality by allocating more resources to the maternal and child health (MNCH) program in order to reverse the projected undesirable future trends of U5MR. The government should quickly identify and address factors that significantly contribute to mortality among under five children.**

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

The focus of all UN member states should be directed towards addressing the current challenges affecting different populations around the world. Issues highlighted in the Agenda 2030 for sustainable development should not be ignored to ensure peace, security, health and prosperity on this planet (UN, 2016; UN, 2015). The current unemployment levels in various countries is a cause for concern as we continue to witness women and children being forced into commercial sex work and child labor. In Sub-Saharan Africa, school dropouts are being driven by poverty and hunger, and long walking distances to schools. Many adolescents and young adults have destroyed their lives by engaging into unprotected sex which leads to adverse maternal and child health outcomes ((Mulye *et al.* 2009; WHO, 2008; Negash *et al.* 2016). Drug and substance abuse has become a huge problem with many youths being diagnosed of substance induced psychosis. All these challenges require urgent attention, therefore all UN member states should accelerate their efforts in implementing all the 17 objectives of the Agenda 2030 for sustainable development in order achieve all the 169 targets by 2030 (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). The objective of this study is to forecast future trends of under-five mortality rate for Fiji Islands using the Holt's linear exponential smoothing method with the aim of reducing adverse child health outcomes in Fiji.

II. LITERATURE REVIEW

Reis *et al*. (2021) evaluated the fetal and infant mortality rates due to congenital anomalies (CA) in Maranhão from 2001 to 2016 in Brazil. Data were obtained from the SINASC, and SIM databases. The study used simple linear regression, Poisson distribution, and ANOVA (Bonferroni's post hoc test) and analyzed the public data (2001–2016) of 1934858 births and determined the fetal, neonatal, perinatal, and post-neonatal mortality rates associated with CA by mesoregions. The results indicated mortality rates due to CA in Maranhão increased over the period 2001–2016 possibly as a result of improved maternal-infant health conditions eliminating other causes of death. Nath *et al.* (2020) examined the effect of extreme prematurity and early neonatal deaths on infant mortality rates in England. The study 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. Iriondo *et al.* (2020) developed and validated different mortality predictive models, using Spanish data, to be applicable to centers with similar morbidity and mortality. Infants born alive, admitted in NICU, and registered in the SEN1500 database, were included. Multivariable regression models were used for the different time periods. The study concluded that using dynamic models to predict individual mortality can improve outcome estimations. Development of models in the prenatal period, first 24 hours, and during hospital admission, cover key stages of mortality prediction in preterm infants. In a 2019 study, Souza *et al* investigated the determinants of neonatal mortality in Foz do Iguassu in Brazil. The authors analyzed all neonatal deaths that occurred in Foz do Iguassu from 2012 to 2016. Birth and mortality data were extracted from two national governmental databases (SINASC and SIM). It was found that high rate of neonatal death

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in Foz do Iguassu is strongly associated with newborn characteristics and not associated with maternal socio-demographic characteristics. Caluza (2018) utilized data mining technique using decision tree called J48 algorithm in classifying child mortality rate, life expectancy at birth, annual population growth, and the gross domestic product. Results revealed that annual population growth is highly correlated in predicting child mortality and generate three distinct rules. The generated model had high acceptability with 97.4% ROC curve result of the three classes in predicting child mortality under five years old.

III. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of under-five mortality rate in Fiji Islands. In exponential smoothing forecasts are generated from the smoothed original series with the most recent historical values having more influence than those in the more distant past as more recent values are allocated more weights than those in the distant past. This study uses the Holt's linear method (Double exponential smoothing) because it is an appropriate technique for modeling linear data.

$J_t = \mu_t + b_t t + \varepsilon_t$

Smoothing equation

$L_t = \alpha J_t + (1-\alpha)(L_{t-1} + b_{t-1})$

Trend estimation equation

$T_t = \beta (L_t - L_{t-1}) + (1-\beta) b_{t-1}$

Forecasting equation

$f_{t+h} = L_t + h b_t$

J_t is the actual value of time series at time t

L_t is the exponentially smoothed value of time series at time t

α is the exponential smoothing constant for the data

β is the smoothing constant for trend

f_{t+h} is the h step ahead forecast

T_t is the trend estimate

Data Issues

This study is based on annual under five mortality rate in Fiji Islands for the period 1960 – 2020. The out-of-sample forecast covers the period 2021 – 2030. All the data employed in this research paper was gathered from the World Bank online database.

IV. FINDINGS OF THE STUDY

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	J
Included Observations	61 (After Adjusting Endpoints)
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	1.027530

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Sum Square Error (SSE)	300.864706
Mean Square Error (MSE)	4.932208
Mean Percentage Error (MPE)	0.984475
Mean Absolute Percentage Error (MAPE)	2.408150

Residual Analysis for the Applied Model

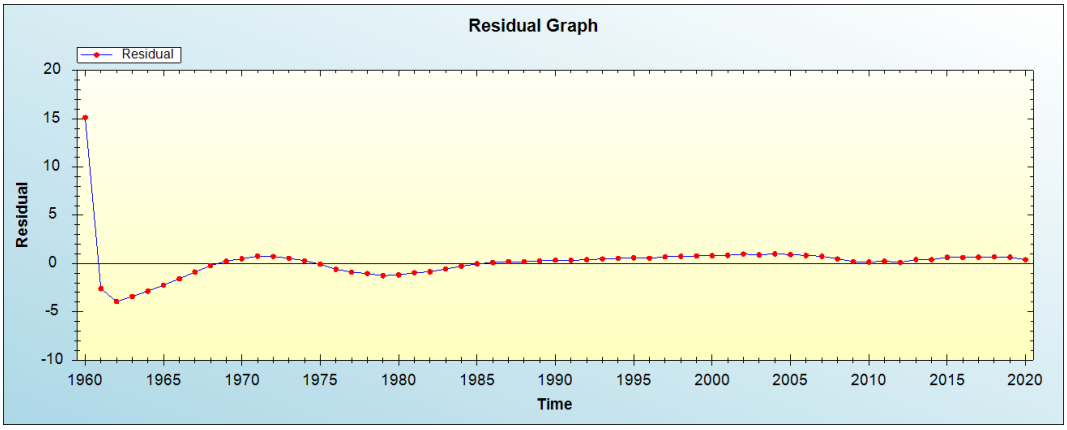

Figure 1: Residual analysis

In-sample Forecast for J

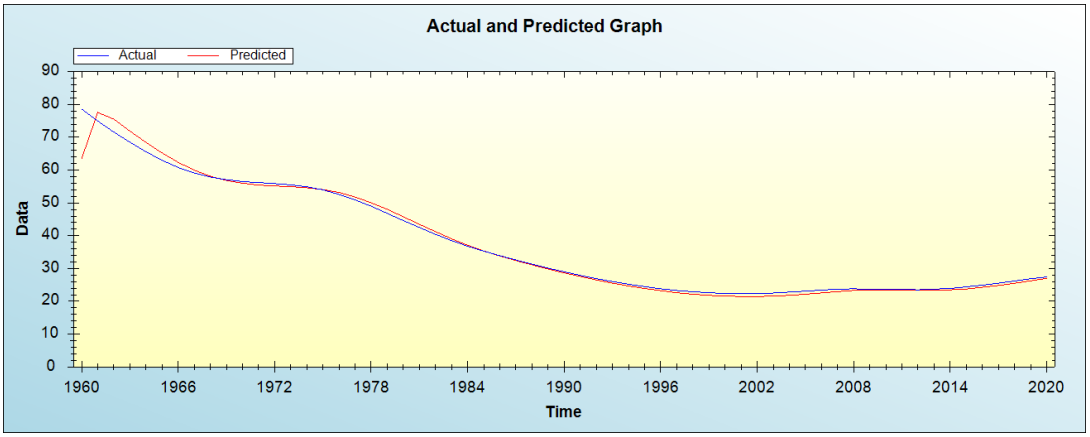

Figure 2: In-sample forecast for the J series

Actual and Smoothed graph for J series

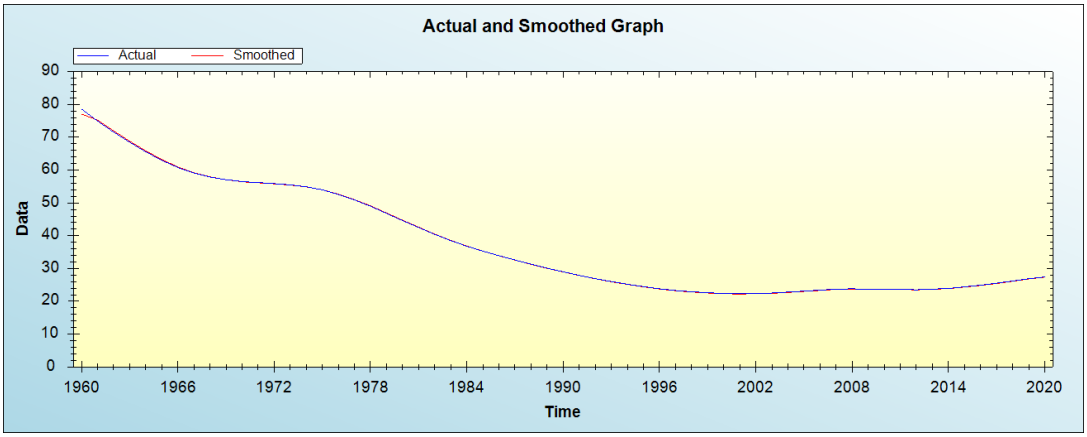

Figure 3: Actual and smoothed graph for J series

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Out-of-Sample Forecast for J: Actual and Forecasted Graph

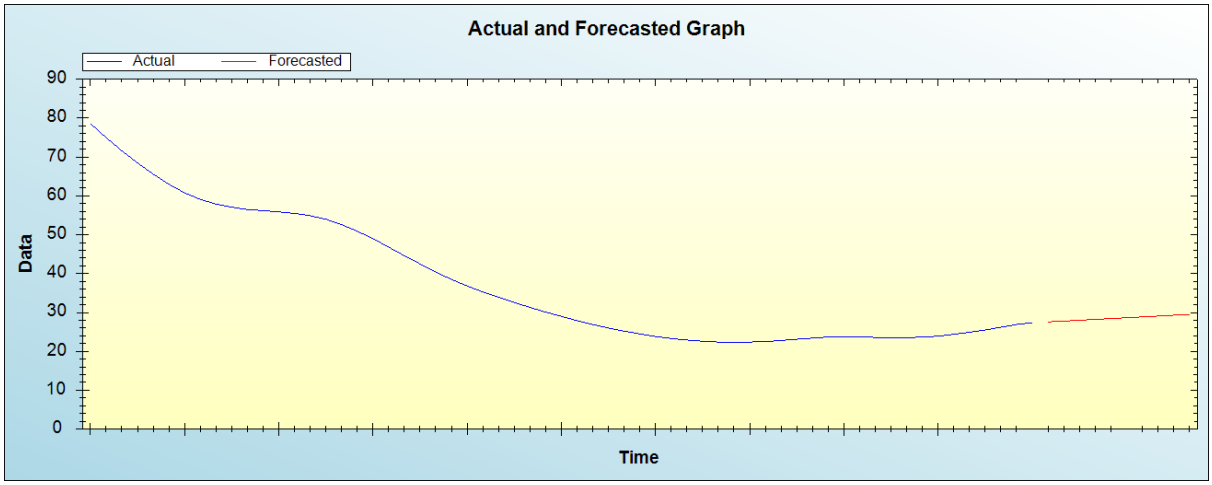

Figure 4: Out-of-sample forecast for J: actual and forecasted graph

Out-of-Sample Forecast for J: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	27.5741
2022	27.7870
2023	27.9998
2024	28.2127
2025	28.4255
2026	28.6384
2027	28.8512
2028	29.0641
2029	29.2769
2030	29.4898

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that annual under five mortality rate will increase over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Under-five mortality is a global public health problem which requires all stakeholders to contribute to its eradication. Underlying poverty, hunger and economic challenges will make it difficult to reach the desired SDG targets by 2030. Political leaders must be sensitized on this important problem to facilitate smooth implementation of strategies that are aimed at reducing mortality among under five children. This study proposes the double exponential smoothing model to forecast future trends of under-five mortality rate in Fiji. The Forecast results suggest that under five mortality rate will increase over the out of sample period. Hence, the government of Fiji should quickly respond to the undesirable projected trends of under-five mortality by addressing all the major drivers of mortality among under five children.

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