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# Maldives's Success Story in Controlling Under Five Mortality: Evidence From The Holt's Linear Method

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***Abstract* - This study uses annual time series data on under five (U5MR) for Maldives from 1962 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and model evaluation statistics indicate that the applied Holt's linear method is stable in forecasting U5MR in Maldives. The optimal values of smoothing parameters α and β are 0.9 and 0.2 respectively based on minimum MSE. The double exponential smoothing model projections revealed that under five mortality will be under control throughout the out of sample period. Therefore, we implore the government of Maldives to address all the existing challenges that contribute to mortality among under five children in order to keep under five mortality under control.**

***Keywords:*** Exponential smoothing, Forecasting, U5MR.

## I. INTRODUCTION

During this era of sustainable development goals (SDGs) it is critical to recognize the importance of time series forecasting techniques in the formulation of policies, planning and allocation of resources. Times series prediction acts as an early surveillance tool that helps in the detection of abnormal trends of diseases and other health related events (Zhao *et al*. 2020; Panch *et al.* 2018; Zhou *et al.* 2018). Accurate and reliable forecasts are dependent on the quality of the data, hence national statistical systems are encouraged to play an effective leadership and coordinative role. There must be supervision of all basic statistical activities and programs. SDG 3 focuses on good health and promotion of well-being for all at all ages (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015). SDG 3 target 3.2 aims at the substantial reduction of neonatal and under five deaths to as low as 12 neonatal deaths per 1000 live births and 25 under deaths per 1000 live births by 2030 (Ouedraogo *et al*. 2020; UNICEF, 2019;Gulmezoglu *et al*. 2016). This study applies the Holt's linear exponential smoothing method by utilizing univariate time series data on under five mortality rate for Maldives. The findings are expected to guide policy and resource allocation so as to end all preventable under five deaths.

## 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. Weiland *et al.* (2021), in Portugal, examined the effects of the 2006 National Program of Maternal and Neonatal Health policy on spatial inequalities in access to care and consequently avoidable infant mortality. A thematic analysis of qualitative data including interviews and surveys and a quantitative spatial analysis using Geographic Information Systems was applied. Spatial inequalities were found which may lead to avoidable infant mortality. Inequalities exist in freedom of choice and autonomy in care, within a medicalized system. Bandeira *et al*. (2016) described Portugal's achievements in the maternal and child health program. The study highlighted that the joint venture of pediatricians and obstetricians with adequate top-down government commissions for maternal and child health for the decision making by health administrators and a well-defined schedule of preventive and managerial measures in the community and in hospitals, registry of special diseases and training of medical personnel are the most likely explanations for this success. Another study descriptive study in Portugal was done by Guimarães (2015) who outlined the contribution of Portuguese reform of perinatal healthcare in the reduction of perinatal mortality. The author highlighted that the organization in primary, secondary and tertiary healthcare resulted in the improvement of perinatal care centered on both mother and child needs.

 

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## III. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of under-five mortality rate in Maldives. 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.

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

*Smoothing equation*

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

*Trend estimation equation*

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

*Forecasting equation*

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

$M_t$ is the actual value of time series at time t

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

$\alpha$ is the exponential smoothing constant for the data

$\beta$ 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 Maldives for the period 1962– 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 | M |
|---|---|
| Included Observations | 59 (After Adjusting Endpoints) |
| | |
| Smoothing constants | |
| Alpha (α) for data | 0.900 |
| Beta (β) for trend | 0.200 |
| | |
| Forecast performance measures | |
| | |
| Mean Absolute Error (MAE) | 3.250288 |
| Sum Square Error (SSE) | 3703.180679 |
| Mean Square Error (MSE) | 62.765774 |
| Mean Percentage Error (MPE) | 2.909510 |
| Mean Absolute Percentage Error (MAPE) | 4.125626 |

 

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Residual Analysis for the Applied Model

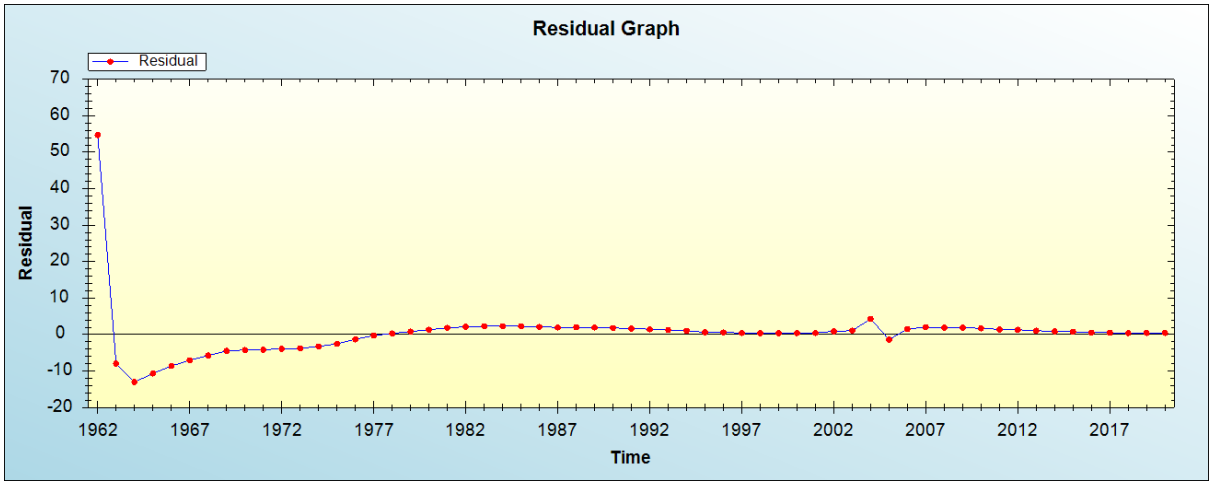


Figure 1: Residual analysis

In-sample Forecast for M

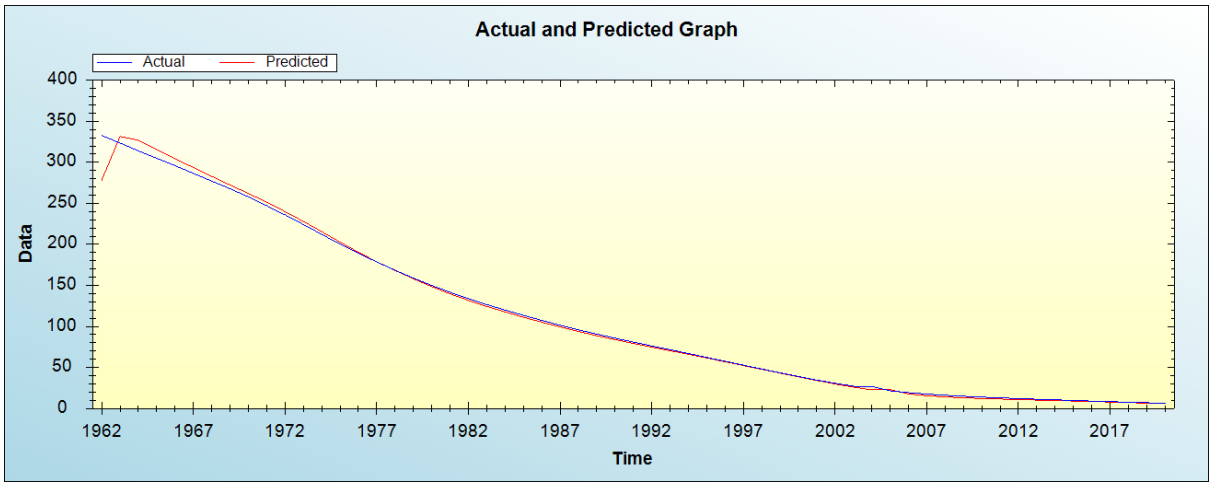


Figure 2: In-sample forecast for the M series

Actual and smoothed graph for M

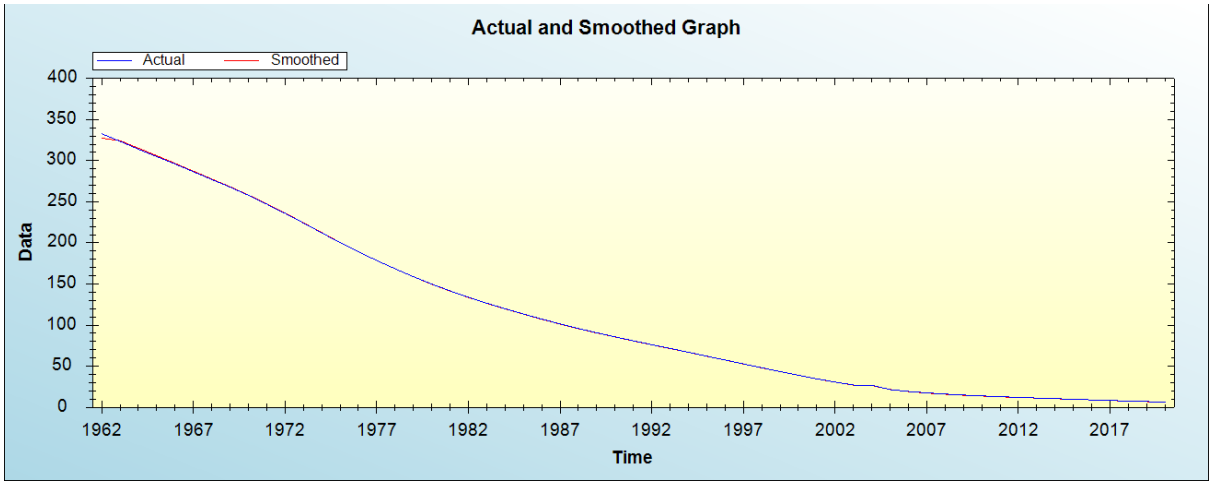


Figure 3: Actual and smoothed graph for M

 

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

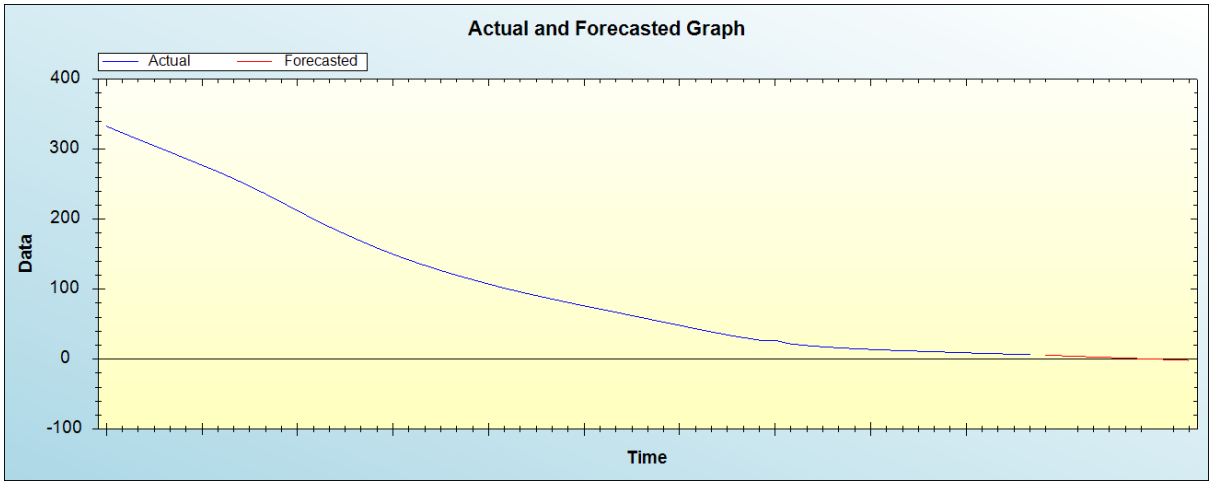


Figure 4: Out-of-sample forecast for M: actual and forecasted graph

Out-of-Sample Forecast for M: Forecasts only

Table 2: Tabulated out-of-sample forecasts

| | |
|---|---|
| 2021 | 5.6242 |
| 2022 | 4.7940 |
| 2023 | 3.9638 |
| 2024 | 3.1335 |
| 2025 | 2.3033 |
| 2026 | 1.4731 |
| 2027 | 0.6428 |
| 2028 | -0.1874 |
| 2029 | -1.0176 |
| 2030 | -1.8479 |

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 under five mortality will be under control throughout the out of sample period.

## V. POLICY IMPLICATION & CONCLUSION

The government of Maldives has made significant progress towards achieving all the set targets under the 3rd sustainable development goal (SDG-3). Over the years the country has witnessed a downward trend in under five and neonatal mortality as a result of concrete measures implemented by the government. Forecasting under five mortality rate using the Holt's linear method will guide child health policies, decisions and allocation of resources. The results of this study revealed that under five mortality will be under control throughout the out of sample period. Therefore, we encourage the government of Maldives to address all the existing challenges in order to keep under five mortality under control.

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