

## PROJECTION OF ANNUAL MATERNAL MORTALITY RATE FOR MALAYSIA USING THE DOUBLE EXPONENTIAL SMOOTHING MODEL

Smartson. P. NYONI <sup>1</sup>

Thabani NYONI <sup>2</sup>

<sup>1</sup>Independent Researcher & Medical Doctor, Harare, Zimbabwe

<sup>2</sup>Independent Researcher & Health Economist, Harare, Zimbabwe

### ABSTRACT

This study uses annual time series data on MMR for Malaysia from 1985 to 2023 to predict future trends of MMR over the period 2024 to 2035. The study utilizes Holt's double exponential smoothing model. The optimal values of smoothing constants  $\alpha$  and  $\beta$  are 0.4 and 0.1 respectively based on minimum MSE. The results of the study indicate that MMR will decline from around 33.8 in 2024 to about 35.2 deaths per 100 000 live births by 2035. Therefore, we encourage authorities to continuously address local causes of maternal mortality.

**Keywords:** Exponential smoothing, Forecasting, Maternal Mortality Ratio.

### INTRODUCTION

Ending preventable maternal deaths is an initiative of all UN member states who signed the 2015 outcome document- "Agenda 2030 for Sustainable Development" which has 17 goals and associated targets. The third sustainable goal, target. 3.1 encourages governments around the world to lower global maternal mortality to levels below 70 per 100 000 live births by 2030 (WHO, 2013). According to WHO, in relation to upper middle-income countries, maternal mortality ratio (MMR) in Malaysia is comparable to China, and has lower MMR compared to Thailand, Egypt and Argentina (WHO, 2019). The Ministry of Health Malaysia, in 2004 highlighted that the maternal mortality ratio dropped from 530 per 100,000 live births in 1957 to 148 per 100,000 in 1970 and 30 per 100,000 live births in 2000. After 2000, Malaysia continued to lower maternal mortality ratio. In 2019, the maternal mortality ratio in Malaysia was at 21.1 maternal deaths per 100 000 live births (KPWKM, 2019). In 2017, UNICEF data indicated that Malaysia had the second lowest maternal mortality ratio in South East Asia region, ranked below Singapore (WHO, 2019). This substantial progress is attributed to improvements in access to quality health services, increased professional skills of trained delivery attendants to manage pregnancy and delivery complications, investments in upgrading the quality of essential obstetric care in district hospitals, improved efficiency of referral and feedback systems to prevent delays, close engagement with communities to remove socio cultural barriers, improved acceptability of modern maternal health services and improved monitoring system (Achanna et al. 2018). The purpose of this paper is to model and forecast future trends of maternal mortality for Malaysia using the double exponential smoothing model. The results of this study are anticipated to stimulate an appropriate national response in order to eliminate all preventable maternal deaths.

## LITERATURE REVIEW

| Author (s)               | Objective(s)                                                                                                                                                        | Methodology                                                                                             | Main finding(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mackin et al. (2026)     | to understand how levels of MNH care are organized in different country contexts                                                                                    | Scoping review                                                                                          | Three or four levels of MNH facility care were most commonly reported. Linking maternal and newborn facility care to community connections is an important consideration to ensure equitable access to routine and emergency care                                                                                                                                                                                                                                                                                                      |
| Al-Taïar et al. (2025)   | to assess the prevalence of anemia in pregnant women and its associated factors in the Kuwait Birth Cohort study                                                    | Prospective cohort study                                                                                | -The prevalence of anemia was 28.16% (95% CI:25.53–30.91%), with 8.75% of women experiencing moderate anemia and 19.40% mild anemia. No cases of severe anemia were observed<br>-Multivariable analysis identified current iron supplement use, (Adjusted Odds Ratio [AOR] 0.52, 95%CI:0.28–0.99; $p = 0.049$ ), vitamin D status (sufficient vs. insufficient/deficient), (AOR 0.63, 95%CI:0.43–0.92; $p = 0.018$ ), iron levels ( $p < 0.001$ ), and ferritin levels ( $p < 0.001$ ) as factors significantly associated with anemia |
| Cresswell et al. (2025)  | To obtain updated evidence on causes of maternal death to accelerate SDG progress                                                                                   | conducted a multi-strategy systematic review to identify causes of maternal deaths occurring in 2009–20 | Hemorrhage remains the leading cause of death, despite the existence of effective clinical interventions, emphasizing the need for improved access to quality health care                                                                                                                                                                                                                                                                                                                                                              |
| Hamdan et al. (2025)     | To describe postpartum Hemorrhage Burden, Management and Challenges in Malaysia                                                                                     | Scoping review                                                                                          | the review identified critical gaps in blood loss estimation methods, with visual estimation being unreliable and leading to underdiagnosis, while patient intrinsic factors such as uterine atony, retained placenta, and placenta accreta spectrum disorders contribute to treatment complexity.                                                                                                                                                                                                                                     |
| Kama et al. (2025)       | to establish the period prevalence of MNM and mortality index, and to compare near-miss cases with maternal mortality and to identify their risk factors and causes | Cross-sectional study                                                                                   | The leading causes of MNM were eclampsia (47.8%), abruptio placentae (19.7%) and postpartum hemorrhage (8.3%), and the leading causes of maternal death were eclampsia (29.2%), puerperal sepsis (25%) and postpartum hemorrhage (12.5%)                                                                                                                                                                                                                                                                                               |
| Bhalotra & Clarke (2024) | to investigate the association of women's education with maternal and child mortality                                                                               | Panel regression                                                                                        | moving an additional 1 percentage point of women into primary education reduces rates of maternal death by 4.6%, and reduces the rate of infant deaths by 1.9%                                                                                                                                                                                                                                                                                                                                                                         |
| Duka et al. (2024)       | to quantify the inequalities in the distribution of nurses in Albania, analyzing the nurse-to-population                                                            | Descriptive analytic study                                                                              | The average nurse-to-population ratio in Albania is 28 nurses per 10,000 inhabitants, with significant variations between regions. Tirana has the highest ratio (60 nurses per                                                                                                                                                                                                                                                                                                                                                         |

|                          |                                                                                                                                   |                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                       |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                          | ratio and its impact on the quality of healthcare                                                                                 |                                                                                                                                                                                                                                                                                                           | 10,000 in habitants), while Kukës and Dibër have the lowest values (10 per 10,000 inhabitants)                                                                                                                                                                                                                                        |
| Chin et al. (2023)       | to understand the demography, case characteristics and causes of maternal mortality in Sabah from 2015 through 2020               | Retrospective study                                                                                                                                                                                                                                                                                       | Majority of deceased women, 56.7%, never attended antenatal visits prior to their death in the latest pregnancy. Overall, 63.88% deaths were due to direct obstetric causes, postpartum hemorrhage was the leading direct cause of death (24.53%), and most of the maternal deaths (65.5%) were preventable                           |
| Diguisto et al. (2022)   | to compare maternal mortality in eight countries with enhanced surveillance systems                                               | Descriptive multi-country population-based study.                                                                                                                                                                                                                                                         | Variations in maternal mortality ratios exist between high income European countries with enhanced surveillance systems. In-depth analyses of differences in the quality of care and health system performance at national levels are needed to reduce maternal mortality further by learning from best practices and each other      |
| Pouyanfar et al. (2022)  | to investigate the factors affecting the maternal mortality ratio (MMR) in different regions of Iran                              | Systematic review                                                                                                                                                                                                                                                                                         | The leading causes of maternal death were hemorrhage (43.7%), preeclampsia/eclampsia (24.5%), other hypertensive disorders (24%), and embolism (22.8%)                                                                                                                                                                                |
| Gabrani et al. (2020)    | to identify key factors influencing the utilization of governmental and private primary healthcare services in Albania            | cross-sectional health facility survey using a 4-point Likert scale questionnaire to rank the importance of factors driving services utilization.                                                                                                                                                         | The use of primary healthcare is strongly influenced by geographical and financial access for public facility users and availability of equipment for private users. This study found that aspects of acceptability and adequacy of services are equally valued                                                                       |
| Norhayati et al. (2016)  | to study severe maternal morbidity and maternal near miss among women in two tertiary hospitals in Kota Bharu, Kelantan, Malaysia | A cross-sectional study with record review was conducted in 2014. Severe maternal morbidity and maternal near miss were classified using the new World Health Organization criteria. Health indicators for obstetric care were calculated and descriptive analyses were performed using SPSS version 22.0 | The maternal near miss mortality ratio was 23.5 and the mortality index was 4.1 %. The process indicators for essential interventions were almost 100.0 %. Hemorrhagic disorders were the most common event for severe maternal morbidity (68.6 %) and maternal near miss (80.9 %) and management-based criteria accounted for 85.1 % |
| Tamburlini et al. (2011) | to identify issues in maternal and neonatal care and promote action                                                               | -A standard based tool was utilized                                                                                                                                                                                                                                                                       | Neonatal care scored better than obstetric care                                                                                                                                                                                                                                                                                       |

## METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for Malaysia. 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.

Holt's linear method is specified as follows:

Model equation

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

Smoothing equation

$$S_t = \alpha M_t + (1-\alpha) (S_{t-1} + b_{t-1})$$

$$0 < \alpha < 1$$

Trend estimation equation

$$b_t = \beta (S_t - S_{t-1}) + (1-\beta)b_{t-1}$$

$$0 < \beta < 1$$

Forecasting equation

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

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

$\varepsilon_t$  is the time varying **error term**

$\mu_t$  is the time varying mean (**level**) term

$\rho_t$  is the time varying **slope term**

$t$  is the trend component of the time series

$S_t$  is the exponentially smoothed value of MMR 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

$b_t$  is the trend estimate (slope of the trend) at time  $t$

$b_{t-1}$  is the trend estimate at time  $t-1$

## Data Issues

This study is based on annual MMR in Malaysia for the period 1985– 2023. The out-of-sample forecast covers the period 2024 – 2035. All the data employed in this research paper was gathered from the World Bank online database.

## Findings of the study

### Exponential smoothing Model Summary

Table 1: ES model summary

| Variable                              | M          |
|---------------------------------------|------------|
| Included Observations                 | 39         |
| <b>Smoothing constants</b>            |            |
| Alpha ( $\alpha$ ) for data           | 0.400      |
| Beta ( $\beta$ ) for trend            | 0.100      |
| <b>Forecast performance measures</b>  |            |
| Mean Absolute Error (MAE)             | 2.604606   |
| Sum Square Error (SSE)                | 988.493731 |
| Mean Square Error (MSE)               | 25.345993  |
| Mean Percentage Error (MPE)           | 0.931409   |
| Mean Absolute Percentage Error (MAPE) | 6.553957   |

### Residual Analysis for the Applied Model

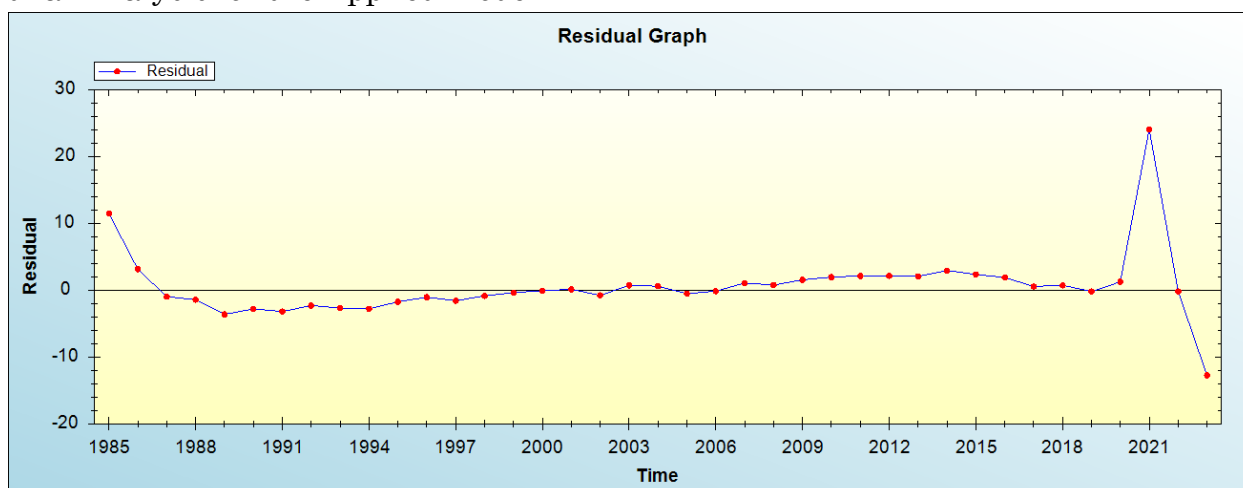


Figure 1: Residual analysis

### In-sample Forecast for M

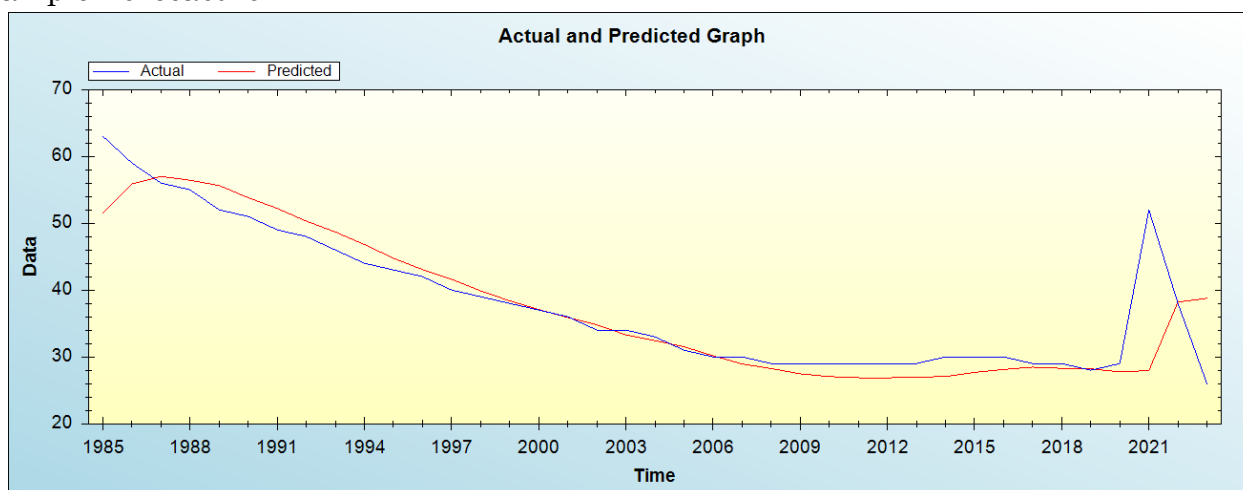


Figure 2: In-sample forecast for the M series

## Actual and Smoothed graph for M series

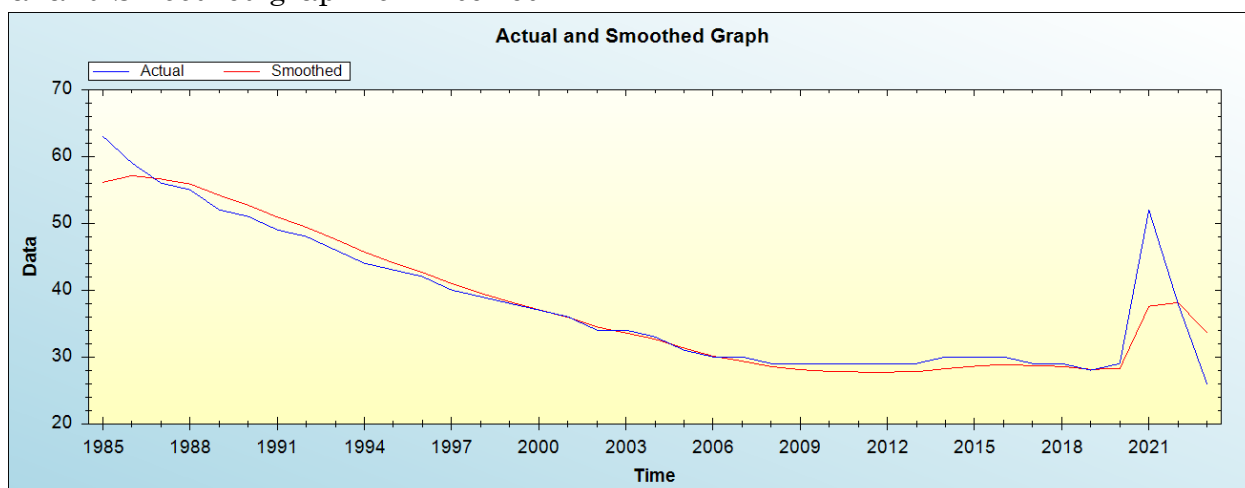


Figure 3: Actual and smoothed graph for M series

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

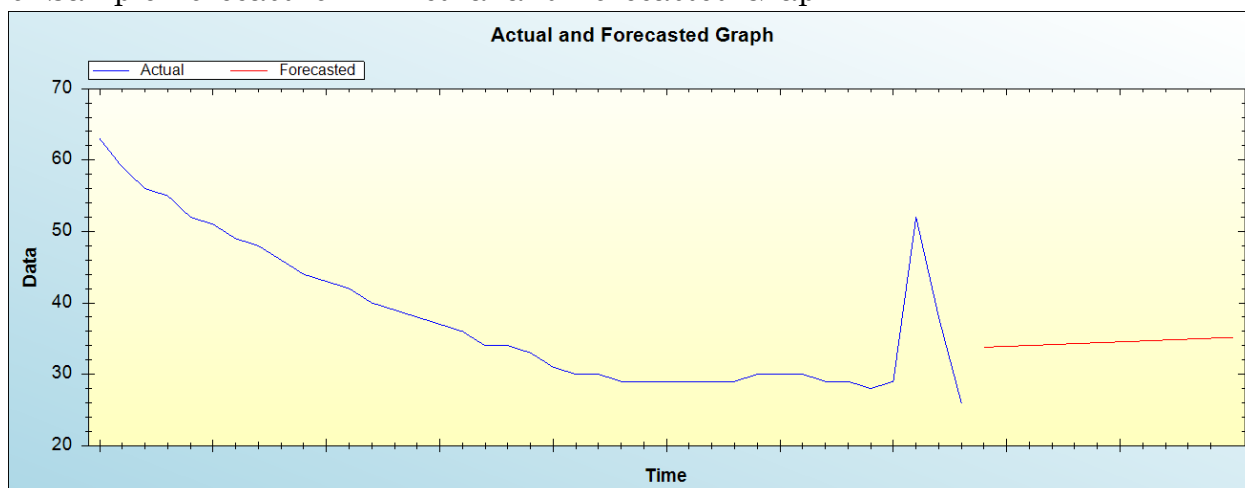


Figure 4: Out-of-sample forecast for M: actual and forecasted graph

## Out-of-Sample Forecast for M: Forecasts only

Table 2: Tabulated out-of-sample forecasts

| Year | Forecasted MMR |
|------|----------------|
| 2024 | 33.7837        |
| 2025 | 33.9099        |
| 2026 | 34.0361        |
| 2027 | 34.1623        |
| 2028 | 34.2886        |
| 2029 | 34.4148        |
| 2030 | 34.5410        |
| 2031 | 34.6672        |
| 2032 | 34.7934        |
| 2033 | 34.9197        |
| 2034 | 35.0459        |
| 2035 | 35.1721        |

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 MMR will slightly increase from around 33.8 in 2024 to about 35.2 deaths per 100 000 live births by 2035.

### RECOMMENDATIONS & CONCLUSION

Maternal mortality rates in Malaysia are generally very low reflecting high quality maternal healthcare services. This study uses the double exponential smoothing method to forecast MMR for Malaysia and findings suggest that MMR will slightly increase from around 33.8 in 2024 to around 35.2 deaths per 100 000 live births by 2035. Hence, authorities are encouraged to continue addressing local drivers of maternal deaths to keep maternal mortality under control.

### REFERENCES

1. Achanna S., Krishnaswamy G., Ponnampalam P., and Bondhu A (2018). Maternal Mortality in Malaysia: Progress Millennium Development Goal (MDG) 5 – An Analysis of Published Data. Knowl Enterp Inc Journals [Internet]. 6(2):1–14. Available from: [i.org/index.php/mra](http://i.org/index.php/mra)
2. KPWKM (2019). Perangkaan Wanita, keluarga dan Masyarakat. Kementerian Pembang Wanita, Kel dan Masy.
3. Ministry of Health Malaysia (2004). Malaysia's Health 2004.
4. WHO (2019). World Health Organization, UNICEF, UNFPA WBG and the UNPD. Trends in maternal 2000 to 2017: estimates [Internet]. Sexual and Reproductive Health. 2019. 12 p. Available from: <https://www.who.int/reproductivehealth/publications/maternal-mortality-2000-2017/en/>
5. World Health Organization (2013). Strategies toward ending preventable maternal mortality (EPMM). 2015;6736(2013):1–4.