



PREDICTION OF MATERNAL MORTALITY FOR BURKINA FASO USING THE DOUBLE EXPONENTIAL SMOOTHING TECHNIQUE

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Abstract:

This study uses annual time series data on MMR for Burkina Faso 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 α and β are 0.9 and 0.1 respectively based on minimum MSE. The results of the study indicate that MMR will decline but still remain high throughout the out of sample period. Therefore, we encourage authorities to adopt the suggested 4-fold policy prescription.

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

INTRODUCTION

Burkina Faso is a low-income landlocked country in West Africa with an estimated population size of 20,505,155 in 2021 (INSD, 2022). Women of reproductive age and children account for 17.43% and 24.10% of the total population, accordingly (Burkina Faso, 2021). Maternal and child mortality rates are still high, at 371 per 100,000 live births and 61 per 1,000 infants under five, respectively (WHO, 2019). In the previous decades, Burkina Faso carried out three major health financing reforms to improve maternal and child health. These were comprised of a national subsidy policy for maternity care made up of an 80% reduction of fees at primary healthcare facilities, district hospitals, and referral hospital levels, a results-based financing scheme, and a free healthcare policy for maternal and child care introduced in all public health facilities and

some confessional accredited facilities. In Burkina Faso, the fight against maternal mortality is one of the top priorities of the Ministry of Health (Ministry of Health Burkina Faso, 2020). Despite several efforts that are made, the maternal mortality ratio remains high (Burkina Faso, 2017). In 2014, maternal mortality ratio (MMR) stood at 303.3 for the Sahel region (Burkina Faso, 2015). In the Sahel region, the desired overall fertility rate is at a higher level than the national value (7.2 vs 5.5) while the proportion of assisted births is lower (35.90% vs. 67.10%) (INSD, 2016). The purpose of this study is to model and forecast MMR for Burkina Faso using the double exponential smoothing technique. We anticipate that study findings will stimulate an appropriate national response in order to further reduce maternal mortality by eliminating all preventable maternal deaths.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Main finding(s)
Compaoré et al. (2025)	to determine the frequencies and causes of severe maternal outcomes (SMO: MNM + MD) in regional and district hospitals in Benin, Burkina Faso and Niger	Between 1st February 2008 and 31st October 2010, we conducted an SMO incidence study in 36 hospitals in the three countries	-the burden of severe maternal outcomes was high in Benin, Burkina Faso and Niger -most women had a near miss complication on admission to a participating hospital, indicating the need to facilitate access to obstetric care for women with high-risk pregnancies and complications
Ilboudo et al. (2023)	To examine the effects of this policy on the use	Interrupted time-series regressions were used	the user fee removal policy significantly



	of services, health outcomes, and removal of costs.	to investigate the effects of the policy on the use of health services and health outcomes. In addition, an analysis of household expenditures was conducted to assess the effects of spending on delivery, care for children, and other exempted (antenatal, postnatal, etc.) services on household expenditures	increased the use of healthcare facilities for child consultations and reduced mortality from severe malaria in children under the age of five years. It also has increased the use of health facilities for assisted deliveries, complicated deliveries, and second antenatal visits, and reduced cesarean deliveries and intrahospital infant mortality, although not significantly
Rahman et al. (2022)	To analyze ANC visits among adolescent and adult mothers.	Using all available Demographic and Health Survey and Multiple Indicator Cluster Surveys between 2000 and 2019 in 54 LMICs, we estimated proportion of ANC visits among women. Bayesian hierarchical regression models were used to estimate trend, projection, and determinants of single and four ANC visits (ANC1 and ANC4) independently	Determinant analysis found increased odds of receiving ANC visits during pregnancy for adolescent mothers with higher educational levels, frequency of listening/watching mass media, and various household socio-economic status factors
Musarandega et al. (2021)	to identify the leading causes of maternal deaths using the international classification of disease – 10th revision, for maternal mortality (ICD-MM)	Systematic review	Obstetric hemorrhage, hypertensive disorders in pregnancy, non-obstetric complications, and pregnancy-related infections are the leading causes of maternal deaths in SSA
Zamane et al. (2018)	to study the cases of maternal deaths in the Dori Regional Hospital, Burkina Faso in the Sahel region, by analyzing the epidemiological aspects of these deaths in order	descriptive cross-sectional study which spanned the period from January 1, 2014 to December 31, 2016. Cases of maternal death and live births that occurred in the hospital during this period were	A total of 141 maternal deaths and 2,626 live births were recorded with a maternal mortality ratio of 5,369 for 100,000 live births. In 99 (72.20%) cases, death occurred in the postpartum. A home



	to guide decision-making	collected by documentary review	delivery had been reported in 33.70% of cases. Direct obstetric causes were found in 72.10% of cases. They were mainly represented by infections (32.40%) and hemorrhages (23%). Anemia was the indirect cause of death in 25 women (17.80%). The delay in health care access and the lack of blood products contributed to maternal deaths in 64.50% and 26.20% of cases
Girum and Wasie (2017)	to identify correlates of maternal mortality in developing countries	Systematic review	Maternal mortality is correlated with multiples of socio-economic factors, health care system associated factors, disease burden and their complex interactions
Storeng et al. (2012)	To investigate mortality in women in Burkina Faso in the 4 years following a life-threatening near-miss obstetric complication and to identify the medical, social and health-care-related causes of death	In total, 1014 women were recruited after hospital discharge and followed for up to 4 years: 337 had near-miss complications and 677 had uncomplicated pregnancies. Significant differences in mortality between the groups were assessed using Fisher's exact test	Women in Burkina Faso who initially survived a near-miss obstetric complication had an increased risk of all-cause and pregnancy-related death in the ensuing 4 years

METHODOLOGY

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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

Z_t is the actual value of MMR at time t

ε_t is the time varying **error term**



μ_t is the time varying mean (**level**) term
 ρ_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
 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
 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 Burkina Faso 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

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	Z
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	12.424844
Sum Square Error (SSE)	17632.188791
Mean Square Error (MSE)	452.107405
Mean Percentage Error (MPE)	-0.040023
Mean Absolute Percentage Error (MAPE)	3.010650

Residual Analysis for the Applied Model

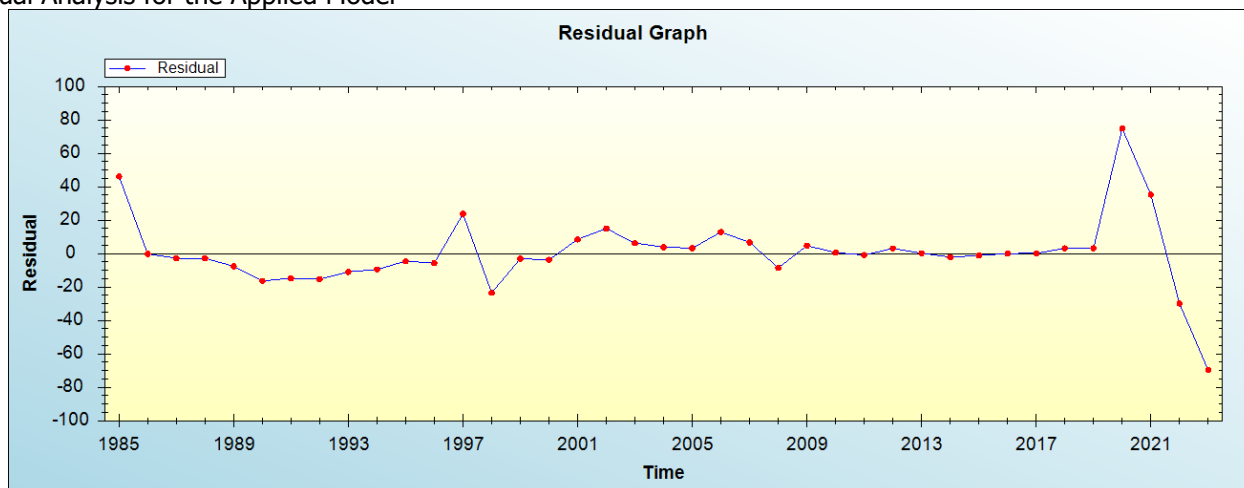


Figure 1: Residual analysis

In-sample Forecast for Z

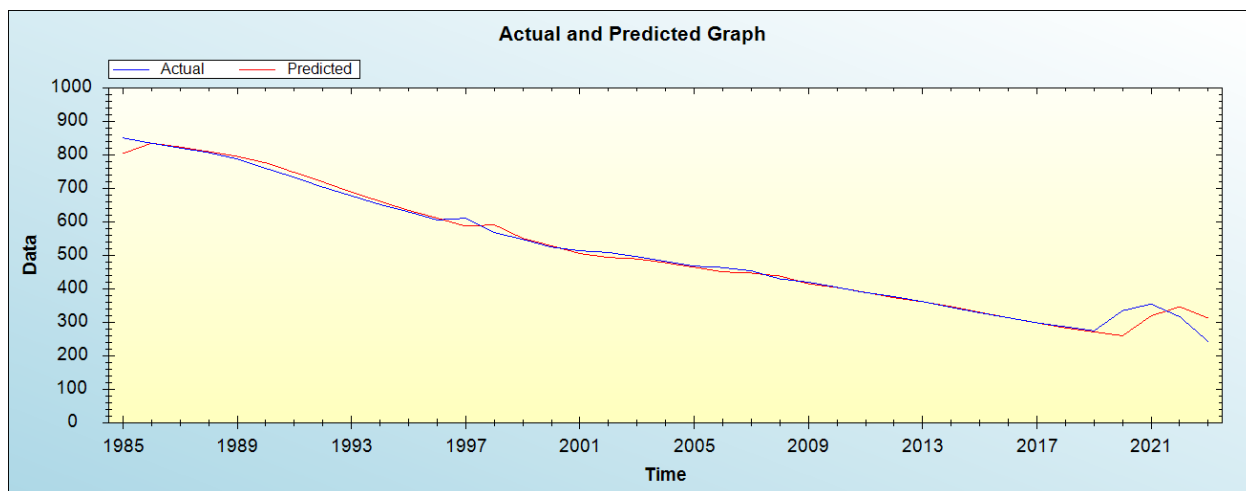


Figure 2: In-sample forecast for the Z series

Actual and Smoothed graph for Z series

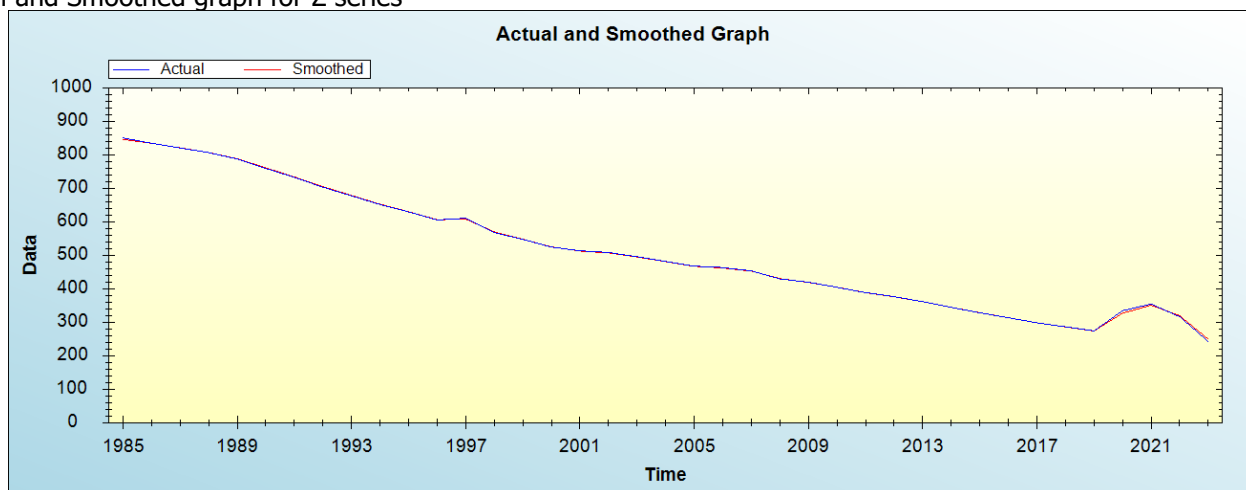


Figure 3: Actual and smoothed graph for Z series

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

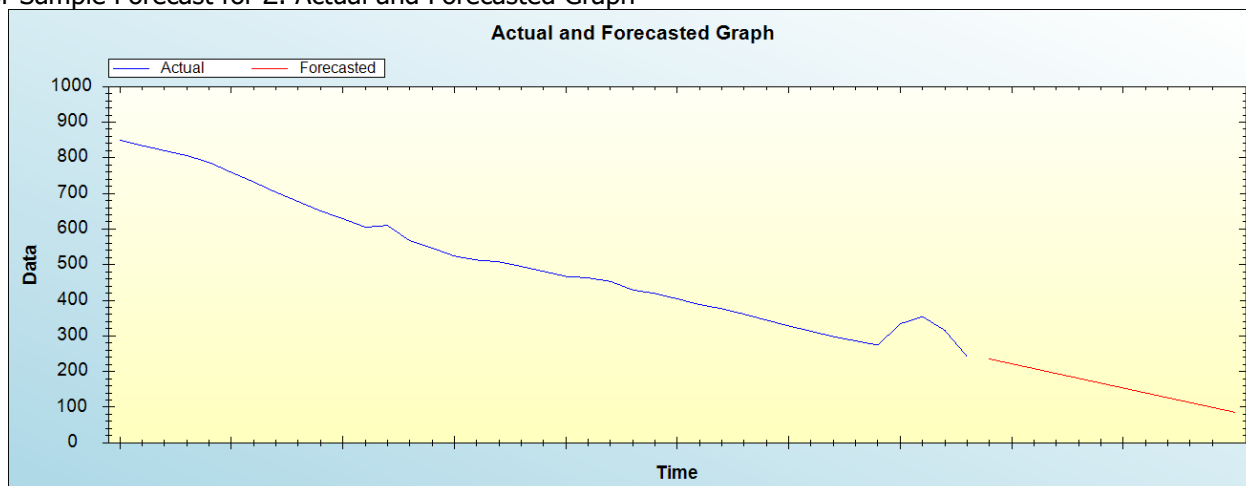


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph



Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	235.3541
2025	221.7443
2026	208.1346
2027	194.5248
2028	180.9151
2029	167.3053
2030	153.6956
2031	140.0858
2032	126.4761
2033	112.8663
2034	99.2566
2035	85.6468

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 decline but still remain high over the out of sample period.

RECOMMENDATIONS & CONCLUSION

Maternal mortality rates are still very high in Burkina Faso highlighting an urgent need to craft new strategies that will effectively reduce maternal deaths to levels below 70 deaths per 100 000 live births by 2030. This paper uses the double exponential smoothing model to forecast MMR for Burkina Faso and the results indicate that MMR will decline but still remain high throughout the out of sample period. Therefore, health authorities are encourage to adopt the following policy prescription: (1) promote female education & enforce laws that curb child marriages, (2) ensure availability of adequate medical supplies and staff retention schemes at all levels of the healthcare system particularly in the rural areas, (3) secondment of obstetricians at high volume district/ general hospitals so that complicated maternity patients receive appropriate care in time and (4) routine implementation of quality improvement initiatives.

REFERENCES

- [1] INSD (2022). Cinquième Recensement Général de la Population et de l'Habitation du Burkina Faso. Chiffres clés des résultats définitifs.
- [2] Institut National de la Statistique et de la Démographie Ouagadougou, Burkina Faso. Enquête Démographique et de Santé et à

Indicateurs Multiples (EDSBF-MICS IV) Burkina Faso. 2010. http://www.insd.bf/n/contenu/enquetes_recensements/enq_demo_sante/edsbf_mics_rapport_definitif.pdf (accessed December 15, 2016)

- [3] Ministère de l'économie, des finances et du développement, Institut national de la statistique et de la démographie, Burkina Faso. Annuaire statistique 2015. http://www.insd.bf/n/contenu/pub_periodiques/annuaire_stat/Annuaire_stat_nationaux_BF/Annuaire_stat_2015.pdf
- [4] Ministère de la santé du Burkina. Plan national de développement sanitaire 2011-2020, Burkina Faso https://www.uhc2030.org/fileadmin/uploads/ihp/Documents/Country_Pages/Burkina_Faso/Burkina_Faso_National_Health_Strategy_2011-2020_French.pdf
- [5] Ministère de la santé. Annuaire statistique 2021. Ouagadougou, Burkina Faso; 2021.
- [6] Ministère de santé, Burkina Faso (2017). Profil sanitaire complet du Burkina Faso. Module 1 Situation socio-sanitaire du Burkina Faso et mise en œuvre des ODD. <https://afro.who.int/sites/default/files/2018-08/Profil%20sanitaire%20complet%20du%20Burkina%201.pdf>
- [7] WHO (2019). Global Health Observatory. Country views: Burkina Faso statistics summary (2002 - present) Geneva, Switzerland: WHO;



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2019 [updated 2019-02-08. Available from:

<http://apps.who.int/gho/data/node.country.country-BFA?lang=en>.