MODELLING MONKEYPOX OUTBREAK USING EXPONENTIAL SMOOTHING MODELS

Ansor Hakimi Bin Shamsul, Azlan Bin Abdul Aziz
Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Perlis Branch, Malaysia

e-mail: 2022461416@student.uitm.edu.my, azlan172@uitm.edu.my

Abstract

Monkeypox has re-emerged as a global health concern, especially in the Democratic Republic of Congo (DRC), where monthly case trends show a worrying rise (WHO, 2022). Accurate forecasting of outbreak patterns is essential for public health planning and timely interventions. This study aims to model and forecast monkeypox cases using exponential smoothing methods. Monthly case data from January 2023 to February 2025 was collected from the World Health Organization and preprocessed to correct outliers using the Interquartile Range (IQR) method and median imputation. Five models Naïve, Mean, Simple Exponential Smoothing, Holt's Linear Trend, and Brown's Double Exponential Smoothing were evaluated using Repeated Time Series Cross-Validation (Aziz et al., 2018). The Holt model achieved the best performance, with a MAPE of 18.28% and a six-month forecast accuracy of 81.7%, proving it effective for short-term outbreak prediction. These findings highlight the practical application of exponential smoothing in disease forecasting and support its use in improving public health readiness and response strategies.

***Keywords**: Monkeypox, Exponential Smoothing Models, Time Series Forecasting*

1. Introduction

Monkeypox is now considered a major public health problem in regions such as the Democratic Republic of Congo (DRC), whose cases keep rising each month. Health authorities are unable to act in time because they have little instrument to accurately forecast the outbreaks. This paper tries to provide a model and prediction of monkeypox cases in the future through the use of exponential smoothing techniques. The purpose would primarily be to determine the trend of monkeypox cases on a monthly basis in the DRC, find out the most appropriate forecasting model, and short-term predictions. Within the framework of this work, the reporting period is limited to January 2023-February 2025, with the data of the World Health Organization. This study is beneficial as improving the disease surveillance and planning of public health might be achieved profiting by the application and comparison of various forecasting models.

2. Methodology

This study used monthly monkeypox case data from the Democratic Republic of Congo from January 2023 to February 2025 obtained from the World Health Organization website. Outliers in the dataset were detected using the Interquartile Range (IQR) method and replaced with median values to improve data quality (Acuna & Rodriguez, 2004). Five forecasting models were applied which are Naïve, Mean, Simple Exponential Smoothing, Holt's Linear Trend, and Brown's Double Exponential Smoothing. Each model was tested using Repeated Time Series Cross-Validation with three data splits of 90:10, 80:20 and 75:25 to ensure fair and accurate comparison (Aziz et al., 2018). Model performance was evaluated using standard accuracy metrics: Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE).

3. Results / Findings

In this paper, five forecasting models were used to forecast monthly monkeypox cases in the Democratic Republic of Congo. The RTS-CV on 90:10, 80:20, 75:25 data splits were used to test each model and the performance of each model was assessed using RMSE, MAE, and MAPE. Holt Linear

Trend model proved to be the best of all models, performing specifically well in the data split which was 80:20 that brought the lowest MAPE of 18.28. The model of Holt was reliable in short-term forecasting, with an average prediction accuracy of 81.7%, even in a six-month ahead forecasting (September 2024 to February 2025). Less complex models such as Naive and Mean recorded greater errors and were poor at trend capture. The following findings point out that exponential smoothing specifically the Holt model work well to identify and forecast the trend of the disease. This can enable the public health authorities to be in a better position to forecast future outbreaks to their advantage in utilizing precision and convenient use of the forecasting tools.

4. Novelty of Research

This study presents a novel approach by applying multiple exponential smoothing models to forecast monkeypox outbreaks using actual case data from the Democratic Republic of Congo. While many forecasting studies focus on larger global diseases like COVID-19, this research targets monkeypox, an underrepresented topic in data-driven modelling. The integration of Repeated Time Series Cross-Validation across different data splits adds robustness to the model comparison, a technique rarely used in monkeypox forecasting (Aziz et al., 2018). Furthermore, the study highlights the effectiveness of simple yet powerful forecasting tools such as Holt's Linear Trend model, which can deliver accurate results without complex algorithms. This practical method supports timely health responses, especially in resource-limited settings where advanced systems may not be available.

5. Conclusion or Future Work

Holt's Linear Trend model accurately forecasted monkeypox cases in the DRC, showing strong short-term prediction performance. This study proves that simple models can support public health planning. Future work could explore advanced models and include more data such as population or vaccination rates for better accuracy.

REFERENCE LIST

Aziz, A. A., Haris, N. A., Nor, N. A., & Sharif, N. (2018). Improving Air Pollution Index (API) predictive accuracy using time series cross-validation technique. *Journal of Fundamental and Applied Sciences*, 10, 1257–1267. http://dx.doi.org/10.4314/jfas.v10i1s.93

Aziz, A. A., Mustaffa, Z., Ismail, S., Nor, N. a. M., & Fozi, N. Q. M. (2025). A hybrid simple exponential Smoothing-Barnacles mating optimization approach for parameter estimation: Enhancing COVID-19 forecasting in Malaysia. *MethodsX*, *14*, 103347. https://doi.org/10.1016/j.mex.2025.103347

Aziz, A. A., Yusoff, M., Yaacob, W. F. W., & Mustaffa, Z. (2024). Repeated Time-Series Cross-Validation: a new method to improved COVID-19 forecast accuracy in Malaysia. *MethodsX*, *13*, 103013. https://doi.org/10.1016/j.mex.2024.103013

World Health Organization. (2022). *Monkeypox – Fact Sheet*. Retrieved from https://www.who.int/news-room/fact-sheets/detail/monkeypox