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Analysis on Malaysia Mortality Data

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Abstract
The advancement in medical technologies and people awareness on healthy lifestyle as well as promotion from government to maintain a good health has improve life expectancy in Malaysia. However, COVID-19 outbreak in January 2020 has raised a question if longer life expectancy in Malaysia is still valid or not. Previously, several authors have proposed forecasting mortality model to estimate future life expectancy. However, due to COVID-19 disease, forecasting of mortality rate using previous mortality model might not be adequate to predict on mortality rate that involve epidemic related disease. Motivate from this issue, this study would like to compare Malaysian mortality data before and after the outbreak of an epidemic-related disease and propose suitable model to capture abrupt changes happen due to COVID-19 disease.
Keywords: Life expectancy, Mortality, COVID-19 disease

Introduction

People awareness on healthy lifestyle and campaigns by government to increase public awareness on health has led to increasing life expectancy of the whole population (bin Ridzuan *et al.,*2018]. Department of Statistic Malaysia expect that Malaysia is leading to an ageing nation where percentage of older people will be increase from 6.7 percent to 7.0 percent over the same year. World Health Organization (WHO) has expected the number of older people between 2015 and 2050 will increase two times from 12 percent to 22 percent due to awareness of public on calorie intake, physical activity and social life. However, Malaysia has reported the case of COVID-19 on 25th January 2020 and this pandemic has been declared as major public health outbreak in Malaysia (Sim *et* al., 2020). Hence, it is questionable whether prediction of longer life expectancy is still valid.

Therefore, this study aims to analyze the mortality model that has been proposed by the previous researchers to find an adequate mortality model to forecast accurate mortality rate in the future. Lee and Carter (1992) model develop single population mortality model and forecast mortality data by using ARIMA time series. However, Lee-Carter model forecast poorly on the data where cohort effect observed in the past and assimilate the relation between gender. Then Plat (2009) model try to improve Lee-Carter model but, the Plat model only perform well for age above 20. O'Hare and Li modify Plat model and propose O'Hare and Li (2012) model that better in capturing non-linear mortality model. Li and Lee (2005) is the first author that introduce multi-population mortality model by incorporating the relation between gender. However, Li and Lee model does not capture the variances across ages effectively. Nor *et al*. (2018) has proposed Augmented O'Hare and Li (Augmented OH) model to capture the variances of all ages and incorporate gender relation. However, Augmented OH model used historical data and does not take into account current situation like epidemic related disease. These mortality models used ARIMA time series model to predict errors that are linear and independent and errors are assumed to be normally distributed (Schaffer *et al*., 2021).

In order to improve the forecast accuracy of multi-population mortality model, this study aims to analyze the model of Augmented OH with ARIMA model on Malaysian mortality rate and proposed time series of ARIMA-intervention model. ARIMA-intervention model is more precise to predict immediate changes happen due to sudden event (Chung *et al*., 2009). ARIMA-intervention can predict abrupt changes that happen on mortality rate due to epidemic related disease and to evaluate the impact of large-scale intervention and allows the researchers to estimate abrupt changes and long run effect of pandemic towards life expectancy (Cook, 2020).

Materials and methods

Understanding the effect of COVID-19 on life expectancy is important for the government and non-government agencies to plan on the needs of elderly and wellbeing, since the number of older people are increasing (Ibrahim *et al*., 2020). Therefore, recognizing the importance of accurately predicting mortality rate, this study analyzes the mortality model of Augmented OH with ARIMA model and proposed time series of ARIMA-intervention model to improve accuracy of forecasting mortality rate. Augmented OH model that proposed by Nor *et al*. (2018) are combination of Lee and Carter (1992) model, Plat (2009) model, O'Hare and Li (2012) model, Li and Lee (2005) model and Wan Bertschi (2015) model. Nor *et al*. (2018) proposed Augmented OH model to overcome the weaknesses of previous mortality model where most of the mortality models unable to capture the mortality rate at young age and variation across all age-groups is not effectively captured. Meanwhile, ARIMA-intervention model is chosen to capture abrupt changes happen in mortality rate due to the pandemic. Therefore, combination of Augmented OH model with intervention of time series model will develop accurate forecasting based on historical data with impact of epidemic disease on mortality rate.

The equation of Augmented O'Hare and Li model is as below,

$$\ln(\boldsymbol{m}_{x,t,i}) = \boldsymbol{\alpha}_x + \boldsymbol{k}_t^1 + \boldsymbol{k}_t^2(\bar{x} - x) + \boldsymbol{k}_t^3((\bar{x} - x)^+ + [(\bar{x} - x)^+]^2) + \boldsymbol{\alpha}_{x,i} + \sum_{j=1}^{L} \boldsymbol{\beta}_{x,i,j}\boldsymbol{k}_{t,i,j} + \boldsymbol{\varepsilon}_{x,t,i} \quad (1)$$

where $\boldsymbol{m}_{x,t,i}$ represent central of mortality rate at age *x*, year *t* and population *i*. $\boldsymbol{\alpha}_x$ describe the overall death rates for people of different ages and $\boldsymbol{\beta}_x$ is parameter of additional age specific that describe the speed of rate of death that simultaneous with changes in the time-varying mortality index $\boldsymbol{k}_t, \boldsymbol{k}_t^1, \boldsymbol{k}_t^2, \boldsymbol{k}_t^3$ and $\boldsymbol{k}_t^i$.

The ARIMA-intervention model can be described as below,

$$\boldsymbol{k}_t = \boldsymbol{V}(\boldsymbol{B})\boldsymbol{I}_t + \boldsymbol{N}_t \quad (2)$$

where $\boldsymbol{I}_t$ refer to intervention parameter, *V*(*B*) represent slope parameter divide by impact parameter and $\boldsymbol{N}_t$represent autoregressive parameter divide by moving average parameter.

This study collects the data from Department of Statistics Malaysia (DOSM). The mortality data are obtained from year 1991 to 2021 within the age range of 0 to 80 years old for both male and female. The mortality data will use three different variables which are the number of deaths, the rate of deaths and the exposure to risk. In order to determine the accuracy of forecasting mortality rate by using ARIMA model and to suggest ARIMA-intervention model, this study will used data of COVID-19 cases from COVIDNOW from January 2020 until December 2021 to predict abrupt events that cause changes in mortality rate.

Results and discussion

In this section, the existing model of Augmented OH model with ARIMA time series model is choose to predict the performance of mortality model and to find adequate mortality model to capture abrupt changes happen due to epidemic related disease.

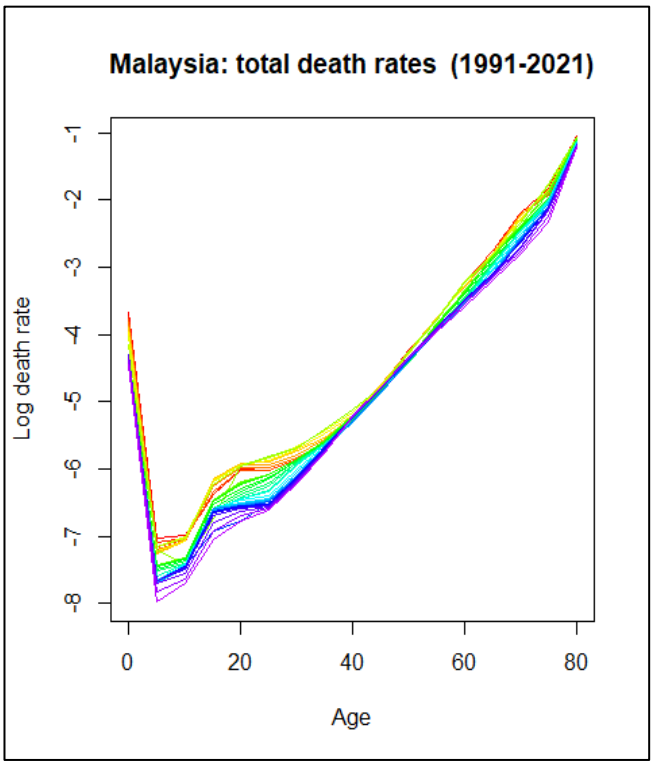

Figure 1 Malaysia mortality rate from year 1991 to 2021.

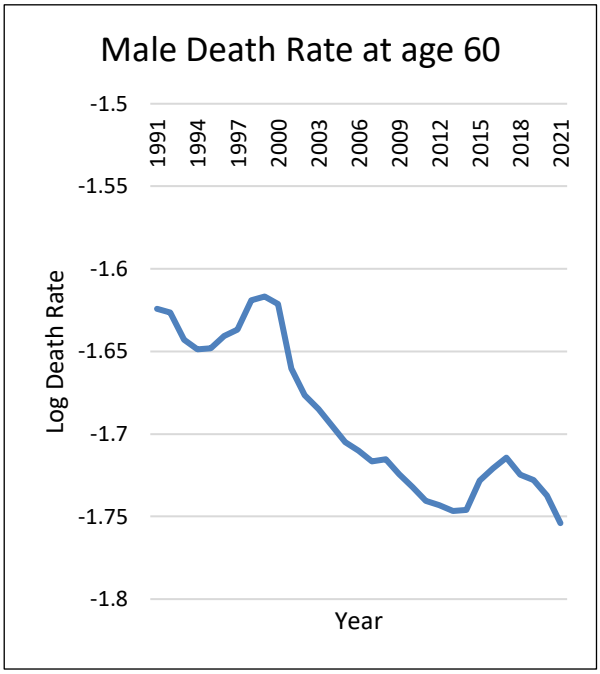

Figure 2 Male death rate at age 60.

Figure 1 shows total death rate consist of male and female death rate from year 1991 to 2021 by using Augmented OH model with ARIMA time series model with mortality rate and the number of death people is decreasing along the year. This might be happened due to the practice of healthy lifestyle, increase income and better education (Ibrahim and Siri, 2014). Higher income leads to longer life expectancy because people could spend their money to practice healthier lifestyle and access to health care (Tafran and Osman, 2020). Advancement in medical and enhancement in hygiene and food supply are also contribute to the increase of life expectancy in Malaysia. Besides, Malaysia government play important role to develop lower mortality rate by giving the best care to the older people with priorities on

public health. National Policy for Older Person and Plan of Action for older person are effort from the government to improve health, wellbeing, safety and security.

However, **Figure 2** shows that the plot of male age at 60 years old is non-linear and have abrupt changes on year 2015 to 2021. Augmented O'Hare and Li model used as a based model with ARIMA time series model shows result of mortality rate that are linear and cannot predict abrupt changes that happen due to sudden event ARIMA time series only capture linear correlation structure and cannot predict non-linear correlation structure (Zhang, 2003). According to Astro Awani on 8 November 2021, COVID-19 has become one of the main factors that contribute to the highest number of deaths. WHO reported on 15 December 2021, around 272 million cases of Coronavirus reported around the world. This epidemic related disease is likely to affect older people and people with chronic disease such as cardiovascular disease, diabetes, chronic respiratory disease and cancer. Their body immune system is different with healthy young people so they are easier to get infected and live shorter lives than those who are not (Brodin, 2021).

Therefore, this study aims to propose Augmented O'Hare and Li model with ARIMA-intervention model that can predict accurate forecasting on mortality rate that happen due to epidemic related disease.

Conclusion

As a conclusion, it is important to develop mortality model that could capture the outbreak patterns in the data that happen due to unplanned event. Therefore, this study aims to use Augmented O'Hare and Li model with ARIMA-intervention model to capture the epidemic related disease. Augmented O'Hare and Li model is choosing because this model can incorporate the relation between population and suitable for variances of all ages, therefore this model might generate forecast that are coherent in the future. ARIMA-intervention model is used as a time series model to capture the abrupt changes in the time series index of the epidemic related disease.

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