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COVID–19 mortality trends before and after the national vaccination program in Iran: A joinpoint regression analysis

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ABSTRACT

Objective: To investigate the trend of mortality by COVID-19 before and after the national vaccination program using joinpoint regression analysis from 19 February 2020 to 5 September 2022.

Methods: In the present study, a joinpoint regression analysis of monthly collected data on confirmed deaths of COVID-19 in Iran from February 19, 2020 to September 5, 2022 was performed.

Results: After national vaccination in Iran, the trend of new monthly deaths due to COVID-19 was decreasing. The percentage of monthly changes from the beginning of the pandemic to the 19th month was 6.62% (95% CI: 1.1, 12.4), which had an increasing trend. From the 19th month to the end of the 31st month, the mortality trend was decreasing, and the percentage of monthly changes was –20.05% (95% CI: –8.3, –30.3) ($P=0.002$). The average percentage of monthly changes was –5% with a 95% CI of (–10.5, 0.9).

Conclusions: Along with other health measures, such as quarantine, wearing a mask, hand washing, social distancing, etc., national vaccination significantly reduces the mortality rate of COVID-19.

KEYWORDS: COVID-19; Iran; Joinpoint regression; Mortality; Trend; Vaccination

1. Introduction

World Health Organization (WHO) confirmed COVID-19 as a state of epidemic[1]. The highest number of recorded cases is followed by a high number of deaths worldwide[2]. Non-pharmacological interventions including social distancing, travel restrictions, quarantine and closure of schools and universities, travel bans, and restrictions in mass gathering activities to prevent COVID-19 in Iran and other parts of the world started[3]. Vaccination is suitable along

with other health interventions to reduce the increasing burden of this disease[4,5]. A large number of successful vaccines and the first generation of SARS-COV-2 have played a major role in controlling COVID-19[6]. Safe and effective vaccination is a long-term solution to control this disease and reduce mortality[7,8]. Studies have been conducted in the field of the death trend of COVID-19[9,10], but there is a lack of study on the mortality trend of COVID-19 before and after the national vaccination program in Iran using the joinpoint regression model. Diseases trend analysis provides an opportunity to better understand the behavior of the epidemic as well as technical support through data analysis to predict patterns of the pandemic[11]. To assess whether the trend of mortality due to COVID-19 changed before and after the national vaccination program in Iran, we used the joinpoint regression method. Joinpoint regression is one of the appropriate models to describe change trends in specific periods and

Significance

This study shows that vaccination could significantly reduce the COVID-19 mortality and provides an opportunity for researchers and public health professionals to assess whether the trends of COVID-19 mortality changed over time as well as before and after the implementation of the national vaccination in Iran as a country with more than 80 million populations in the Persian Gulf region.

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significant increases or decreases in mortality caused by a disease. The basic assumption of joinpoint regression is that the trend is not constant during the studied period[12]. Joinpoint regression as opposed to conventional regression method could identify the connection points and estimate their location in the data. Joinpoint regression could assess significant changes in the mortality pattern over time as well as estimate the average weekly percent change[13]. This study aimed to offer a model that fits the time series data and estimates the joinpoints.

2. Patients and methods

In this ecological study, time series data (confirmed deaths of COVID-19) from February 19, 2020 to September 5, 2022 which included 31 months in Iran were extracted from <http://ourworldindata.org/coronavirus>.

In this study, we examined the number of new deaths from COVID-19 monthly. A P -value <0.05 is considered significant.

This article was approved by ethics committee (Code: IR.BMSU.REC.1401.085; Approval Date: 2022-12-19) at Research Ethics Committees of Baqiyatallah University of Medical Sciences.

Because vaccination in Iran based on prioritization of high-risk groups started in March 2021, national vaccination based on the order of the Ministry of Health started in Iran in September 2021[14].

According to Islamic Republic News Agency, with a significant increase in the import of required vaccines in addition to domestic production, national vaccination has accelerated throughout the country since December 2021[15].

Joinpoint regression model is a method for dividing the nonlinear regression model into separate linear segments, which are separated by breakpoints. In this case, for each piece, we will have a linear regression function $f_i(X)$ with different parameters.

The regression model in this case is obtained as follows:

$$E[y|x] = \beta_0 + \beta_1x + \delta_1(x - \tau_1) + \dots + \delta_k(x - \tau_k)$$

where k is the number of unknown change points, τ_i for $i = (1, \dots, k)$ are the locations of unknown change points and δ_i are the regression coefficients of the parts[16]. The weighted least squares method was used to calculate and derive the joinpoint regression model. Also, we used the values of monthly percentage changes (MPC) and average monthly percentage changes (AMPC) to compare the trend of decreasing or increasing COVID-19 mortality. MPC shows how much the death rate of COVID-19 has increased or decreased each month, and AMPC is the average of the changes. Descriptive analysis was done with EXCEL 2016. Statistical analysis was performed using joinpoint trend analysis software version 4.9.1.0 (US National Cancer Institute).

3. Results

According to our results, during the study period, 143983 deaths due to COVID-19 occurred. The results of our study showed that the highest frequency of deaths caused by COVID-19 in Iran was observed in the 19th month with the number of deaths of 17733 people, and its frequency was 12.32%. From the 19th month onwards, the death rate decreased and the lowest death rate was in the 29th month with a number of 81 people and its frequency was 0.06%, which coincides with the national vaccination in September and October 2021 which happened in the same time (Figure 1).

Figure 2 shows the mortality trend during 31 months from February 19, 2020 to September 5, 2022. From the beginning of the pandemic to the 19th month, the trend was increasing, and MPC was 6.62% with a confidence interval (1.10, 12.94).

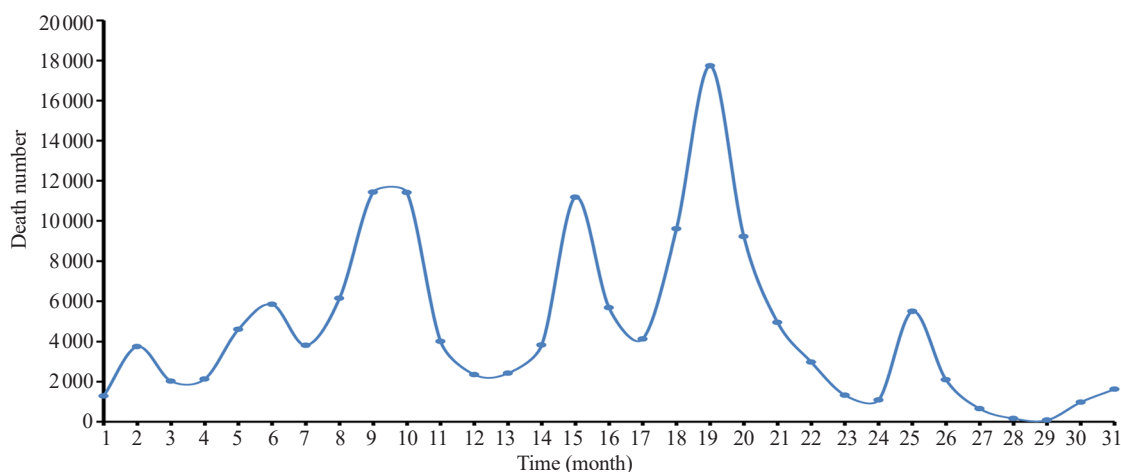


Figure 1. New death of COVID-19.

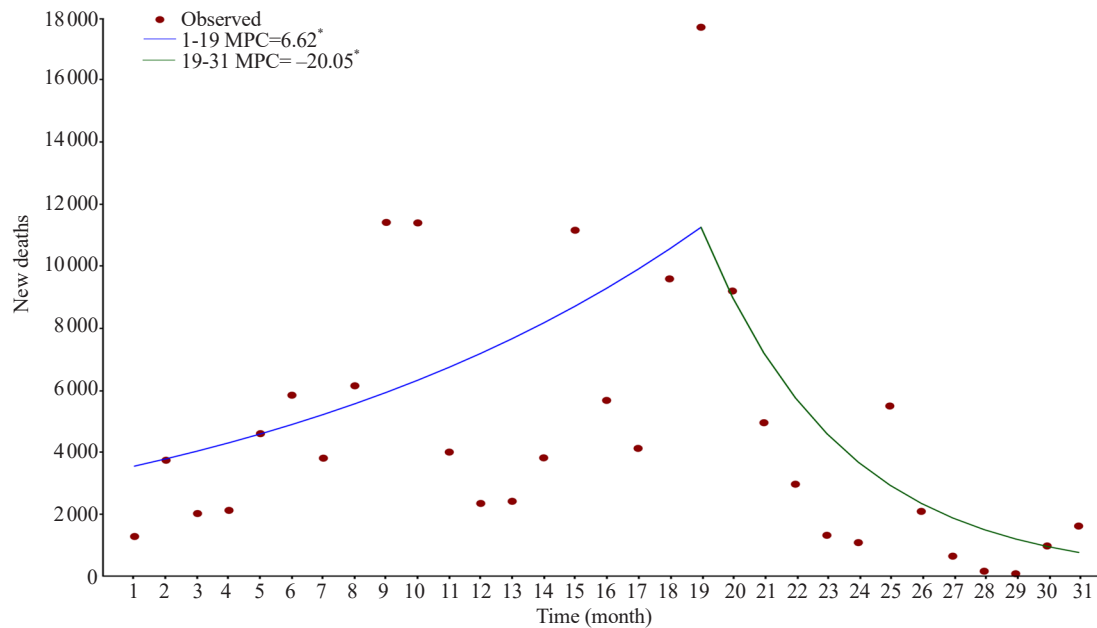


Figure 2. The mortality trend of the COVID-19 disease from February 19, 2020 to September 5, 2022. MPC: monthly percentage changes.

Table 1. Standard parameterization of the regression model of joinpoints.

Parameter	Parameter estimate	Standard error	t	P
Intercept 1	1.42	0.30	4.71	0.00
Slope 1	0.06	0.02	2.49	0.01
Slope 2- Slope 1	-0.28	0.07	-4.02	0.00

From the 19th month to the end of the 31st month, the trend of mortality was decreasing and the percentage of monthly changes was -20.5% with a confidence interval $(-30.3, -8.3)$, which is statistically significant ($P=0.002$). Also, the AMPC was -5% with a confidence interval $(-10.5, 0.9)$ (Table 1).

4. Discussion

The results of the present study showed that according to MPC and the AMPC, the mortality trend of COVID-19 has an upward trend until the 19th month, and from the 19th month onwards, this trend is downward and decreasing. The downward trend observed in the second part can be due to the effect of national vaccination in September and October 2021 in Iran, when the injection of the vaccine accelerated after the special group and the 19th month coincides with the same date[15]. In a study conducted by Horwitz *et al.* on trends in risk-adjusted mortality rates in COVID-19, they found that early reports indicated a high mortality rate for COVID-19. They examined the association of in-hospital mortality with changing demographic characteristics in a three-hospital university health system in New York. Their study showed

that the mortality rate of COVID-19 according to demographic characteristics such as age, co-morbidities, *etc.* among 5 121 hospitalized patients decreased from 26.1% in March to 7.6% in August[10]. In a study conducted by Chen *et al.* on the impact of vaccination on the COVID-19 pandemic in the United States, they found that vaccination reduced the total number of new cases by 4.4 million and prevented about 0.12 million hospitalizations and reduced the infection rate of the population by 1.34%[17]. In our study, the highest frequency of deaths due to COVID-19 in Iran was 12.32% in the 19th month, which decreased after national vaccination and its frequency was 0.06%. In another study conducted by Nordstrom *et al.*, they found that the effectiveness of vaccination against severe cases of COVID-19 remains high for up to 9 months, depending on the conditions of the individuals, and booster doses are required[18]. Qiu *et al.*'s study showed that by using the regression of connection points, it is possible to analyze the change in the death rate caused by different cancers in Japan. They found that the decline in some cancers was due to lifestyle changes economic growth and public health in the decades after the war[12]. Fernández *et al.* looked at changes in trends in cancer mortality in Catalonia (Spain) between 1975 and 1998 using point regression analysis, with statistically significant changes in data rates[19]. However, although this study provides important information, there is a major limitation. The data were aggregated and we did not have information at the individual level. Further research could be done on the effect of vaccination on the incidence and mortality.

The current study indicates that vaccination may significantly reduce the mortality caused by COVID-19. This information could be useful for policymakers to predict mortality. Public health

officials should investigate the factors affecting the transmission of COVID-19.

Conflict of interest statement

The authors report no conflict of interest.

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This study received no extramural funding.

Data availability statement

The data supporting the findings of this study are available from the corresponding authors upon request.

Authors' contributions

KA designed the initial study, analyzed the research material, and finalized the final manuscript. MS conducted the research, and collected, organized, and interpreted the data. YA proofread and critically reviewed the final draft. All authors approved the final draft and are responsible for the content and similarity index of the manuscript.

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