ORIGINAL ARTICLE

Effect of epidemic management and control plan on COVID-19 mortality in Iran: an interrupted time series analysis

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Key words

COVID-19 • Control Measures • Iran • Mortality

Summary

Background. *Globally, several measures have been taken to decrease COVID-19 mortality. However, the effectiveness of preventive measures on the mortality related to COVID-19 has not been fully assessed. Thus, the present study aimed the present study aimed to assess the success of COVID-19 epidemic management and control plan on the mortality associated with COVID-19 in Iran from February 19, 2020, to February 5, 2021.*
Methods. *In the current quasi experimental study an interrupted time series analysis of daily collected data on confirmed deaths of COVID-19 occurred in Iran and in the world, were performed using Newey ordinary least squares regression-based methods.*
Results. *In Iran, the trend of new deaths increased significantly every day until 24 November 2020 according to pre-intervention slope of [(OR 1.14, 95% CI 0.96 - 1.32,); P < 0.001]. The occurrence of new deaths had a decreasing trend after November 24, 2020, with a coefficient of [(OR -5.12, 95% CI -6.04 - -4.20), P < 0.001)]. But in the global level daily new deaths was increasing before [(OR 18.66, 95% CI 14.41-2292; P < 0.001)] and after the 24 November 2020 [(OR 57.14, 95% CI 20.80 - 93.49); P: 0.002].*
Conclusions. *Iranian COVID-19 epidemic management and control plan effectively reduced the mortality associated to COVID-19. Therefore, it is essential to continue these measures to prevent the increase in the number of deaths.*

Introduction

The number of deaths from COVID-19 continues to increase universally, and the first COVID-19 death was formally reported in Iran on February 19 2020 [1]. On March 1, the Ministry of Health and Medical Education (MOHME) stated 135 new deaths [2]. On March 20 (Nowruz; The first day of the Iranian New Year), 149 deaths were reported. On April 4 (The day after the Iranian New Year holidays), daily new deaths had increased to 158 [2]. On June 14, daily deaths touched over 100, with 107 deaths reported [2]. This reduction is stated to be due to a social distancing started formally by the Iranian government in late March 2020 of to March 2020 [3]. On June 29, MOHME reported a new record figure of deaths in a day, with 162 deaths [2]. On July 7, the number of fatalities jumped by 200 deaths [2]. On October 19, 2020, Iran topped the list with 337 new deaths [2]. October 28 On November 16, another rise of 486 deaths was reported [2]. According to some mathematical models, the number of daily deaths in the country in December was predicted to reach more than 800 per day [4]. To deal with this terrible increase in the number of deaths from the disease, on November 10 Nov, the COVID-19 epidemic management and control plan was implemented by the MOHME in a family-oriented manner [5]. The plan's goal was to break the transmission chain and reduce deaths from COVID-19 disease with the help of non-governmental organizations (NGOs) and through supportive coverage of high-risk groups in the community [5]. As of November 21, over 1.4 million out of 3 million families in Tehran have undergone screening [5]. The plan is designed in three phases of care, support, and monitoring [5]. In the support phase, to cut the transmission chain and reduce the contact of infected people, through which, 40 centers in Tehran receive COVID-19 patients who cannot quarantine at home [5]. Also, from the beginning of December 2020, the government completed the plan by intensifying social distancing measures [5]. In this plan, the status of cities across the country is divided into three categories: yellow, orange, and red, based on the number of patients admitted whose disease was confirmed by PCR [5]. Restrictions were then placed on long-distance travel, closure of offices and unnecessary jobs depending on the situation in each city [5]. At February 5, 2021 Iran in terms of the number of deaths due to COVID-19, is ranked 11th after the United States, Brazil, Mexico, India, the United Kingdom, Italy, France ,Russia Germany and Spain [2]. The effectiveness of the control measures implemented in Iran on COVID-19 mortality has not been fully investigated. This is essential to improve ongoing health decisions and responses to similar pandemics in the future. The present study aimed to explore the efficacy of preventive measures undertaken by the Iranian government aimed to investigate the

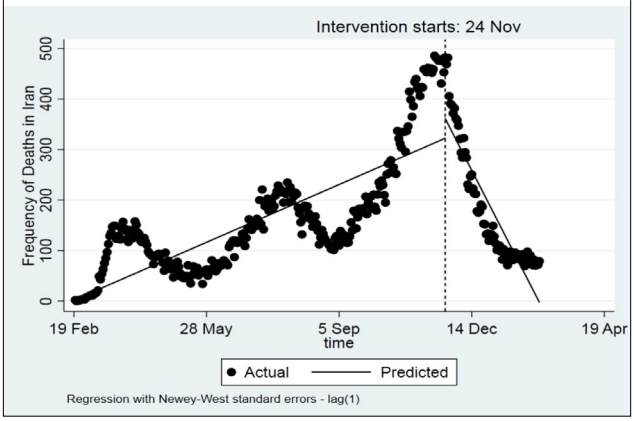
effectiveness of preventative measures undertaken by the Iranian government to reduce the mortality related to COVID-19 among the Iranian population from February 19, 2020 to February 5, 2021.

Methods

We did an interrupted time series analysis (ITS) of daily collected data on confirmed deaths of COVID-19 occurred in Iran and in the world, from February 19, 2020, to February 5, 2021. The dataset which is available at (https://ourworldindata.org/coronavirus) was used in the current study. The data included 351 observations of the death occurred in Iran and the world. Although COVID-19 epidemic management and control plan started formally in November 10,2020, Due to the Incubation period of this infection, November 24, 2020, considered as the starting time of preventive measures in the analysis. Findings from the Princess Diamond cruise ship shows that deaths occurred about 14 days after the time which the Index case was identified [6]. Hence, it is rational that one assesses the COVID-19 mortality with a two-week delay in this case. So, in the current analysis deaths occurred before November 24, 2020, were considered as control period, while deaths occurred after November 24, 2020, were considered as the intervention period in Iran. However, the starting date of the COVID-19 epidemic management and control plan was November 1010,2020, in the current analysis, November 24, 2020 was considered as time of intervention start. This is also is in accordance with the average incubation period of the SARS-CoV-2 which has been reported to be 5.1 days [7]. Segmented regression model and ITS analysis using Newey ordinary least squares regression-based methods were used. The standard ITS regression model was as follows [8, 9]: $[Y_t = \beta_0 + \beta_1 T_t + X_t + \beta_3 X_t T_t + e]$.

Y_t is the aggregated number of deaths that occurred at each time point t, T_t is the time since the first day of the study, X_t is representing the intervention (pre-intervention periods 0, otherwise 1), and $X_t T_t$ is an interaction term. The β_0 represents the intercept. β_1 is the slope of the trend of deaths before the start of the intervention. β_2 represents the change in number of deaths in the period after the start of the intervention. β_3 represents the difference between pre-intervention and post-intervention slopes of the trend of deaths. A significant β_2 shows an effect immediately after the intervention, while a significant β_3 means an effect over the time [10, 11]. In order to attribute the observed change in the number of deaths before and after the implementation of the Iranian COVID-19 epidemic management and control plan, the correlation between the number of daily deaths due to COVID-19 in Iran and the world was examined in two-time stages before and after November 24, 2020. All analyzes were done using Stata Corp. 2017. h Station, TX: StataCorp LLC (USA).

Fig. 1. Segmented regression model new deaths of COVID-19 in Iran since February 19, 2020 to February 5, 2021 using the Newey-West standard errors.



Results

The Median (Interquartile range) of registered cases during the understudied period in Iran was 133(362-83) cases per day. The minimum and maximum number of deaths during this period was 0 and 486 deaths per day. The highest number of deaths in Iran was recorded in November and early December 2020.

Figure 1 shows the trend of COVID-19 deaths from February 19, 2020, to February 5, 2021, in Iran. The starting point of the deaths of COVID-19 was estimated at 3.11 and the trend of new deaths increase significantly every day until November 24 2020 according to pre intervention slope of [(OR 1.14, 95% CI 0.96 - 1.32); P < 0.001]. The occurrence of new deaths had a decreasing trend after 24 November 2020 with a coefficient of [(OR -5.12, 95% CI -6.04 - -4.20); P < 0.001] (Tab. I).

Tab. I. Estimated coefficients of segmented regression model for new deaths of COVID-19 in Iran since February 19, 2020 to February 5, 2021.

Regression with Newey-West Standard Errors Maximum Lag: 1 Number of Observation = 351 F (3, 347) = 97.41, P < 0.001						
New cases	Coefficients	Standard error	t	P	95% confidence interval	
Intercept	3.11	10.84	0.29	0.77	-18.22	24.44
Pre intervention slope	1.14	0.08	12.79	< 0.001	0.96	1.32
Chang in intercept	39.13	25.50	1.53	0.12	-11.03	89.30
Chang in slope(interaction)	-6.26	0.47	-13.09	< 0.001	-7.21	-5.32
Post intervention linear trend	-5.12	0.46	-10.92	< 0.001	-6.04	-4.20

Fig. 2. Segmented regression model new deaths of COVID-19 in the world since February 19, 2020 to February 5, 2021 with Newey-West standard errors.

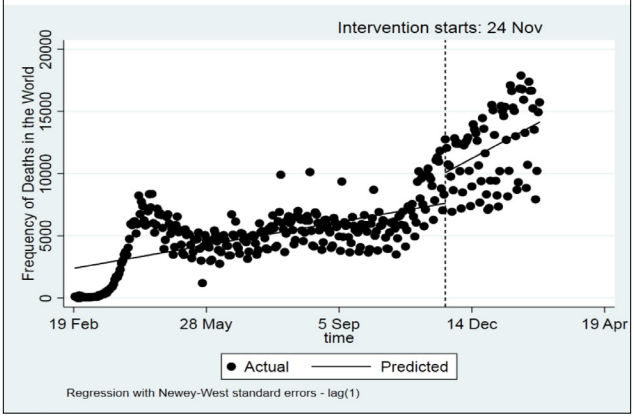


Fig. 3. Correlation between the I the number of new COVID-19 happened in the world and Iran from February 19, 2020, to November 24 2020.

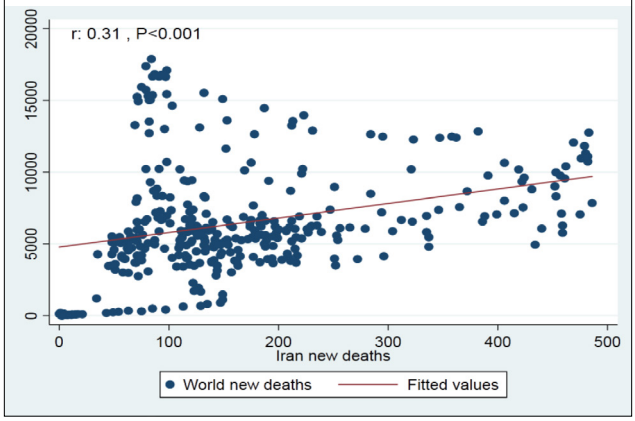
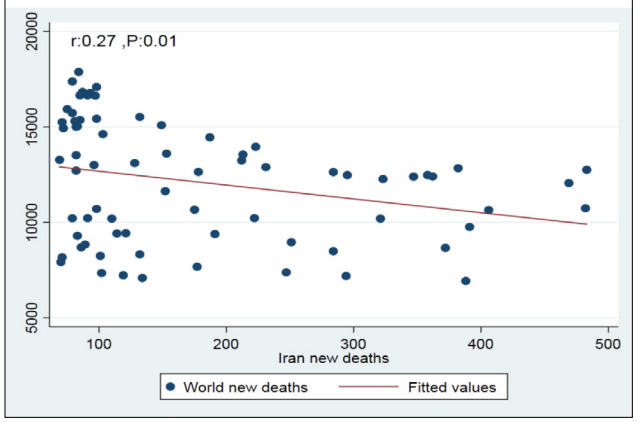


Figure 2 shows the trend of COVID-19 deaths from February 19, 2020, to February 5, 2021, in the world. The starting point of the new deaths of COVID-19 was estimated at (2405.19), and the trend of daily new deaths was increasing before [(OR 18.66,95% CI 14.412292); P < 0.001] and after the 24 November 2020 [(OR 57.14, 95% CI 20.80-93.490); P: 0.002] (Tab. II). Figure 3 demonstrates that there was a significant and positive correlation (r: 0.31, p < 0.001) between number of new deaths of COVID-19 that occurred in the world and Iran since February 19, 2020, to November 24 2020. On the other hand, Figure 4 shows a significant but reverse Correlation between number of new deaths of COVID-19 that occurred in the world and Iran since November 24 2020 to February 5, 2021(r: -0.27, P: 0.01).

Fig. 4. Correlation between the number of new deaths of COVID-19 occurred in the world and iran from November 24 2020 to February 5, 2021.



Discussion

RespondAny government must respond proactively in front of a pandemic, including the COVID-19 pandemic. The response, in this case, must include making policies to provide adequate personal protective equipment [12] and quick implementation of preventive measures such as lockdown, effective quarantine, social distancing, and screening, along with patient management and treatment [13, 14]. However, Iranian government has focused on gentle and without coercion measures to control the pandemic, rather than mandatory quarantine or lockdown [3]. In fact, for the Iranian government, which has been under the most severe economic sanctions in recent years, it is not even possible to implement a strict social distance program, let alone the government wants to enforce a complete lockdown or so-called stay-at-home policies, like what is done in some European countries [15].

From the early days of the COVID-19 pandemic, In Iran, a significant reduction in the number of new deaths due to COVID-19 has been observed in 2 weeks after the implementation of social distancing in the 4th

Tab. II. Estimated coefficients of segmented regression model for new death of COVID-19 in the world since February 19, 2020 to February 5, 2021.

Regression with Newey-West Standard Errors Maximum Lag: 1 Number of Observation = 351 F (3, 347) = 105.16, P < 0.001						
New cases	Coefficients	Standard Error	t	P > t	[95% confidence interval]	
Intercept	2405.19	372.56	6.46	< 0.001	1672.42	3137.96
Pre intervention slope	18.66	2.16	8.63	< 0.001	14.41	22.92
Chang in intercept	2462.09	714.63	3.45	< 0.001	1056.54	3867.65
Chang in slope (interaction)	38.48	18.60	2.07	0.03	1.88	75.08
Post intervention linear trend	57.14	18.47	3.09	0.002	20.80	93.49

week of March 2020 [3]. Unfortunately, Relying on the success achieved in the previous step, due to economic constraints, Iran has decided to implement a kind of smart distancing instead of a rigid social distancing program, ring spite of health experts concerns and warning about the consequences of such a decision [3]. In fact, the smart distancing allows the Iranian society to gradually return to normal condition, and many jobs are to be resumed steadily [3]. Consequently, about a month after the reopening of schools and universities, the number of deaths due to COVID-19 reached (415). The present study results showed that Iranian COVID-19 epidemic management and control plan, which started on November 10, 2020, significantly reduced the number of COVID-19 deaths in Iran. The direct correlation between the number of deaths that occurred in Iran and the world before November 24, 2020, and the inverse correlation between the two after the date mentioned can also be a proof and confirmation of the results obtained (Figs. 3,4). In fact, these figures show that before the mentioned date, the number of daily deaths in Iran has increased along with the number of deaths in the world, but after that date, while the number of deaths in the world has continued to increase, the number of deaths in Iran has decreased. Despite the economic and psychological impacts of the COVID-19 epidemic management and control plan and other preventive measures [15, 16], their role in containing the pandemic is undeniable. Some studies with ITS analysis approach reports significant effects of control measures on the COVID-19 mortality [3, 16-19]. A study on 149 countries found that social distance measure reduced in 13% the COVID-19 morbidity [16]. Figueiredo et al. [17] reported a daily decrease of 7.88% in deaths, after the implementation of preventive policies in China. Siedner et al. [18], in the United States also showed a daily reduction in COVID-19 epidemic growth after the implementation of social distancing. Ghanbari et al. [3, 19] and also Alimohamadi et al reported a significant effect of preventive policies on COVID-19 mortality in Iran. One thing to note is that such success has been achieved without severe restrictions heavy fines. Another point is that this success was achieved despite the limited number of COVID-19 diagnostic tests (which also has economic reasons). Iran as a country with more than 84 million population, currently, is ranked 121th in the world and 6th (Last) in Persian Gulf region in terms of the number of tests per one million (with 112,305 tests /1 milion population and more than 9 million tests population since the beginning of the pandemic [2]. However, COVID-19 mortality rate has been reported to be negatively associated with COVID-19 test number [20]. The current study had some limitations; during the study period, some variables such as people knowledge, attitude and practice about the disease, the criteria for the confirmed deaths. The accuracy of the diagnostic tests as well as the people's compliance to health principles (such as using face masks, avoid attending gatherings and crowded places, etc), may be altered and this could affect the effectiveness of the preventive measures. Nevertheless, controlling the role of above-mentioned variables was not possible due to unavailability of data.

Conclusions

The Iranian COVID-19 epidemic management and control strategy reduced the mortality associated with COVID-19. Therefore, it is essential to continue these measures, in order to prevent the increase in the number of deaths.

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There is no financial source of this study.

Ethical Statement

There is no ethical consideration of this study.

Conflict of interest statement

The authors declare that there is no conflict of interests.

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Authors' contribution

YA and MS formulated the research questions, methodology, formal analysis, prepare drafts of the manuscript, review and editing. All authors have read and approved the final version of the manuscript.

References

[1] Takian A, Raoofi A, Kazempour-Ardebili S. COVID-19 battle during the toughest sanctions against Iran. Lancet 2020;395:1035-6. https://doi.org/10.1016/S0140-6736(20)30668-1. Erratum in: Lancet 2020;395(10232):1258.

[2] Worldometers. Available at https://www.worldometers.info/coronavirus/#countries

[3] Alimohamadi Y, Holakouie-Naieni K, Sepandi M, Taghdir M. Effect of social distancing on COVID-19 Incidence and mortality in Iran since February 20 to May 13, 2020: an interrupted time series analysis. Risk Manag Healthc Policy 2020;13:1695-700. https://doi.org/10.2147/RMHP.S265079

[4] COVID-19 Projections Available at https://covid19.healthdata.org/iran-(islamic-republic-of)?view=total-deaths&tab=trend

[5] Available at https://vchealth.arums.ac.ir/fa/page/6934/

[6] Russell TW, Hellewell J, Jarvis CI, van Zandvoort K, Abbott S, Ratnayake R, Cmmid COVID-Working Group, Flasche S, Eggo RM, Edmunds WJ, Kucharski AJ. Estimating the infection and case fatality ratio for coronavirus disease (COVID-19) using age-adjusted data from the outbreak on the Diamond Princess

cruise ship, February 2020. Euro Surveill 2020;25:2000256. https://doi.org/10.2807/1560-7917.ES.2020.25.12.2000256

[7] Lauer SA, Grantz KH, Bi Q, Jones FK, Zheng Q, Meredith HR, Azman AS, Reich NG, Lessler J. The incubation period of Coronavirus Disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application. Ann Intern Med 2020;172:577-82. https://doi.org/10.7326/M20-0504.

[8] Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. Int J Epidemiol 2017;46:348-55. https://doi.org/10.1093/ije/dyw098. Erratum in: Int J Epidemiol 2020;49:1414.

[9] Bottomley, Christian, Scott, J. Anthony G, Isham V. analysing interrupted time series with a control. Epidemiologic Methods 2019;8:20180010. https://doi.org/10.1515/em-2018-0010

[10] Piroozi B, Takian A, Moradi G, Amerzadeh M, Safari H, Faraji O. The effect of Iran's health transformation plan on utilization of specialized outpatient visit services: an interrupted time series. Med J Islam Repub Iran 2018;32:121. https://doi.org/10.14196/mjiri.32.121

[11] Rashidian A, Moradi G, Takian A, Sakha MA, Salavati S, Faraji O, Piroozi B. Effects of the Health Transformation Plan on caesarean section rate in the Islamic Republic of Iran: an interrupted time series. East Mediterr Health J 2019;25:254-61. https://doi.org/10.26719/emhj.18.044

[12] Stoller JK: Reflections on leadership in the time of COVID-19. BMJ Leader 2020.

[13] Flaxman S, Mishra S, Gandy A, Unwin HJT, Mellan TA, Coupland H, Whittaker C, Zhu H, Berah T, Eaton JW, Monod M; Imperial College COVID-19 Response Team, Ghani AC, Donnelly CA, Riley S, Vollmer MAC, Ferguson NM, Okell LC, Bhatt S. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. Nature 2020;584:257-61. https://doi.org/10.1038/s41586-020-2405-7

[14]. Tian H, Liu Y, Li Y, Wu CH, Chen B, Kraemer MUG, Li B, Cai J, Xu B, Yang Q, Wang B, Yang P, Cui Y, Song Y, Zheng P, Wang Q, Bjornstad ON, Yang R, Grenfell BT, Pybus OG, Dye C. An investigation of transmission control measures during the first 50 days of the COVID-19 epidemic in China. Science 2020;368:638-42. https://doi.org/10.1126/science.abb6105

[15] Vokó Z, Pitter JG. The effect of social distance measures on COVID-19 epidemics in Europe: an interrupted time series analysis. Geroscience 2020;42:1075-82. https://doi.org/10.1007/s11357-020-00205-0

[16] Islam N, Sharp SJ, Chowell G, Shabnam S, Kawachi I, Lacey B, Massaro JM, D'Agostino RB Sr, White M. Physical distancing interventions and incidence of coronavirus disease 2019: natural experiment in 149 countries. BMJ 2020;370:m2743. https://doi.org/10.1136/bmj.m2743

[17] Figueiredo AM, Codina AD, Figueiredo D, Saez M, León AC. Impact of lockdown on COVID-19 incidence and mortality in China: an interrupted time series study. Bull World Health Organ 2020, 6. http://doi.org/10.2471/BLT.20.256701

[18] Siedner MJ, Harling G, Reynolds Z, Gilbert RF, Venkataramani A, Tsai AC. Social distancing to slow the US COVID-19 epidemic: an interrupted time-series analysis. MedRxiv 2020. https://doi.org/10.1101/2020.04.03.20052373

[19] Ghanbari MK, Behzadifar M, Imani-Nasab MH, Behzadifar M, Bakhtiari A, Mir I, Wu J, Bragazzi NL. The impact of the social distancing policy on COVID-19 new cases in Iran: insights from an interrupted time series analysis, 2020. https://doi.org/10.21203/rs.3.rs-25818/v1

[20] Liang LL, Tseng CH, Ho HJ, Wu CY. COVID-19 mortality is negatively associated with test number and government effectiveness. Sci Rep 2020;10:12567. https://doi.org/10.1038/s41598-020-68862-x

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