

Interrupted time series analysis of the implementation of social distancing policy, its lifting and the mandate of wearing face masks in Iran to mitigate against COVID-19

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Research Article

Keywords: Interrupted time series analysis, COVID-19, health policies, social distancing, face masks, Iran

Posted Date: September 25th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-83125/v1>

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Abstract

Background

COVID-19 was first reported in Wuhan, China, and has spread rapidly around the world. The purpose of this study was to investigate the effects of implementing social distancing policy, and the impact of its lifting, with the resumption of social contacts and activities, as well as the effects of mandating face masks on the temporal trend of new COVID-19 cases in Iran.

Methods

We employed the interrupted time series analysis (ITSA), which is a very valuable method that can be used to evaluate the impact of the implementation of various policies in the health sector to help health policy-makers make effective decisions. Daily data were collected from the Ministry of Health and Medical Education and the World Health Organization from 954 public hospitals and health center settings. Data were extracted 14 days before and after the implementation of each policy. Results were computed with their 95% confidence interval (CI) and p-values equal to or less than 0.05 were considered as statistically significant. All data were analyzed using the open-source software R Version 3.6.1 using the “nlme” and “car” packages.

Results

The slope of changes in new confirmed cases following the implementation of the social distancing policy decreased by 118.79 ($P < 0.001$). With the resumption of social and economic activities in all provinces except for Tehran, initially the number of new daily confirmed cases was 3300, which was statistically significant ($P < 0.001$). The slope of changes due to the implementation of this policy was 47.89 ($P < 0.001$). A similar trend was detected with the resumption of social and economic activities in Tehran. With the implementation of the policy of mandatory use of masks, the slope of changes showed a decrease of 25.84 ($P < 0.001$).

Conclusion

Given the absence of effective drugs and vaccines against COVID-19, policy-makers have implemented non-pharmacological interventions to reduce the transmission of the disease and prevent more deaths. Social distancing may be unsustainable in the long-term, while wearing masks is both a cost-effective and efficacious measure to curb disease transmission.

Background

“Severe Acute Respiratory Syndrome Coronavirus type 2” (SARS-CoV-2), an emerging infectious agent responsible for a novel infection termed as “Coronavirus disease 2019” (COVID-19), was first reported in

Wuhan, province of Hubei, mainland China, and has spread rapidly around the world (1). This infection has imposed and is still imposing a high toll of deaths, challenging the health systems of all countries (2). Morbidity and mortality have been a major concern for public health policy- and decision-makers globally (3). On 11 March, 2020, the World Health Organization (WHO) officially declared COVID-19 a global pandemic (4). According to the WHO, about 17 million people worldwide are infected with COVID-19, and about 669,000 people have died from the infection (5).

On 19 February, 2020, the first COVID-19 case in Iran was reported in Qom (6). With the increase in cases, policy-makers in Iran tried to implement prevention and treatment policies in all provinces (7). However, the rapid increase in the number of patients and the lack of financial resources, equipment and manpower caused the Iranian health system to face many problems at the beginning of the pandemic (6). According to the Ministry of Health and Medical Education (MOHME) in Iran, about 304,000 people have been infected and about 17,000 have lost their lives.

Policy-makers in different countries have developed various policies and programs to prevent and control COVID-19 (8). These include use of masks, regular hand washing, mobility restrictions, closure of schools and universities, as well as of unessential businesses, stay home orders, and social distancing (9, 10). The implementation of these policies has reduced the incidence of new cases and deaths from COVID-19 (11).

The Iranian health system, despite its many challenges in dealing with COVID-19, has implemented a policy of social distancing to effectively control COVID-19 (6). Given the high prevalence of COVID-19 in Iran, it seemed that the implementation of this policy could help the Iranian health system (7). The high number of hospitalizations and the shortage of manpower had also led to considering policies such as social distancing (6, 12).

The purpose of this study was to investigate the effects of implementing social distancing policy, and the impact of its lifting, with the resumption of social contacts and activities, as well as the effects of mandating face masks on the temporal trend of new COVID-19 cases in Iran.

Methods

Design of the study

Interrupted time series analysis

Interrupted time series analysis (ITSA) can be a useful method in order to assess the effects of the different health policies (13, 14). This approach can explore temporal trends before and after the implementation of health policies and their effects on an array of outcomes (15, 16). Utilizing such results can better inform decision-making processes (17).

Policies about COVID-19 related control and prevention in Iran

Following the outbreak of COVID-19, on 27 March 2020, the Iranian government enforced a 1.8 m social distancing policy in all provinces. With the implementation of this policy, social and economic activities were restricted. On April 11 2020, the Iranian government began resuming social and economic activities in all provinces except the capital (Tehran). On 18 April 2020, activities resumed also in Tehran. On 5 July 2020, the Iranian government made it mandatory for everyone to wear a face mask.

Data collection

To investigate the effects of the implementation of COVID-19 related policies on the incidence of new cases, daily data were retrieved from the WHO and the MOHME from 954 public hospitals and facilities. Data were collected both two weeks before and after the implementation of each policy. Table 1 reports the various timelines. We confirm they have not been reported in other previous manuscripts.

Statistical analysis

An ITSA based segmented regression model was used to evaluate the impact of each public health policy on the trends of COVID-19 cases (18). This approach can assess the changes resulting from the implementation of each public health policy in terms of coefficients and slope (19). This model was fitted utilizing segmented longitudinal data (20).

We chose the Newey-West method (21). We extensively performed several diagnostic and sensitivity assessments (19). The results of the Dickey-Fuller statistics showed whether the residuals were stationary and normally distributed. An ordinary least squares (OLS) regression model with a time series specification (an intercept and a trend term, a level and a trend change) was used to verify serially correlated errors by visually inspecting the residuals from the OLS regression and plotting the autocorrelation and partial autocorrelation functions (ACF/PACF) (15). Also, the Durbin-Watson test was utilized for assessing the autocorrelation between data in the generalized least squares regression model (19, 22).

The following segmented regression model was built:

$$Y = \alpha_0 + \alpha_1 * \text{time}_t + \alpha_2 * \text{Policy}_t + \alpha_3 * \text{after_Policy}_t$$

α_0 is the initial number of new confirmed cases at the starting of the study. Time_t is the temporal interval from baseline. α_1 is the slope of the number of new confirmed cases before the implementation of the public health policy. α_2 and α_3 are the slopes of the numbers of new confirmed cases at the first day of the policy implementation and in the following days, respectively. After_Policy_t is the time passed after

the policy implementation. Results were calculated with their 95% confidence interval (CI) and p-values set at values <0.05 were considered significant. All statistical analyses were done by means of the open-source software R Version 3.6.1.

Results

Social distancing

The initial number of new confirmed cases before the implementation of the social distancing policy was estimated at 1020 and had a daily growth of 40.98 before the implementation of the policy, which was not statistically significant ($P=0.16$). The slope of changes in new confirmed cases following the implementation of the social distancing policy decreased by 118.79, which was statistically significant ($P <0.001$).

Resumption of social and economic activities

With the resumption of social and economic activities in all provinces except for Tehran, initially the number of new daily confirmed cases was 3300, which was statistically significant ($P <0.001$). The slope of changes due to the implementation of this policy was 47.89 which was statistically significant ($P <0.001$).

With the resumption of social and economic activities in Tehran, the initial number of new daily confirmed cases was estimated at 2552.31, which was statistically significant ($P <0.001$). Slope changes due to these activities increased by 58.84 which was statistically significant ($P <0.001$).

Mandatory use of face masks

Initially, before the implementation of the policy of wearing masks in the community and the ban on the entry of people without masks, the trend of the number of new daily confirmed cases was estimated at 2,491.97, which was statistically significant ($P <0.001$). With the implementation of the policy, the slope of changes resulting from this policy showed a decrease of 25.84, which was statistically significant ($P <0.001$)

Discussion

Lack of drugs and vaccines for treating and preventing COVID-19, respectively, has led many countries to implement various non-pharmacological policies to reduce and control the disease (23). In addition to putting too much pressure on health systems, COVID-19 has also generated economic and political issues (24).

Iran is one of the countries with the highest morbidity and mortality rates for COVID-19 among the countries of the world. With the onset of the disease in Iran, there was initially an optimism about a quick response to the disease, but its prevalence increased rapidly (6). The coincidence of the severity of the disease outbreak and the beginning of the Nowruz holiday in Iran caused serious concern about the increasing prevalence of the disease among policy-makers (25). During the Nowruz holiday, many families have travelled to different cities to visit relatives and friends, and to see ancient and tourist sites (26). Nowruz holiday sounded as an alarm for health policy-makers in Iran. With the establishment of a national committee for the management of COVID-19, the Minister of Health, as the key person of the committee, decided to put prevention and control policies on the government's agenda (7).

Due to the lack of personal protective equipment such as masks, gloves and disinfectants, as well as sanctions and the inability of buying this equipment, Nowruz holiday has represented an opportunity for easy transmission of the disease in Iran (26). The increase in hospitalized patients and the lack of manpower caused the health system to experience more problems than other countries with a more resilient and robust healthcare system (27). The experience of implementing social distancing in countries such as China, Thailand, Hong Kong and New Zealand has shown that this policy can prevent further outbreaks of the disease (28, 29).

On March 27, 2020, the Iranian government implemented a policy of social distancing. The government banned all occupations (except some essential occupations) (6). Inter-city and inter-provincial travels were restricted. Attendance of parks, sports clubs and places of pilgrimage were banned. ITSA studies can assess the impact of implementing a given public health policy (15). Our ITSA findings showed that the implementation of this policy has reduced the number of new daily confirmed COVID-19 cases in Iran. Findings from studies employing ITSA and conducted in Italy and Spain (11), as well as in other countries (30) with high COVID-19 infection rate, showed that the implementation of social distancing has been an effective policy in reducing the incidence of this disease, which is consistent with the findings of our study.

Stay home orders, ban of gathering and avoiding crowded places are effective ways to reduce the transmission of the disease (29). The available body of evidence recommends the implementation of social distancing policy for reducing transmission (31).

Of course, in addition to the implementation of this policy in Iran, at the same time increasing the production of disinfectants and implementation of educational campaigns and hygiene interventions can also be one of the reasons for the decrease in COVID-19 cases. Also, treating patients with different (even though non-specific) therapeutics and increasing the number of tests, ensuring that more people have access to tests, enhancing the accuracy of laboratory tests, can be other reasons for this decrease.

After the implementation of this policy in Iran, the burden of hospitalizations was reduced as well as the pressure on the hospital staff members, who could increase the quality of services delivered to patients, being themselves less at risk (6).

With the decline in social activities, economy was highly disrupted. Many closed industries and factories needed to be reopened (32). The implementation of the policy of social distancing could not be on the agenda for a long time, and for this reason, the Iranian government issued economic licenses in two stages and reopened various jobs (33). COVID-19 has had a devastating effect on the economies of many countries and has created many problems for everyone (7).

Our ITSA findings showed that the resumption of social and economic activities led to the growth of newly confirmed cases of the disease. With the relaxing and easing of the policies in Iran, the transmission of the disease through social relations and contacts increased.

Health policy-makers have warned that the resumption of social activities could result in the resumption of the spread of the disease. However, economic issues, not only in Iran but also in other countries, forced governments to lift COVID-19 related strictures (6, 33). After the increase in cases, the Iranian government could not re-implement the policy of social distancing as in the past and decided to mandate the use of masks as a major intervention (34).

As a consequence, the production of masks and other preventive equipment in Iran increased and the conditions for providing this equipment were better than before. Our findings show that the implementation of this policy has also reduced the incidence of COVID-19 (35).

The use of masks in case of viral outbreaks can be a valuable intervention, although recommendations regarding its use of masks vary among countries. Available evidence suggests that SARS-CoV-2 can survive in the air for hours, and therefore the use of a mask can be effective in reducing the transmission of the disease (36).

The use of masks in the prevention of diseases such as SARS, avian influenza and swine flu suggests that wearing masks can be an important measure to control COVID-19 (35). Population density speeds up the transmission of COVID-19, so the mandatory use of a mask can be an effective policy to control the disease.

Wearing a mask is a crucial preventative measure, as many people with the disease may be asymptomatic (37). Singapore enforced the use of masks for the general public, a measure which was able to achieve good results. The South Korean experience also confirmed the use of masks as an appropriate strategy to reduce disease transmission (38).

Of course, it should not be forgotten that the mandatory use of masks can increase demand and cause shortages, so it can be a threat to health workers who are more involved in the management of the disease (37). Iran was able to solve the mask problem to some extent by establishing mask factories and also using the capacity of non-governmental organizations (NGOs).

The mandatory use of masks in public places can be a very effective way for reducing the transmission of COVID-19 (9). The long-term implementation of social distancing is practically unfeasible and unsustainable, and can have very disruptive effects on the economy, whereas the use of masks can help

protect people against this disease (37). Even if there is a shortage of medical masks, it is recommended that people can use non-medical masks, which can be cost effective. Medical masks can be stored for healthcare and other frontline workers.

The present study examined the implementation of several COVID-19 related policies in Iran. The findings of this study showed that the transmission of the disease was reduced through social distancing and wearing a mask. Community cooperation to maintain proper distance and reduce unnecessary contacts and activities helps a lot to reduce the disease transmission. On the other hand, the need for resuming economic and social activities has resulted in an increase of cases.

Limitations of the study

This investigation is not without limitations. The major shortcoming is given by the short study period (2 weeks before and after the implementation of each policy), which is not enough to evaluate the impact and effectiveness of a policy. On the other hand, especially during an emergency situation like the ongoing outbreak, health policy- and decision-makers cannot wait long in that time is of paramount importance during a pandemic and even short-term data can be meaningful and helpful to inform and guide decision-making processes. Besides this main shortcoming, it should be emphasized that different contextual factors and variables such as the quality of healthcare services in Iran, underlying comorbidities, among selected sample, may contribute to explain the findings of the present study. Moreover, confirmed data could suffer from under-reporting bias or reporting delays. Finally, other measures implemented at similar time of the social distancing measures could also contribute to reducing the spread of the disease.

Conclusion

Given the absence of effective drugs and vaccines against COVID-19, policy-makers in all countries have implemented non pharmacological interventions to reduce the transmission of the disease and prevent more deaths. Different policies are being implemented based on the situation of the countries. COVID-19 has had a detrimental effect on different parts of the country. Iran was able to reduce the transmission of the disease by implementing social distancing and mandating the use of masks. Due to economic problems and sanctions, social activities resumed and the rate of disease transmission increased again. Based on the cost-effectiveness of various policies, and the state of the health system, Iranian policy-makers can use other measures, such as enhancing access to diagnostic tests and helping families in need to reduce their economic activities to curb disease transmission.

List Of Abbreviations

ITSA: Interrupted time series analysis

WHO: World Health Organization

MOHME: Ministry of Health and Medical Education

Declarations

Ethics approval and consent to participate

The ethics committee of the Lorestan University of Medical Sciences (LUMS) approved this study (approval code no: IR.LUMS.REC.1399.083).

Consent for publication

Not applicable.

Availability of data and materials

Data was publically available in the website of the MOHME and the WHO.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors' contributions

MaB, MS, MKG and MeB : Conceptualization, MaB, JW and NLB:Methodology, MaB, JW and NLB: Software, MaB, MS, MKG, HAG, AB, SA and MeB: Data collection, MaB, MS, HAG, and NLB:Writing-Original draft preparation, MB: Visualization, Investigation, MaB and MS: Supervision, : **MaB and NLB:** Software, Validation: MaB , **MS, HAG, and NLB:** Writing- Reviewing and Editing.

Acknowledgements

This study was supported by the Lorestan University of Medical Sciences.

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Tables

Policy	14 days before	Inception of policy	14 days after
Social distancing	13 March 2020	27 March 2020	10 April 2020
Suppression of social and economic activities (except for Iran)	28 March 2020	11 April 2020	25 April 2020
Suppression of social and economic activities in all provinces	4 April 2020	18 April 2020	2 May 2020
Mandatory use of face masks	21 June 2020	5 July 2020	19 July 2020

Table 1. Time frames used in the present study

Parameter	Coefficients	Newey-West Standard Errors	P-Value	Lower bound of CI (95%)	Upper bound of CI (95%)
Intercept	1020.51	145.63	0.00	720.58	1320.44
Pre-policy slope	40.98	28.41	0.16	-17.53	99.50
Change in intercept	1563.82	427.15	0.00	684.07	2443.57
Change in slope	-118.79	33.89	0.00	-188.59	-48.98
Post-policy linear trend	-77.80	27.52	0.00	-134.48	-21.12
F (3, 25)		45.91			
Number of observations		29			
Prob > F		0.00			

Table 2: Coefficients of the segmented regression model for social distancing policy

Parameter	Coefficients	Newey-West Standard Errors	P-Value	Lower bound of CI (95%)	Upper bound of CI (95%)
Intercept	3300.11	155.94	0.00	2978.93	3621.29
Pre-policy slope	-103.16	18.87	0.00	-142.03	-64.28
Change in intercept	-4.059	155.90	0.97	-325.16	317.04
Change in slope	47.89	18.71	0.01	9.34	86.43
Post-policy linear trend	-55.26	5.12	0.00	-65.81	-44.71
F (3, 25)			170.65		
Number of observations			29		
Prob > F			0.00		

Table 3. Coefficients of the segmented regression model for the resumption of social and economic activities except for Tehran

Parameter	Coefficients	Newey-West Standard Errors	P-Value	Lower bound of CI (95%)	Upper bound of CI (95%)
Intercept	2552.31	88.95	0.00	2369.10	2735.52
Pre-policy slope	-90.16	10.92	0.00	-112.67	-67.66
Change in intercept	106.06	85.03	0.22	-69.07	281.19
Change in slope	58.84	12.32	0.00	33.45	84.23
Post-policy linear trend	-31.32	3.65	0.00	-38.84	-23.80
F (3, 25)			134.51		
Number of observations			29		
Prob > F			0.00		

Table 4. Coefficients of the segmented regression model for the resumption of social and economic activities in Tehran

Parameter	Coefficients	Newey-West Standard Errors	P-Value	Lower bound of CI (95%)	Upper bound of CI (95%)
Intercept	2491.97	39.35	0.00	2410.91	2573.02
Pre-policy slope	4.46	5.35	0.41	-6.56	15.49
Change in intercept	-10.86	100.95	0.91	-218.78	197.04
Change in slope	-25.84	10.33	0.01	-47.12	-4.56
Post-policy linear trend	-21.37	8.91	0.02	-39.73	-3.01
F (3, 25)			5.45		
Number of observations			29		
Prob > F			0.00		

Table 5. Coefficients of the segmented regression model for the mandatory use of face masks

Figures

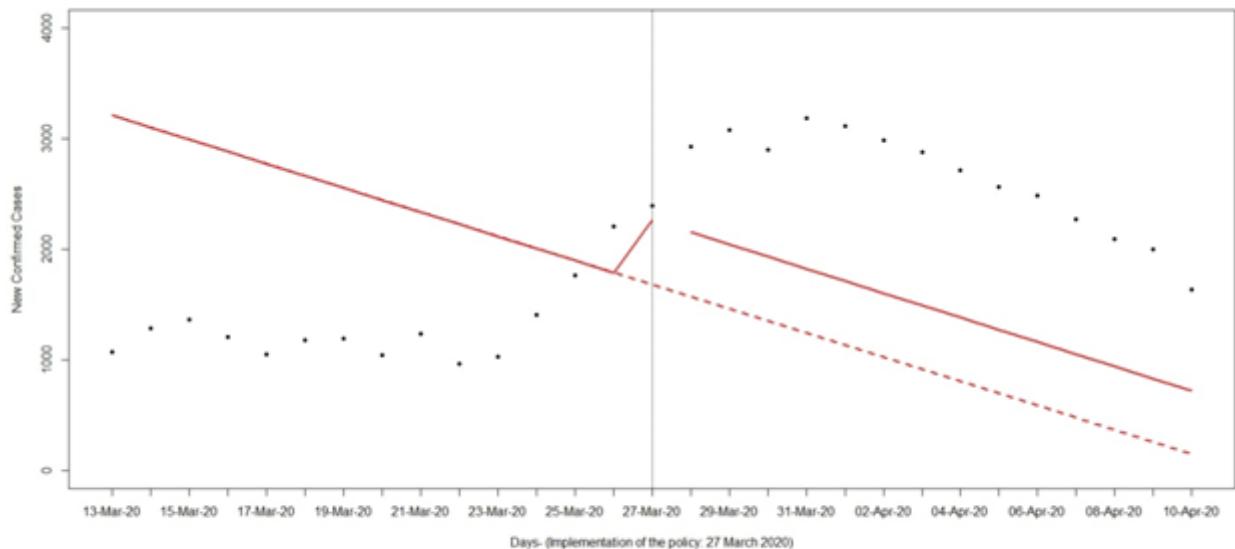


Fig 1:

Figure 1

Interrupted time series analysis for social distancing policy

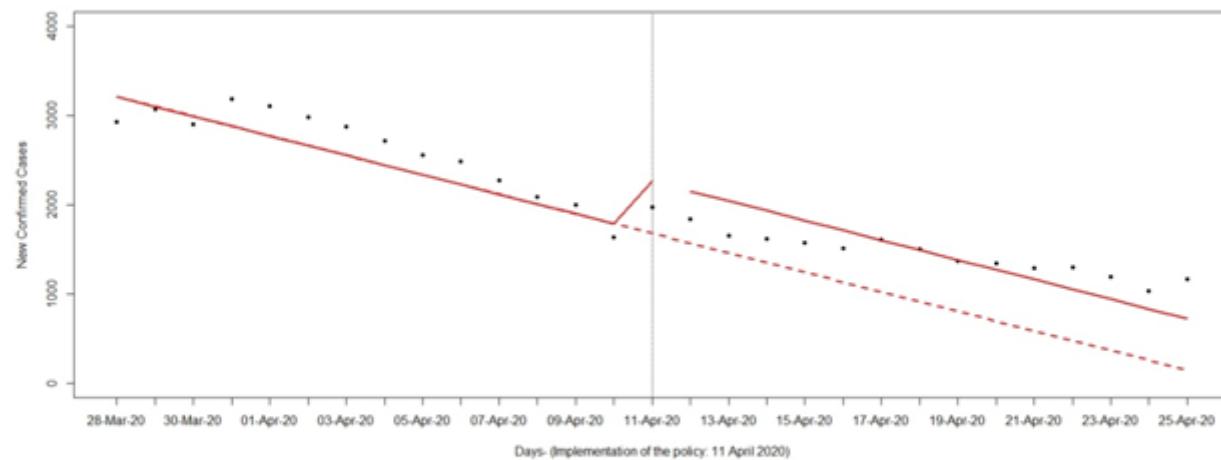


Fig 2:

Figure 2

Interrupted time series analysis for the resumption of social and economic activities except for Tehran

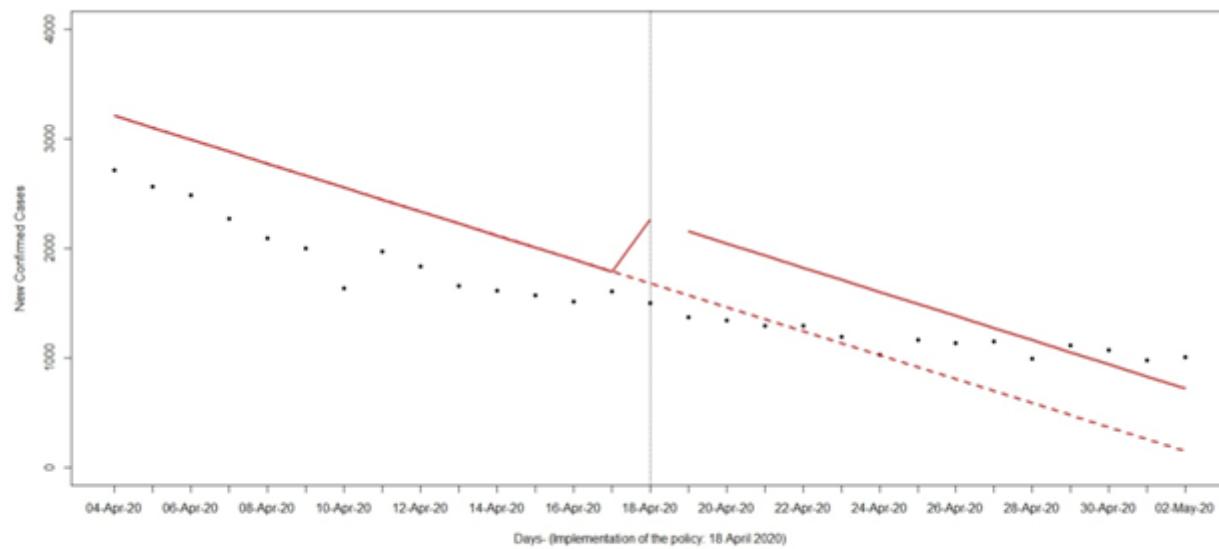


Fig 3:

Figure 3

Interrupted time series analysis for beginning of social and economic activities with Tehran

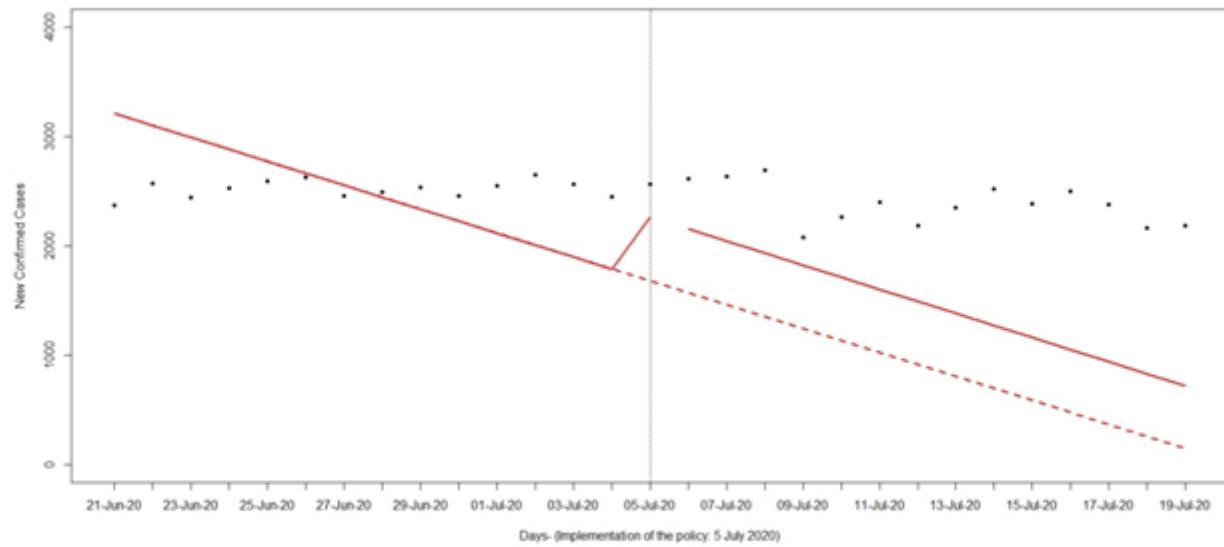


Fig 4:

Figure 4

Interrupted time series analysis for the mandatory use of face masks