

## Impact of suspending traffic management plan in Tehran on air quality and COVID-19 mortality and morbidity

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### ABSTRACT:

**Introduction:** The novel coronavirus disease 2019, namely COVID-19, has been known as a global pandemic by the World Health Organization (WHO). To prevent of COVID-19 spread, most countries including Iran have implemented many preventive measures. This study aimed to evaluate the effect of implementation (Phase-01)/non-implementation (Phase-02) of the traffic plan on confirmed cases, suspected cases, and mortality cases by COVID-19 as well as on air quality in Tehran.

**Materials and methods:** Daily data of confirmed COVID-19 cases, suspected COVID-19 cases, mortality COVID-19 cases, air pollutants concentration and meteorological variables were obtained from 26 February, 2020 to 5 August, 2020 in Tehran megacity and data were compared during the period's implementation /non-implementation of traffic plan in Tehran.

**Results:** Our results showed that the non-implementation of traffic plan has been effective in reducing the number of daily confirmed cases, suspected cases and mortality by COVID-19. Also, the average concentration of PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub>, O<sub>3</sub>, SO<sub>2</sub> and CO have reduced significantly during non-implementation traffic plan phase.

**Conclusion:** Our findings indicate that there is a significant association between non-implementation traffic plan and reduce risk of COVID-19 infection.

### Introduction

Coronavirus (COVID-19) is an infectious illness caused by a new strain discovered of coronavirus, subsequently called SARSCoV2 [1, 2]. COVID-19 was initially figured out in the Wuhan

region of Central Hubei Province of China in late 2019 [3]. Since then, it was spread rapidly to neighboring cities, all provinces in China, and all over the world. The World Health Organization (WHO) announced the novel COVID-19

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outbreak a “Global pandemic on March 11, 2020 [4, 2, 5]. Since that time, researcher person-to-person transmission of the Coronavirus have confirmed [6, 7]. Most common clinical symptoms of COVID-19 include fever, sore throat, dry cough, shortness of breath and fatigue. Symptoms may appear 2-14 days after exposure to the virus and [8-10]. On February 19, 2020, the first case of death from COVID19 was confirmed in Qom city by the Iranian Ministry of Health and Medical Education (MOHME). The virus rapidly spread to other parts of Iran, and by March 5, 2020, all 31 provinces were infected [11, 12]. Following the outbreak COVID-19 in Iran, in early February, the national campaign on Coronavirus was formed in Iran .So, as of 20 February to control the spread of COVID-19, many preventive measures such as social distancing, ask to stay indoors and closing schools, educational institutions and universities, movie theaters, holy shrines and sporting events in Tehran and other cities were recommended by the Iran’s national campaign against Coronavirus temporarily, but we was faced with two or three weeks’ time lag to perform the abovementioned recommendations in Iran, especially in Tehran [13]. So that, the highest number of confirmed COVID-19 and death cases have been reported in Tehran. Tehran is the capital and most populous city of Iran with a population of about 9 million urban residents. Tehran has faced high levels of criteria air pollutants due to the transportation of more than 4.5 million vehicles , industrialization and urbanization in two decades [14]. In recent years, the two traffic plans have been performed for reducing air pollution level and restricting car use in Tehran. In the first one, Odd-Even Zone (OEZ) plan was conducted from the city center

from Saturday to Thursday (except Fridays and public holidays) which odd license-plate numbers vehicles will be allowed from the door of each house to the Odd-Even plan zone on odd dates and even license-plate numbers vehicles will be allowed on even dates on weekdays between 6:30 a.m. and 7:00 p.m. except for taxis, public transport, and motorcycles. The other, the Restricted Traffic Zone (RTZ), car access to the city center is based on pass permission on weekdays between 6:30 a.m. and 5:00 p.m. Odd-Even Zone with 74 km<sup>2</sup> surrounds Restricted Traffic Zone (32 km<sup>2</sup>) [15, 16]. During the outbreak of COVID-19 in Tehran, especially during the first quarter of the year, non-implementation of the traffic plan as a strategy to maintain social distancing has introduced by Iran’s national campaign against Coronavirus. The purpose of this initiative is the limitation of social interaction, reduce the pace of the spread and avoid crowds in public transport such as buses, Bus Rapid Transit System (BRT) and subways. Therefore, it is interesting to assess the impact of non-implementation/implementation of traffic plan on confirmed cases, suspected cases, mortality cases of COVID-19 and the air quality of Tehran. In current study, changes in the concentration of criteria air pollutants during implementation and non-implementation traffic plan in Tehran were quantified. Daily concentrations of PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub>, O<sub>3</sub>, SO<sub>2</sub> and CO were compared between the period’s implementation of traffic plan and during non-implementation of traffic plan. This study has, for the first time, assessed data on daily confirmed cases, daily suspected cases and daily mortality cases of COVID-19 during the period’s implementation/non-implementation of traffic plan in Tehran.

## Materials and methods

### Study timeline

The study was conducted in Tehran. In this section we processed the dataset for two phases: The implementation of traffic plan from 26 February-19 March 2020 and from 6 June-31 July 2020 (Phase-01) and the non-implementation of the traffic plan from, 20 March-5 June 2020 and from 1 August -5 August 2020 (Phase-02). The phase 0-1 and phase 0-2 encompassed the 79 days and 83 days, respectively.

### Data collection

Daily confirmed cases, suspected cases and mortality by COVID-19 for Tehran megacity between February 26, 2020 and August 5, 2020 were obtained from the Ministry of Health and Medical Education database. Also, data were collected by date.

We collected air quality data including particles with diameters  $\leq 10 \mu\text{m}$  ( $\text{PM}_{10}$ ), particles with diameters  $\leq 2.5 \mu\text{m}$  ( $\text{PM}_{2.5}$ ), nitrogen dioxide ( $\text{NO}_2$ ), ozone ( $\text{O}_3$ ), sulfur dioxide ( $\text{SO}_2$ ) and carbon monoxide (CO) from 21 air quality monitoring stations (AQMSs) belonging to the Tehran Air Quality Control Company (TAQCC) during the study period [17]. The air quality trends have been evaluated in two phases: implementation of traffic plan phase (phase-01) (from 26 February-19 March 2020 and from 6 June-31 July 2020) and non-implementation of traffic plan phase (phase 0-2) (20 March-5 June 2020 and from 1 August-5 August 2020). The daily concentration means (24 h) of  $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ ,  $\text{NO}_2$ ,  $\text{O}_3$ ,  $\text{SO}_2$  and CO have been calculated to analyze the different in their mean concentration between implementation of traffic plan and non-implementation of traffic plan phases.

Also, during the study period, meteorological data including daily mean temperature, relative humidity, speed wind and air pressure were derived from the Iran's Meteorological Organization [18].

### Statistical analysis

According to an incubation period of 1 to 14 days for COVID-19 was reported, we performed three lags (lag 14, lag 21 and lag 28 days) to investigate the effect of the implementation /non-implementation traffic plan on mortality cases of COVID-19 and lag 14 days to investigate the effect of implementation /non-implementation traffic plan on confirmed COVID-19 cases and suspected COVID-19 cases. For each analysis, a normal distribution test (Shapiro-Wilk) was performed on the data. Due to the non-compliance of the data with the normal distribution, the non-parametric Mann-Whitney Rank Sum test was used for statistical comparison. Overall, descriptive statistics were calculated for each outcome and measure.

## Results and discussion

### Descriptive analysis

Table 1 presents the statistics for daily Confirmed COVID-19 cases, suspected COVID-19 cases, death COVID-19 cases and concentration of air pollutants during implementation traffic plan. During the implementation traffic plan period, this study included over of average 151.25 confirmed cases, 496.49 suspected cases and 21.34 death cases. Average daily values of  $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ ,  $\text{NO}_2$ ,  $\text{O}_3$ ,  $\text{SO}_2$  and CO were  $72.72 \mu\text{g}/\text{m}^3$ ,  $27.67 \mu\text{g}/\text{m}^3$ ,  $47.4 \text{ ppb}$ ,  $30.97 \text{ ppb}$ ,  $4.88 \text{ ppb}$  and  $1.41 \text{ ppm}$ , respectively. The daily relative humidity, mean temperature, air pressure and wind speed

were 25.96 %, 25.09 °C, 1012 hPa and 3.23 m/s, respectively. During the non-implementation traffic plan period, daily average of confirmed cases, suspected cases and death cases were 144.87, 539.55 and 17.67, respectively. The mean daily levels of PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub>, O<sub>3</sub>, SO<sub>2</sub> and CO were 52.67 µg/m<sup>3</sup>, 20.14 µg/m<sup>3</sup>, 37.80 ppb, 25.72 ppb,

3.60 ppb and 1.19 ppm, respectively. The meteorological conditions of air pressure and wind speed during the non-implementation of traffic plan were almost similar to those of the implementation of traffic plan. The daily mean of relative humidity and temperature were 36.85% and 20 °C, respectively (Table 2).

**Table 1. Descriptive statistics of daily confirmed new cases, suspected cases, deaths and concentration of air pollution during phase-01 period.**

	Mean (SD)	Minimum	Maximum
Daily Confirmed cases	151.25 (84.57)	4	361
Daily Suspected cases	496.49 (199.04)	147	901
Daily death cases	21.34 (10.16)	2	48
O <sub>3</sub> (ppb)	30.97 (9.72)	7.81	47.06
CO (ppm)	1.41(0.30)	0.80	2.26
NO <sub>2</sub> (ppb)	47.4 (8.85)	28.05	71.76
SO <sub>2</sub> (ppb)	4.88 (1.27)	3.12	9
PM <sub>10</sub> (µg/m <sup>3</sup> )	72.72 (18.59)	29.93	122.50
PM <sub>2.5</sub> (µg/m <sup>3</sup> )	27.68 (8.64)	13.37	72.43
Mean temperature (°C)	25.09 (8.55)	6.00	34.91
Relative humidity (%)	25.96 (13.67)	9.83	81.83
Air pressure (hPa)	1012 (3.99)	1004.87	1022.50
Wind speed (m/s)	3.23 (1.22)	1.52	8.08

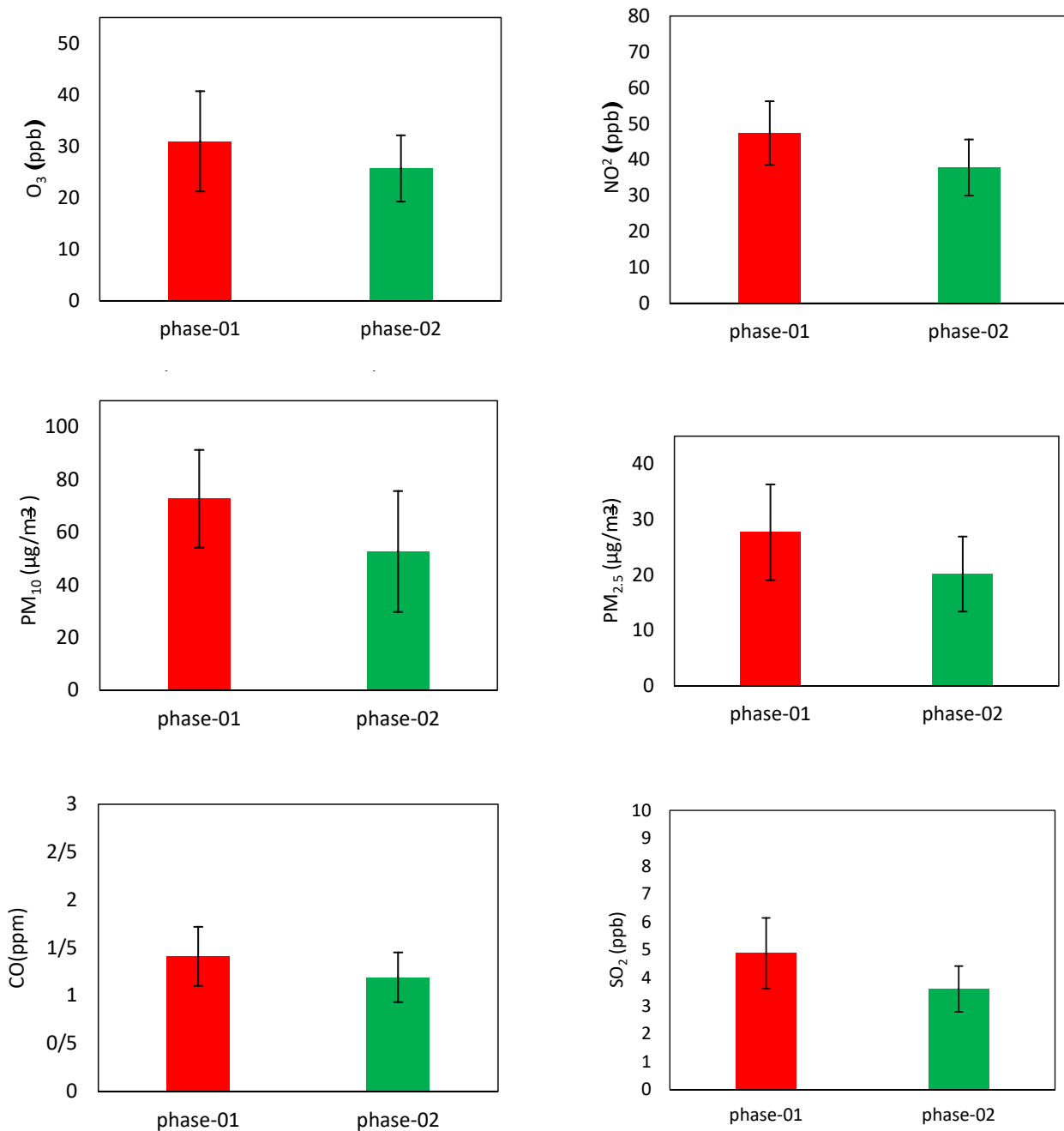
**Table 2. Descriptive statistics of daily confirmed new cases, suspected cases, deaths and concentration of air pollution during phase-02 period.**

	Mean (SD)	Minimum	Maximum
Daily Confirmed cases	144.88 (124.96)	22	646
Daily Suspected cases	539.55 (189.87)	169	1025
Daily death cases	17.67 (12.81)	1	53
O <sub>3</sub> (ppb)	25.72 (6.43)	7.27	48.20
CO (ppm)	1.19 (0.26)	0.538	1.75
NO <sub>2</sub> (ppb)	37.80 (7.79)	19.64	58.56
SO <sub>2</sub> (ppb)	3.60 (0.82)	2.29	6.47
PM <sub>10</sub> (µg/m <sup>3</sup> )	52.66 (22.98)	14	135.93
PM <sub>2.5</sub> (µg/m <sup>3</sup> )	20.14 (6.76)	6.86	45.13
Mean temperature (°C)	20.00 (7.49)	4.12	33.21
Relative humidity (%)	36.85 (18.94)	8.04	90.75
Air pressure (hPa)	1014.58(3.54)	1006.83	1023.08
Wind speed (m/s)	3.54 (1.41)	1.56	8.66

### ***Impact of the implementation/non-implementation of traffic plan on criteria pollutants concentration***

Fig. 1 illustrates the average concentration of air pollutants in during implementation/non-implementation of traffic plan period. We observed

that the average concentrations of all criteria pollutants during non-implementation of traffic plan has decreased significantly ( $p < 0.05$ ) in comparison with the implementation of traffic plan period.



**Fig. 1. Average of criteria pollutants concentration during phase-01 and phase-02.**

### **Impact of the implementation/non-implementation of traffic plan on death COVID-19 cases**

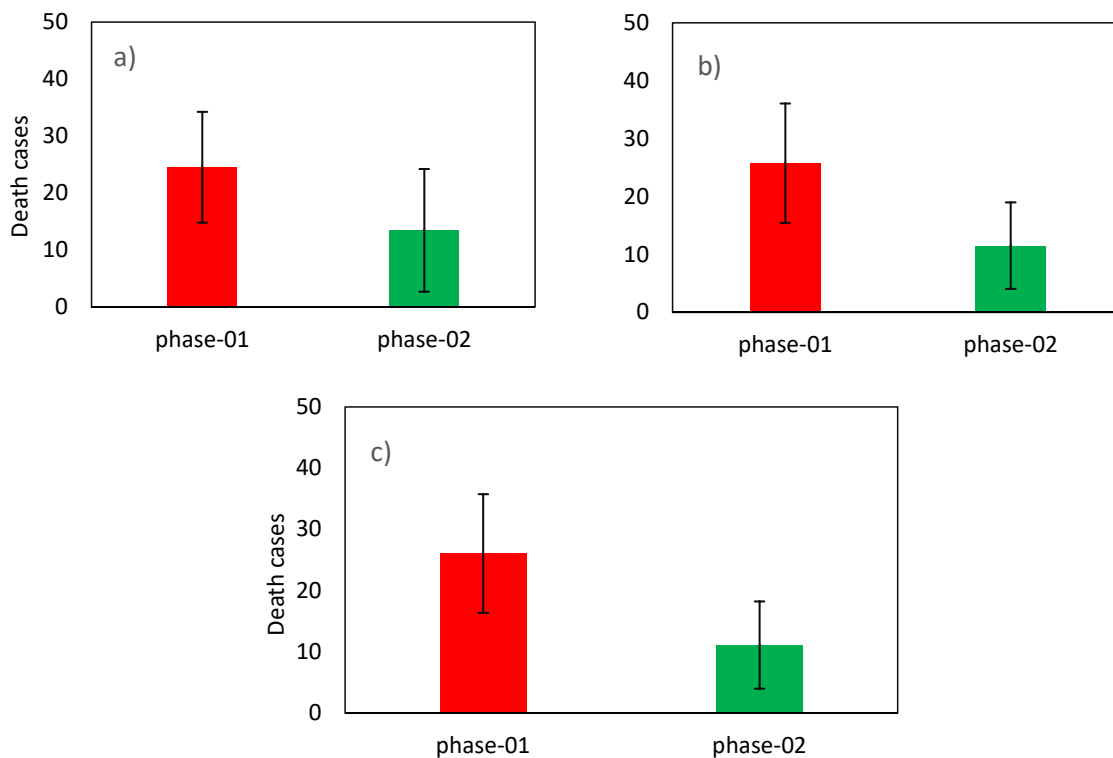
Fig. 2 plots the impact of the implementation/non-implementation of traffic plan on the number of COVID-19 death cases in lags (lag 14, lag 21 and lag 28 days). Distribution analysis of death COVID-19 cases during implementation of traffic plan and non-implementation of traffic plan period showed significant differences. The results show that during the non-implementation of the traffic plan, the death cases of Covid-19 in lag 14, lag 21 and lag 28 days were lower, compared to the implementation of the traffic plan and these differences were statistically significant ( $p < 0.05$ ).

### **Impact of the implementation/non-implementation of traffic plan on confirmed COVID-19 cases and suspected COVID-19 cases**

The impact of the implementation/non-imple-

mentation of traffic plan on the number of confirmed COVID-19 cases and suspected COVID-19 cases in lag 14 was shown in Fig. 3. Mean number of confirmed COVID-19 cases and suspected COVID-19 cases were 182.2 and 611.9 during implementation of traffic plan, whereas mean number of confirmed COVID-19 cases and suspected COVID-19 cases were 131.6 and 468.6.

Tehran is the most populous and one of the most polluted cities in Iran. Considering these factors, the study focused on the implementation/non-implementation of traffic plan in Tehran, its inhabitants may have a higher risk in comparison to other cities due to vehicles, population and high road traffic. The results indicate that the non-implementation of traffic plan was effective in reducing the number of daily confirmed cases, suspected cases and mortality by COVID-19. So, it



**Fig. 2.** The average of death cases during phase-01 and phase-02: (a) lag 14 (b) Lag 21 (c) Lag 28

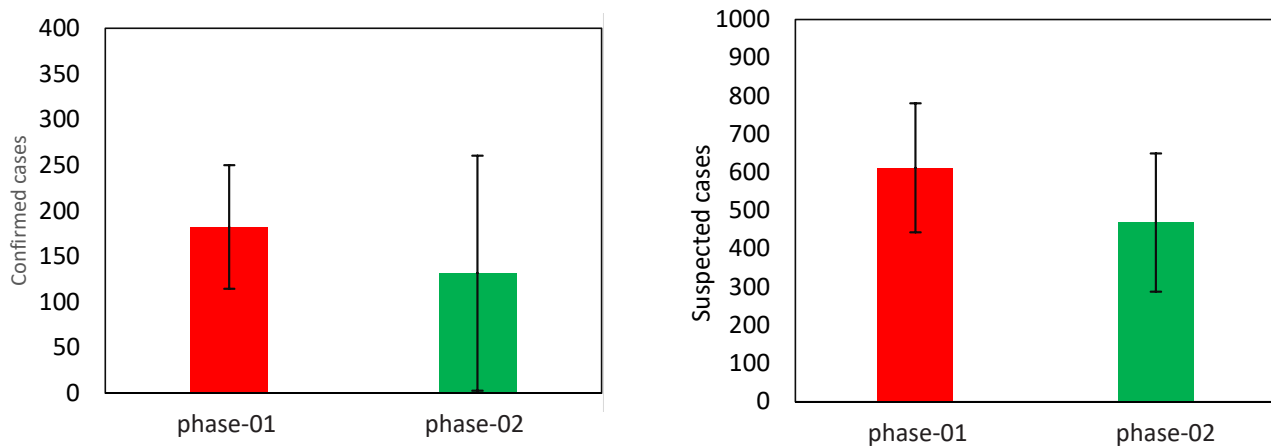


Fig. 3. The average of COVID-19 confirmed cases and suspected cases during phase-01 and phase-02 (Lag14).

can be used as an approach to decrease the spread of the COVID-19. As a result, the impact of the public transport sector on COVID-19 infection and mortality would be significant. This may be a result of one main factor. The public transportation system in Tehran with daily use of between four and five million travelers is very crowded [19] and maintain appropriate physical/social distancing is not possible. Thus, the public transportation system helps to increase the spread of disease. So, the non-implementation of traffic plan (RTZ and OEZ) had been probably an effective factor in reduction of confirmed cases, suspected cases and mortality by COVID-19. Furthermore, Odd-Even Zone is a crucial section of the urban core due to existence commercial and office centers. In agreement with the our study, a conducted study suggest that social distancing measures were useful in reducing morbidity and mortality cases [20]. Also, the non-implementation traffic plan has significantly improved the air quality in Tehran. Some studies have declared that air pollution can enhance the risk of respiratory viruses by transporting microorganisms to make pathogens more invasive to humans and effecting body's

immunity [21, 22]. As COVID-19 infection is a disease respiratory and can settle viable in air for hours, so air quality improvement probably can help to decline COVID-19 cases. Based on our results, the average of ambient  $PM_{10}$ ,  $PM_{2.5}$ ,  $NO_2$ ,  $O_3$ ,  $SO_2$  and CO concentrations noticeably were higher during the phase0-1 as compared to the phase 0-2. There are two potential reasons. First, due to two- or three-weeks' time lag to implement the restricting measures recommended by Iran's national campaign against Coronavirus during phase 0-1. Second, during phase 0-2 many government offices also were work, with two-thirds of their staff and universities were closed during this period. Compared to our results, some researchers have indicated that the mean concentrations of  $PM_{2.5}$ ,  $NO_2$ , and CO reduced during the COVID-19 outbreak due to lockdown measures [23]. Recently, other researchers (2020) indicated that there are significant association between COVID-19 and air pollution [4]. However, in a study by many researchers, it was found that lockdown measures during COVID-19 have had positive impact on air quality of three major Indian cities [24].

**The mass concentration ratios of  $[NO_2]/[SO_2]$  and  $[CO]/[SO_2]$  during the implementation/non-implementation of traffic plan**

The combustion of diesel and gasoline fuel in motor vehicle engines is major source of  $NO_2$  and anthropogenic  $SO_2$  of emissions often comes from coal and oil burning in industrial sources[25]. The ratio of  $[NO_2]/[SO_2]$  is mostly used for demonstrate the change in the contribution rates of stationary and mobile sources in the atmosphere. Both  $SO_2$  and  $NO_x$  are released from fixed sources, with partly more  $SO_2$  [26]. After the non-implementation of traffic plan in Tehran,  $[NO_2]/[SO_2]$  increased partially, and the contribution rate of mobile sources(e.g., transport) increased in the same proportion, which may be related to a number of factors. Firstly, the people more used private vehicles due to social distancing measures and the use of public transport decreased. Most of public transport vehicles in Tehran uses diesel

fuel and diesel fuel is a source of sulfur dioxide emissions. Secondly, industrial sources were not shut down and as well as due to Tehran city proximity to a large number of industrial sources. Therefore,  $SO_2$  concentration was reduced less during phase 0-2 (Fig.4 a). Also, the ratio of  $[CO]/[SO_2]$  can be used to appraise the contribution of local pollutant discharge and external pollutant transportation, which higher ratios indicating higher local contributions[26]. The carbon monoxide emissions mainly caused by the incomplete combustion of fossil fuel in automobile exhaust. Tehran is a megacity with a population about 9 million people and has a large number of motor vehicles. So, CO emissions are higher than  $SO_2$  emissions. After the non-implementation of traffic plan,  $[CO]/[SO_2]$  increased some extent, which indicated that the contribution of local emissions increased, and the air pollution was affected by local sources (Fig. 4b).

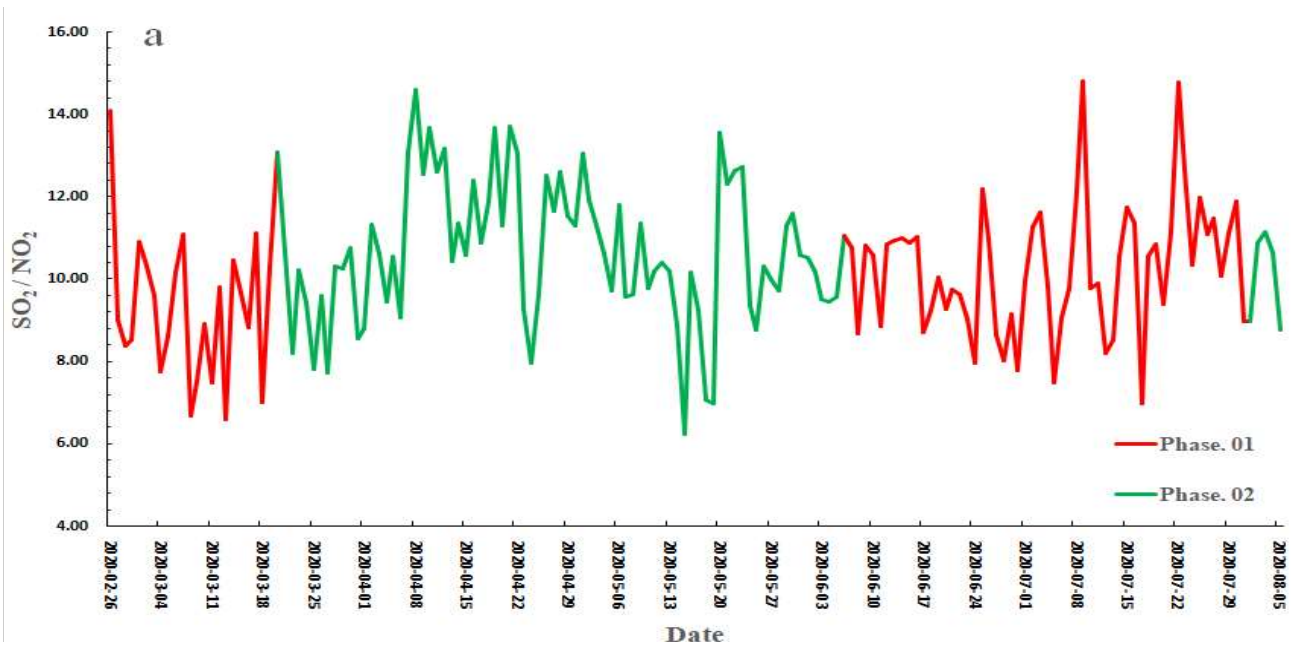


Fig. 4. The change of  $[NO_2]/[SO_2]$  and  $[CO]/[SO_2]$  during phase-01 and phase-02. a,  $[NO_2]/[SO_2]$  b,  $[CO]/[SO_2]$ .



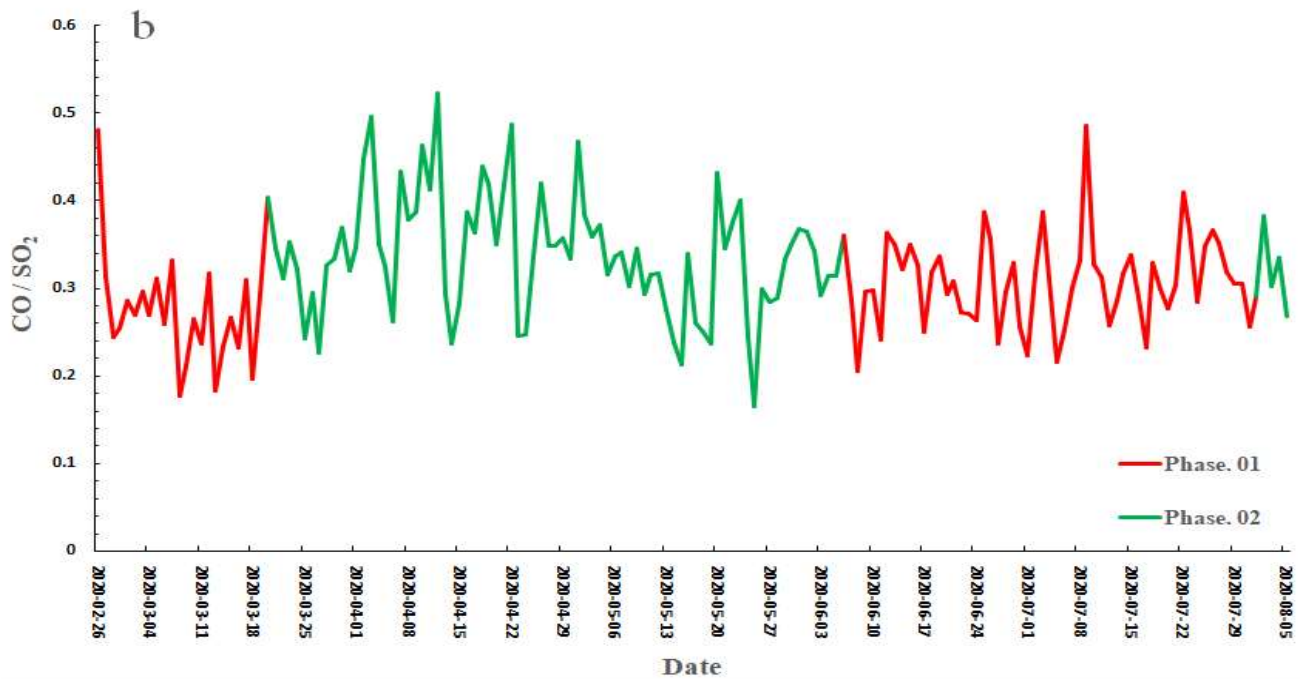


Fig. 4. The change of  $[\text{NO}_2]/[\text{SO}_2]$  and  $[\text{CO}]/[\text{SO}_2]$  during phase-01 and phase-02. a,  $[\text{NO}_2]/[\text{SO}_2]$  b,  $[\text{CO}]/[\text{SO}_2]$ .

## Conclusion

Our result suggest that the non-implementation of traffic plan was effective in reducing the number of daily confirmed cases, suspected cases and mortality by COVID-19. Furthermore, air quality improved during the non-implementation of traffic plan in Tehran. Therefore, it can be used as an approach to decrease the spread of the COVID-19 in Tehran megacity.

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## Competing interests

None of the authors have competing interests to disclose.

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## Ethical considerations

Ethical issues have been completely observed by the authors.

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