

# Epidemiological features and hotspot of COVID-19 in Isfahan province of Iran: Results of a cohort study

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## Research article

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# Abstract

**Background and Aim:** The aim of this study was to description of the epidemiological features and hotspot of COVID-19 in Isfahan province of Iran.

**Method:** In this descriptive, retrospective cohort, multicenter study, all patients admitted to one of the hospitals or health networks of Isfahan province from 3<sup>rd</sup> February to 13<sup>th</sup> June 2020 due to RT-PCR (Reverse transcription-polymerase chain reaction) test were enrolled to study. Trained staff followed up participants for two weeks by a Telephone number, and the outcome was recorded.

**Result:** Up to 13 June, 41,498 patients recruited and their data were analyzed; the incidence of COVID-19 was 27.5% (95% CI: 27.1, 28.2). Among the participants with the positive test, 93.2% of them, treated by outpatient basis or discharged, 2.1% were hospitalized, and the case fatality rate (CFR) was 4.8%. Khansar and Aradestan was the hotspot of COVID-19 and had the highest incidence among cities of Isfahan province. Najafabad, Khomeinishahr, and Shahinshahr&Meymeh had the highest imported cases of COVID-19 to the capital of Isfahan province, Isfahan city. Also, Charmahal & Bakhtiari, Khuzestan, and Fars provinces had the highest number of imported cases from other provinces to Isfahan city. We found that 77.3% of intra-province imported cases and about 83% of inter-province cases were imported after reducing lockdown.

**conclusion:** The incidence and fatality of COVID-19 in Isfahan province is alarming. Inter-city and inter-provincial unnecessary travels have a high impact on the transmission and spread of the COVID-19. Applying more restrictions will prevent this from happening. It is advised to restrict the inter cities travels again by policy makers for the benefit of public health.

## Introduction

The novel coronavirus, named as SARS-CoV-2 was first emerged in Wuhan, China, in December 2019 and caused respiratory illness termed COVID-19. The COVID-19 was highly contagious, and in normal conditions, the R0 level was estimated at 3 (1). Subsequently, the total number of patients has risen sharply around the world in march 2020 and over a hundred countries worldwide become involved (2) On March 11, 2020, the WHO announced COVID-19 as a pandemic aroused emerging global concerns (3).

In Iran, the first official report of COVID-19 diagnosis was coincided with deaths from COVID-19 on February 19, 2020, in the city of Qom (4). On February 24, the Corona Fighting Committee in Iran was formed. Subsequently, schools, universities, religious sites (like the mosque, holy shrine, etc.), sports competitions, public transportation (such as bus, subways, etc.), museums were closed, and travel between cities was restricted until April 20 (5).

According to statistics, in the middle of June 2020, Iran ranks Tenth and ninth in the number of deaths and the number of the infected patients due to COVID- 19, respectively (6). Some epidemiological features of COVID-19 have already been reported in China (7-10) and Iran (11-13). However, further

identification of the epidemiological characteristics and identify regional spatial clusters of COVID-19 can help to increase knowledge about this disease, make appropriate decisions, and subsequently control epidemics.

The aim of this study was description of the epidemiological features and hotspot of COVID-19 in Isfahan province of Iran with a population of more than 5 million people (14).

## **Method**

### **Study design and setting**

This prospective cohort study was conducted in Isfahan province. The cohort members were all individuals (n=49,996 participants) who screened for coronavirus infection at one of Isfahan Health Centers. Isfahan is one of the central regions in Iran, with a total area of 107,018 km<sup>2</sup>. According to the last National Census in 2016, the total population of Isfahan is approximately 5.12 million (14). This province had 24 counties (Isfahan, Natanz, Naein, Tiran&Karvand, Shahinshahr&Meime, Mobareke, Khomeinishahr, Khansar, Ardestan, Najafabad, Lenjan, Semirom, Falavarjan, Faridan, Shahreza, Dehaghan, Golpayegan, Kashan, Borkhar, Chadegan, Fereidoonshahr, Aran&Bidgol, Booein&Miandasht, and Khour&Biyabanak) where their health care are managed by twenty-five health centers .

### **Outcome and predictor variables**

The outcome of participants whom affected by coronavirus, were categorized into five groups (Discharge, Hospitalized, Died, Outpatient, and Died at home) and trained staff followed up participants for two weeks by telephone number. In addition, the age, gender and place of residence of the participants were assessed as predictors' variable.

### **Participants and Data collection**

All data collected and recorded to either to an online program designed for hospital records, hospital information system (HIS) or at specific clinics which allocated for the coronavirus patients. According to the Health Network Centers data, patients were admitted from 3<sup>rd</sup> February 2020, to 13<sup>th</sup> of June 2020. RT-PCR (Reverse transcription-polymerase chain reaction) using throat and nose swab specimens from the upper respiratory tract examined the patients by trained staff. All patients who had a COVID-19 test were included to the study, and patients with missing test result data or non-native cases (imported cases) were excluded from the geographical analysis. All registered cases at the hospital had a unique national identification number so there were no duplicates, and all patient information is kept confidential.

### **Statistical analysis**

The outcome (death or test results) and categorical variables were described by number, percentages and 95% confidence interval (CI); The cumulative incidence of COVID-19 and 95% confidence intervals were

calculated overall and across counties subgroups. Mean, standard deviation (SD) and 95% CI, median and inter-quartile range were used to describe age, which nearly normally distributed.

The chi-square and Fisher exact tests were used to examine the association between categorical variables characteristics such as gender, participant's outcome and COVID-19 test results. Also, the Analysis Of Variance (ANOVA) test was used to analyze the differences in mean age of individuals among outcome categories.

Choropleth map was used to describe the distribution of COVID-19 cases (per 100,000 people) in the Isfahan province community. The analysis was based on complete cases (without any missing data), all *P-value are based on two-tailed tests*, and *P-value* less than 0.05 was considered to statistical significance. Data analyses were performed using ArcGIS ver.10.5 and STATA ver.14 (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP).

### **Ethical Considerations:**

The research project was approved by the research department of Isfahan University of Medical Sciences and coded as 199057. Then, the Medical Ethics Committee of Isfahan University of medical sciences approved this study (Approval Number IR.MUI.RESEARCH.REC.1399.108). The requirement for informed consent was waived since the data used in the study were anonymous.

## **Result**

Among the 49,996 participants tested in 25 health centers in Isfahan province from January 21 to June 27.5% of patient (n=10530, 95% CI: 27.1, 28.2) had a positive coronavirus test and 8,498 had either unexpected test results which needed to repeat the test or unknown test results by the time. Among the participants, 92.9% (n=46,445, 95% CI: 92.7, 93.1) of them, treated by outpatient basis or discharged, 4.1% (n = 2,029, 95% CI: 3.9, 4.2) were hospitalized, and mortality rate was 3.0% (n=1,522, 95% CI: 2.9, 3.2). Also among participants with positive test, 93.2% (n=9809, 95% CI: 92.7, 93.6) of them, treated by outpatient basis or discharged, 2.1% (n = 220, 95% CI: 1.8, 2.4) were hospitalized, and 4.8% (n=501, 95% CI: 4.4, 5.2) participants died from COVID-19 (Table 1). The highest number of tests taken was in Isfahan (51.4%), and the highest percentage of positive tests was in Falavarjan county (29.7%).

The demographic and clinical characteristics of the participants were shown in Table 1. Most (54.9%, n=27,449, 95% CI: 54.5, 55.3) of the participants were male. The mean and median age of participants was 45.5 (SD=20.6) and 43.0 years (IQR: 29.0, min=1 max=112 years), and the highest percentage of patients were in the age group of 31-40 years (22.1%, n=10,762, 95% CI: 21.7, 22.5).

The mortality rate in participants with a positive test was 4.8% (95% CI: 4.4, 5.2) and in participants with a negative test was 2.6% (95% CI: 2.4, 2.8), which was statistically significant ( $P < 0.001$ ). Of the 1,306 deaths, the average age was 70.1 (SD=18.0) years, and most were male (58.28%, 95% CI: 55.8, 60.1). Also, 32.5% (n=489, 95% CI: 30.2, 34.9) of deaths occurred in the age group of 81-99 years. Mortality rates

in women were reported 0.4% (95% CI: 0.7, 0.1) lower than men, which was statistically significant ( $P=0.008$ ) (Table 1).

***Please insert Table 1 here***

Based on the participant's place of residence, our spatial model of the distribution of cases in a four-month time interval showed that Khansar (468 per 100,000) and Aradestan (355 per 100,000) county had the highest incidence of COVID-19 cases of all the Isfahan counties (Kashan and Aran&Bidgol were excluded due to lack of data) (Table 2) (Fig 1).

Also, most Imported cases number were from Najafabad ( $n= 653$ ), Khomeinishahr ( $n=335$ ), and Shahinshahr&meymeh ( $n=331$ ) counties to Isfahan city (Table 3) (Fig 1). Based on the test date as a proxy of importing time, 77.3% cases imported after April 12 (Fig 2).

Figure 1 describe the number of imported cases to Isfahan based on their province of residence, separately. Cases were imported from 16 provinces (Table 4), Charmahal&Bakhtiari ( $n=166$ ), Khuzestan ( $n=96$ ), and Fars ( $n=15$ ) had the highest number of imported cases. Also, based on the test date as a proxy of importing time, our result showed that about 82.9% of cases imported after April 20 (Fig 2).

***Please insert Table 2, 3, and 4 here***

***Please insert Figure 1 & Figure 2 here***

## **Discussion**

The current study aimed to describe the clinical outcome and report the incidence of COVID-19 in Isfahan province. The incidence of COVID-19 in a four-month time interval was 25.4% among screened patients; this incidence was 2.1 per 1000 person among whole province population.

Authors of the paper believe their results are reliable and valid because of prospective cohort design, relatively large number of screened people, covering of all health centres and in turn, the whole cities and hospitals, and data quality control by two member of research project who are a panel member of province coronavirus data collection team.

The incidence of COVID-19 in a four-month time interval was 25.4% among screened patient that was consistent with the results of the study by Arab-Mazar, which mapped the incidence of COVID-19 in Iran (15).

Our result showed that the median age of the patient was 45.5 years (Table 1), that was lower than the result of Guan et al. (47 years) (16), Wu et al. (46.1 years) (17), Pan et al. (52.9) (18), Chen et al. (62.0 years) (19). However, our result was inconsistent with the result of the study in Iran by Shahriarirad et al. (53.0 years) (12) Nikpouraghdam et al. (56.0 years) (11) and Araban et al. (56.9 years) (13).

Most (53.9%) of the patients in this study were male (Table 1). Which nearly consistent with Guan et al. (57.9%) (16), Pan et al. (52.5%), Chen et al. (62.4%) (19), and the result of Nikpouraghdam et al. (66.0%) (11), Araban et al. (58.0%) (13) and Shahriarirad et al. (62.8%) (12) study also the result of Wu et al. showed that the proportion of men was lower than women's (48.75% male) (17).

The result of our study showed that the CFR of COVID-19 was 4.8% (Table 1) which was consistent with the result of Wang et al. (4.3%) (9), Mei et al. (3.6%) (20), and Cai et al. (5.0%) (20) study; however it was higher than the result of Wang et al. (2.8%) (21), Shim et al. (0.7%) (22), and Li et al. (1.1%) (2); and lower than the result of Liu et al. (11.8%) (23), Barrasa et al. (13.0%) (24), Grasselli (15.0%) (25), and Grein et al. (18.0%) (26) study. Different reports on CFR was seen in different studies. The difference between the findings may be due to the age of the participants. In previous studies with higher CFR, the participants age was higher than the present study (23-26). Also, some studies were performed on hospitalized participants (23, 24, 26), while the present study was conducted in health centers, where the cases of the client have a non-severe disease. Some studies may also report low fatality rates due to the high screening rate in the study country and the detection of patients with mild symptoms (22).

Based on the spatial model of the distribution of cases in a four-month time interval, Khansar (469 per 100,000) and Aradestan (355 per 100,000) county had the highest proportion of COVID-19 cases of all the counties (Table 2). This may be due to the lack of enough health facilities and immigration in of suspected cases.

Also, our result showed that most of the imported cases were from the of Najafabad, Khomeini-Shahr, and Shahinshahr&Maymeh. The incidence of COVID-19 in these cities in the four-months was about 246 per 100,000 people (Table3). It seems this migration was due to the proximity of these counties to Isfahan (average distance of 32 km), more facilities in Isfahan (27), and the low capacity of hospitals in these cities (about 126 hospital-beds). Another reason for importing cases was the reduction of travel restrictions since April 15. Our results showed that 77.3% of the cases imported to Isfahan after the reduction of intra province travel restrictions (lockdown) (Figure 2) (28).

The results of our study showed that most of the COVID-19 cases imported from Chaharmahal&Bakhtiari (n=38) and Khuzestan (n=36) provinces (Table 4). Also, our results show that about 83% of cases has been imported since April 20 (Figure 2), That restriction on inter-provincial travel was removed and public transportation such as buses, trains and airlines get started (29).

Despite health advice, there are no restrictions on inter-provincial travel. Isfahan is one of the most famous tourist destinations in Iran. It seems that the trend of importing cases and the prevalence of this disease in the Isfahan will increase in the coming months. Although many cases do not show symptoms, they can spread the virus to susceptible individuals (30). It seems that Isfahan's neighboring provinces have a tremendous impact due to the higher volume of traveling to Isfahan.

## Limitation

The study has very strong components including the study design that is prospective cohort study, and the sample size was large enough, so the reproducibility of the results is acceptable. In addition, the use of multi-center data increases the generalizability of the findings to the population. However, the main pitfall of the study is lack of knowledge on whom migrated to other provinces. The paper also suffers from lack of clinical and lifestyle factors (such as smoking status, comorbidity with other diseases, Socio-Economic Status (SES)) information on coronavirus cases. Other limitations of this study was the high number of invalid PCR tests. We try to collect more background, lifestyle factors, and clinical and biological data and provide a new report soon.

## **Conclusion**

The incidence rate of coronavirus infection (25.4% among screened patients, and 2.1 per 1000 person among whole province population) and fatality of COVID-19 (4.8%, 95% CI: 4.4, 5.2) in Isfahan province which is alarming. It seems that inter-city and inter-provincial unnecessary travels have a high impact on the transmission and spread of the COVID-19. Based on the evidence applying more restrictions will prevent this from happening. It is better for the community health to planners and managers restrict the travels again.

## **Abbreviations**

RT-PCR: Reverse transcription-polymerase chain reaction

CFR: case fatality rate

HIS: hospital information system

CI: confidence interval

SD: standard deviation

ANOVA: analysis Of Variance

GIS: Geographic Information System

IQR: interquartile range

SES: Socio-Economic Status

## **Declarations**

### **Ethics approval and consent to participate**

The Medical Ethics Committee of Isfahan University of medical sciences also approved this study (Approval Number IR.MUI.RESEARCH.REC.1399.108).

## **Consent for publication**

There no any conflict of interest and all authors approved the final manuscript and consent for publication.

## **Availability of data and material**

The dataset used and analysed for this paper could be available from the corresponding author on reasonable request.

## **Conflict of interest**

There are no conflicts of interest to disclose and any competing financial interests in relation to the current study.

## **Funding**

No funding was provided for this research.

## **Authors' contributions**

MJ contributed in data analysis and writing the paper, FB contributed in writing the proposal, paper, and the literature review, HA & AK contributed in the data collection and data quality control, and GY contributed in data quality control and data analysis, writing and revising the paper.

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## Tables

Table 1- Demographic characteristics of patients

<i>P-value</i>	<b>Total n (%)</b> <b>(n=41498)</b>	<b>Neg n (%)</b> <b>(n=30968)</b>	<b>Pos n (%)</b> <b>(n=10530)</b>	<b>Variable</b>
<0.001*	45.5 ± 20.6	44.3 ± 20.2	47.4 ± 19.9	Age (mean ± SD)
	1596 (1.95)	1308 (4.3)	288 (2.7)	0-10
	2370 (5.78)	1818 (5.9)	552 (5.3)	11-20
	5783 (14.11)	4523(14.8)	1260 (12.1)	21-30
	9067 (22.12)	6924 (22.7)	2143 (20.5)	31-40
	7031 (17.15)	5221 (17.1)	1810 (17.3)	41-50
	5611 (13.7)	4031 (13.2)	1580 (15.1)	51-60
	4381 (10.7)	3071 (10.1)	1310 (12.5)	61-70
	2888 (7.0)	1983 (6.5)	905 (8.6)	71-80
	2270 (5.5)	1658 (5.4)	612 (5.8)	+81 years
0.015**	22795/18703	17118/13850	5677/4853	Gender (male/female)
<0.001***				<b>Outcome</b>
		6618 (21.4)	3493 (33.2)	Discharged
	10111 (24.4)	865 (2.8)	220 (2.1)	Hospitalized
	1085 (2.6)	798 (2.6)	483 (4.6)	Died
	1281 (3.1)	7 (0.02)	18 (0.2)	Died at home
	25 (0.06)	22680 (73.24)	6316 (60.0)	Outpatient
	28996 (69.9)			
<i>P-value</i>	<b>Total n (%)</b> <b>(n=49,996)</b>	<b>Alive n (%)</b> <b>(n=48478)</b>	<b>Death n (%)</b> <b>(n= 1522)</b>	<b>Variable</b>
<0.001*	45.4 ± 20.6	44.7 ± 20.2	70.0 ± 18.0	<b>Age (mean ± SD)</b>
	1051 (2.1)	1038 (2.2)	13 (0.1)	0-5 years
	990 (2.0)	983 (2.1)	7 (0.47)	6-10
	2819 (5.7)	2804 (5.9)	15 (1.0)	11-20
	6865 (13.9)	6838 (14.3)	27 (1.8)	21-30

	10762 (21.8)	10715 (22.4)	47 (3.1)	31-40
	8142 (16.5)	8049 (16.8)	93 (6.2)	41-50
	6613 (13.4)	6468 (13.5)	145 (9.6)	51-60
	5423 (11.0)	5156 (10.8)	267 (17.7)	61-70
	3695 (7.5)	3295 (6.9)	400 (26.6)	71-80
	2965 (6.0)	2476 (5.2)	489 (32.5)	81-99
	8 (0.02)	7 (0.01)	1 (0.07)	Over 100 years
0.008**	27449/22547	26562/21912	887/635	Gender (male/female)

\*Analysis of Variances

\*\* Fisher exact test

\*\*\* Chi square test

Table 2- Incidence of COVID-19 in Isfahan province counties

City (code)	Number of cases	Population	Proportion per 100,000
Aran&Bidgol (5)	No data	97409	No data
Ardestan (3)	147	41405	355.0
Booein&Miandasht (23)	22	26137	84.2
Borkhar (7)	294	108933	269.9
Chadegan (22)	98	33942	288.7
Dehaghan (11)	40	34844	114.8
Falavarjan (9)	603	247014	244.1
Faridan (21)	72	53606	134.3
Fereidoonshahr (24)	98	38334	255.6
Golpayegan (19)	204	87479	233.2
Isfahan (4)	4666	2174172	214.6
Kashan (14)	No data	323371	No data
Khansar (20)	152	32423	468.8
Khomeinishahr (8)	712	311629	228.5
Khour&Biyabanak (1)	15	17793	84.3
Lenjan (18)	871	246510	353.3
Mobareke (10)	321	143474	223.7
Naein (2)	96	38077	252.1
Najafabad (16)	817	300288	272.1
Natanz (6)	106	42239	251.0
Semirom (13)	111	65047	170.6
Shahinshahr&Meime (15)	457	196584	232.5
Shahreza (12)	367	149555	245.4
Tiran&Karvand (17)	115	69047	166.6
Total	10384	4879312	212.8

Table 3- Number and proportion of imported cases to Isfahan city

<b>City of residence</b>	<b>Pos n (%)</b>	<b>Neg n (%)</b>	<b>Total n (%)</b>
Aran&Bidgol	0 (0.00)	1 (0.01)	1 (0.01)
Ardestan	20 (0.98)	40 (0.57)	60 (0.66)
Booein&Miandasht	4 (0.20)	6 (0.08)	10 (0.11)
Borkhar	110 (5.41)	216 (3.06)	326 (3.58)
Chadegan	1 (0.05)	17 (0.24)	18 (0.20)
Dehaghan	23 (1.13)	149 (2.11)	172 (1.89)
Falavarjan	75 (3.69)	264 (3.74)	339 (3.73)
Faridan	5 (0.25)	15 (0.21)	20 (0.22)
Fereidoonshahr	83 (4.08)	330 (4.67)	413 (4.54)
Golpayegan	1 (0.05)	17 (0.24)	18 (0.20)
Kashan	7 (0.34)	26 (0.37)	33 (0.36)
Khansar	1 (0.05)	16 (0.23)	17 (0.19)
Khomeinishahr	335 (16.74)	1129 (15.98)	1464 (16.09)
Khour&Biyabanak	0 (0.00)	11 (0.16)	11 (0.12)
Lenjan	79 (3.88)	423 (5.99)	502 (5.52)
Mobareke	129 (6.34)	662 (9.37)	791 (8.69)
Naein	56 (2.75)	251 (3.55)	307 (3.37)
Najafabad	653 (32.10)	1927 (27.28)	2580 (28.35)
Natanz	14 (0.69)	22 (0.31)	36 (0.40)
Semirom	80 (3.93)	330 (4.67)	410 (4.51)
Shahinshahr& Meime	331 (16.27)	1038 (14.69)	1369 (15.05)
Shahreza	20 (0.98)	124 (1.76)	144 (1.58)
Tiran&Karvand	7 (0.34)	51 (0.72)	58 (0.64)
Total	2034 (100)	7065 (100)	9099 (100)

Table 4- Number and proportion of imported cases to Isfahan city

<b>province of residence</b>	<b>Positive n (%)</b>	<b>Negative n (%)</b>	<b>Total n (%)</b>
Tehran	14 (10.77)	56 (10.14)	70 (10.26)
Kermanshah	5 (3.85)	20 (3.62)	25 (3.67)
Chaharmahal & Bakhtiyari	38 (29.23)	166 (30.07)	204 (29.91)
Khozestan	36 (27.69)	96 (17.39)	132 (19.35)
Sistan & Balochestan	0 (0.00)	4 (0.72)	4 (0.59)
Golestan	0 (0.00)	3 (0.54)	3 (0.44)
Markazi	1 (0.77)	6 (1.09)	7 (1.03)
Gazvin	0 (0.00)	1 (0.18)	1 (0.15)
Kohgeloye & Booyerahmad	2 (1.54)	15 (2.72)	17 (2.49)
Fars	15 (11.54)	54 (9.78)	69 (10.12)
Qom	5 (3.85)	4 (0.72)	9 (1.32)
Mazandaran	2 (1.54)	5 (0.91)	7 (1.03)
Boushehr	0 (0.00)	5 (0.91)	5 (0.73)
East Azarbaijan	1 (0.77)	5 (0.91)	6 (0.88)
Gilan	1 (0.77)	5 (0.91)	6 (0.88)
Ilam	1 (0.77)	2 (0.36)	3 (0.44)
Lorestan	5 (3.85)	60 (10.87)	65 (9.53)
Yazd	2 (1.54)	14 (2.54)	16 (2.35)
Hormozgan	1 (0.77)	2 (0.36)	3 (0.44)
Razavi Korasan	0 (0.00)	10 (1.81)	10 (1.47)
Alborz	0 (0.00)	3 (0.54)	3 (0.44)
Kerman	0 (0.00)	7 (1.27)	7 (1.03)
West Azarbaijan	0 (0.00)	2 (0.36)	2 (0.29)
Hamadan	1 (0.77)	1 (0.18)	2 (0.29)
Semnan	0 (0.00)	3 (0.54)	3 (0.44)
Ardabil	0 (0.00)	1 (0.18)	1 (0.15)
Zanjan	0 (0.00)	2 (0.36)	2 (0.29)
<b>Total</b>	<b>130 (100)</b>	<b>552 (100)</b>	<b>682 (100)</b>

# Figures

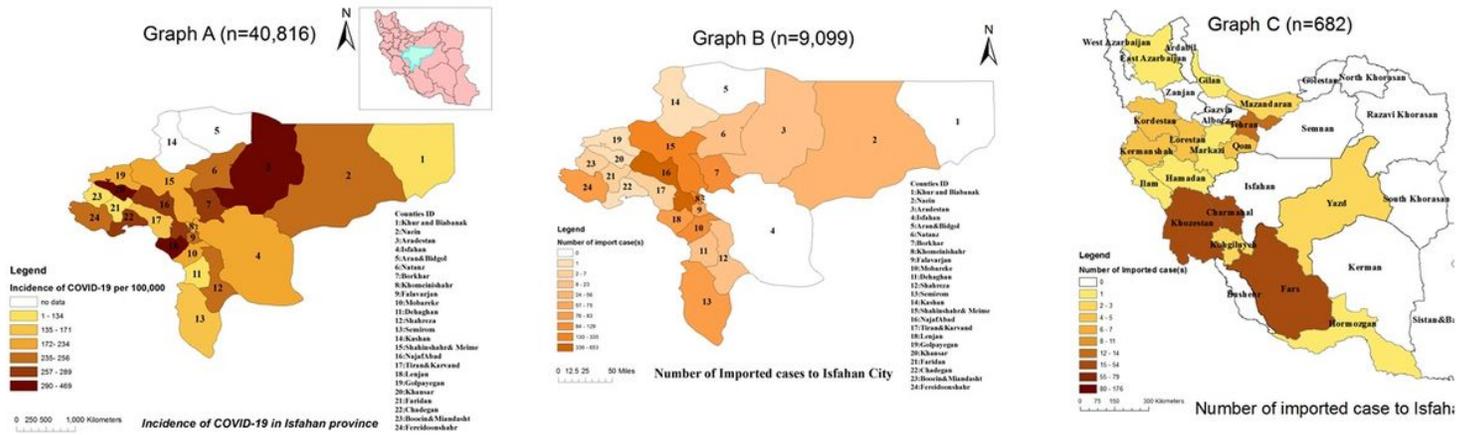
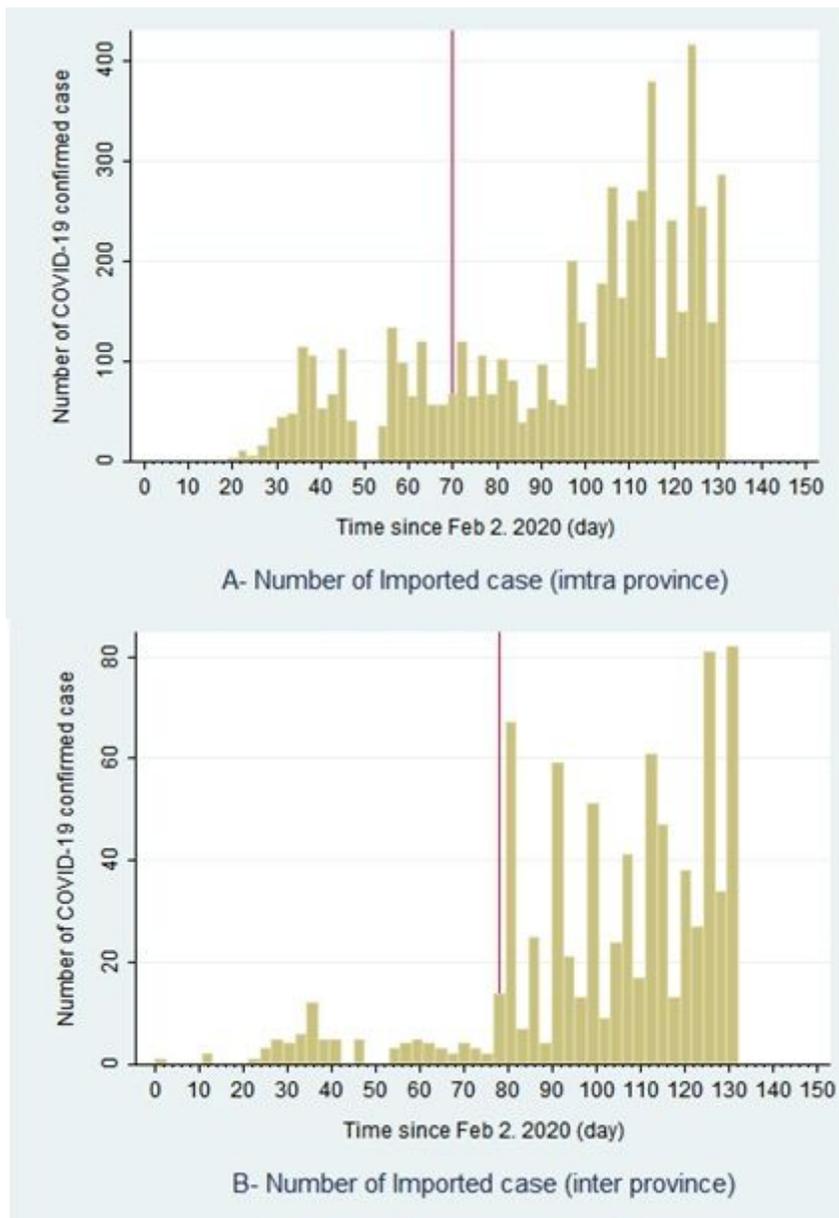


Figure 1

A: Distribution of COVID-19 in Isfahan province, B: Number of imported cases from other counties to Isfahan city, C: Number of imported case from other provinces to Isfahan city.



**Figure 2**

A- Number of imported cases since Feb 2, 2020 from Isfahan counties to Isfahan city (red line show the lockdown restriction date). B- Number of imported cases since Feb 2, 2020 from other provinces to Isfahan city (red line show the lockdown restriction date).