Scientific Journal of Medical Sciences
Volume 2, Issue 3, Summer 2023
Pages: 103-108
Type: Descriptive Study

Basic Reproduction Number of COVID-19 in Southeast Iran

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Abstract

Aims: COVID-19 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) of the coronaviridae family. This disease was first identified in December 2019 in Wuhan, China; however, it has caused a global pandemic. This study was aimed to investigate the basic reproduction number (R_0), epidemiological and clinical characteristics of COVID-19 patients in Jiroft, Kerman, Iran.

Materials & Methods: This prospective, cross-sectional study was conducted during March-August 2020 on COVID-19 patients (positive RT-PCR) of the Jiroft population. Patients were followed for their epidemiological and clinical outcomes. The basic reproduction number was calculated, and the serial interval was modeled as a gamma distribution.

Findings: Among 6550 highly suspicious patients, 3003 were positive for COVID-19. There were significant differences in clinical characteristics between outpatients and inpatients individuals. Early in the epidemic, the Rt was >2, which decreased to <1 until 19 April, when many interventions were implemented in Iran. The Rt increased to >1 from April until mid-June, but it reduced to <1 in July, and the epidemic was controlled.

Conclusion: We estimated that R_0 at the beginning of the epidemic in March 2020 was more than two, which reached to under one in July 2020. Identifying the clinical and epidemiological aspects of COVID-19 helps manage this disease in Iran and other parts of the world.

Keywords
COVID-19 [https://www.ncbi.nlm.nih.gov/mesh/2052179];
SARS-CoV-2 [https://www.ncbi.nlm.nih.gov/mesh/2052180];
Epidemics [https://www.ncbi.nlm.nih.gov/mesh/68058872];
Basic Reproduction Number [https://www.ncbi.nlm.nih.gov/mesh/?term=Basic+Reproduction+Number]

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Received: March 17, 2023 Accepted: August 17, 2023 ePublished: August 28, 2023

Introduction

Coronaviruses are a large family of viruses and a member of the coronaviridae subset [1]. Novel coronavirus 2019 or severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a member of beta coronavirus that causes Coronavirus disease-2019 (COVID-19) [2]. COVID-19 first occurred in Wuhan, China, in December 2019 and spread to other countries rapidly, causing a global pandemic [3, 4]. In Iran, the first case of the disease was reported in 19 February 2020 in Qom and after a short time, it was disseminated to all other parts of the country [5]. SARS-CoV-2 attacks the respiratory tract and shares many clinical signs similar to other respiratory viruses such as Influenza [3]. This disease has respiratory symptoms, including shortness of breath and dry cough; however, multiorgan involvement can be seen in many patients [6].

COVID-19 is transmitted rapidly through viral droplets in human-human contact [7]. It has caused a global pandemic in over 200 countries; however, the epidemiological features of this infection are heterogeneous in different countries [8, 9]. Measuring the epidemiological aspects of COVID-19 helps assess the transmission and epidemiologic trends and design preventive strategies [10]. An infection's basic reproduction number (R_0) is the expected number of patients directly caused by an infected individual in a population through the infection period where all individuals are susceptible to infection [11]. In the context of $R_0 1$, the number of infected patients will rise due to human-human transmission, and for $R_0 1$, the transmission will subside [12]. This factor is a crucial index for predicting an epidemiologic curve [13]. For R0>1, the number infected is likely to increase, and for R0<1, transmission is likely to die out. The basic reproduction number is a central concept in infectious disease epidemiology, indicating the risk of an infectious agent with respect to epidemic spread.

Despite many efforts carried out to control COVID-19 in Iran, its incidence is still high. This study aimed to investigate the basic reproduction number (R_0) and compare epidemiological and clinical characteristics in hospitalized and outpatients of COVID-19 in Jiroft City, Iran.

Instrument and Methods

This cross-sectional study was conducted on the entire population of Jiroft City, Iran (about 700,000 people), for six months in 2020 from 9 March, the detection time of the first positive case of COVID-19, to 13 August. The sample size included the census of all cases of Covid-19 in the study population.

Demographic data (gender, age, and addiction) and past medical history (cardiovascular, respiratory, kidney, liver, nervous diseases, diabetes, asthma, and cancer), in addition to the COVID-19-related data (disease course, clinical symptoms, interpersonal contacts and history of transmission) were recorded in a checklist.

The chi-square test was used for bivariate analysis and calculating central and dispersion indices. In addition, to calculate the basic reproduction number, all contacts of patients were determined based on incidence count. The serial interval, with a mean of 4.55 and a standard deviation of 3.3, estimated with a gamma distribution, was used in SPSS 26 software, and 0.05 was considered a significant level.

Findings

During the study period, 6550 suspected individuals were tested for COVID-19 in Jiroft, and 3003 tested positive. 1218 cases (40.6 %) were hospitalized for further treatment. Most participants were males aged between 14 and 59 years, and their education level was lower than high school (Table 1).

Table 1. The frequency (numbers in parentheses are percentages) of COVID-19 patients according to demographics and past medical history

Parameter		Confirmed	Hospitalized	p-Value
Gender	Male	1522 (50.7)	610 (50.1)	0.587
	Female	1481 (49.3)	608 (49.9)	
Age	<14	45 (1.5)	16 (1.3)	<0.001
	14-59	2336 (77.8)	771 (63.3)	
	>60	622 (20.7)	431 (35.4)	
Cardiovascular Diseases	Yes	269 (9)	183 (15)	<0.001
	No	2734 (91)	1035 (85)	
Diabetes	Yes	304 (10.1)	168 (13.8)	0.046
	No	2699 (89.1)	1050 (86.2)	
Chronic Respiratory Diseases	Yes	100 (3.3)	75 (6.2)	<0.001
	No	2903 (96.7)	1143 (39.4)	
Chronic Kidney Diseases	Yes	75 (2.5)	44 (3.6)	0.001
	No	2928 (97.5)	1174 (96.4)	
Chronic Liver Diseases	Yes	21 (0.7)	8 (0.7)	0.891
	No	2982 (99.3)	1210 (99.3)	
Chronic Immune Diseases	Yes	10 (0.3)	3 (0.2)	0.749
	No	2993 (99.7)	1215 (99.8)	
Cancer	Yes	30 (1)	20 (1.6)	0.003
	No	2973 (99)	1198 (40.3)	
Addiction	Yes	48 (1.6)	33 (2.7)	<0.001
	No	2955 (98.4)	1185 (97.3)	

Table 2. The frequency (numbers in parentheses are percentages) of clinical characteristics of the studied patients

Clinical sign	Total	Outpatients	Inpatients
Fever	1359 (45.6)	734 (41.3)	625 (52)
Cough	1112 (37.3)	567 (31.9)	545 (45.3)
Dyspnea	772 (25.9)	262 (14.7)	510 (42.4)
Rhinorrhea	138 (4.6)	116 (6.5)	22 (1.8)
General weakness	648 (21.8)	382 (21.5)	266 (22.1)
Chest pain	231 (7.8)	122 (6.9)	109 (9.1)
Myalgia	1151 (38.6)	707 (39.8)	444 (36.9)
Headache	831 (27.9)	566 (31.9)	265 (22)
Sore throat	530 (17.8)	407 (22.9)	123 (10.2)
Abdominal pain	136 (4.6)	85 (4.8)	51 (4.2)
Joint pain	309 (10.4)	187 (10.5)	122 (10.1)
Smell/Taste dysfunction	240 (8.1)	195 (11)	45 (3.7)
Confusing	122 (4.1)	74 (4.2)	48 (4)
Diarrhea	194 (6.5)	119 (6.7)	75 (6.2)
Nausea / vomiting	287 (9.6)	142 (8)	145 (12.1)

The most common symptoms of inpatients were fever 625 (52%), cough 1112 (45.3%), dyspnea 510 (42.4%), and myalgia 1151 (36.9%), while the most

common symptoms in outpatients were fever 707 (39.8%), and cough 567 (31.9%; Table 2).

The trend of total confirmed and hospitalized cases were shown in Figure 1.

The R_t>2 at first of the epidemic decreased to <1 until 19 April, after implementing vast interventions and prevention measures in Iran. From the end of April until mid-June, the Rt was increased to >1; however, it decreased to <1 in July, and the epidemic was controlled (Figure 2).

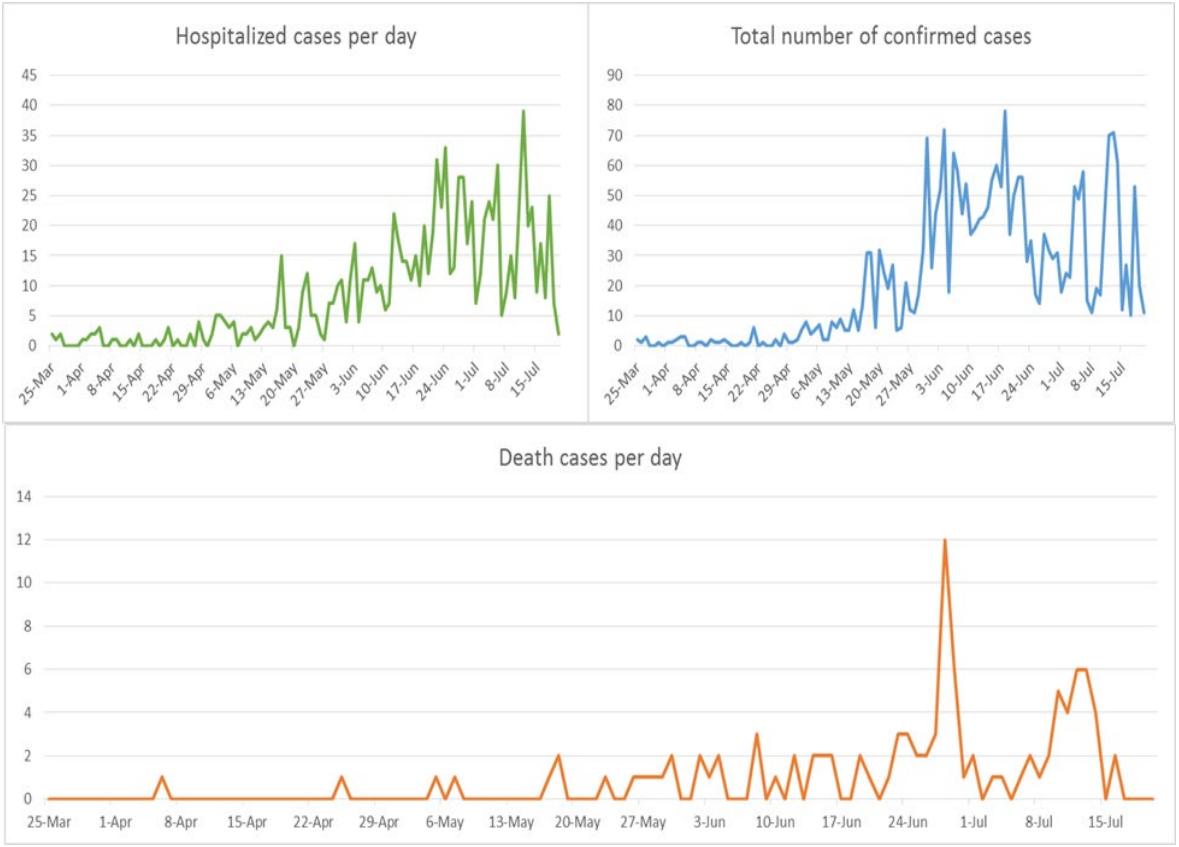

Figure 1. The trend of confirmed COVID-19 cases, hospitalization, and mortality in Jiroft, Iran

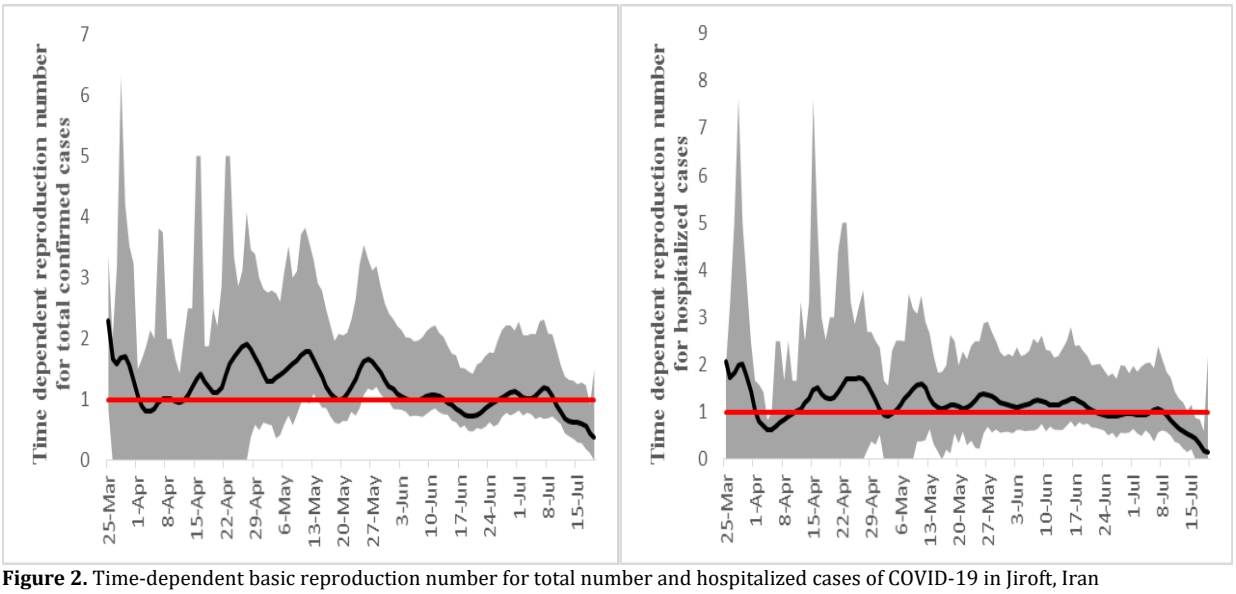

Figure 2. Time-dependent basic reproduction number for total number and hospitalized cases of COVID-19 in Jiroft, Iran

Discussion

In this study, we observed that 40.5% of COVID-19 patients were hospitalized in Jiroft City until 13 August 2020. It was shown that hospitalized patients had significant differences in some variables, such as age and having some underlying diseases. In addition, fever and cough were the most common clinical symptoms in both inpatients and outpatients, although inpatients manifested these symptoms more frequently.

In the evaluation of gender distribution in COVID-19 patients in some recent studies, the distribution of males was significantly higher than females [14-16]. It was suggested that males are more vulnerable to COVID-19 infections due to some possible reasons, including high expressions of angiotensin-converting enzyme-2 (ACE 2; receptors for coronavirus), gender-related immunological diversity caused by sex hormones and X chromosome, and differences in habitual history including high rates of smoking and drinking compared to females [17]. Furthermore, in a study in 2020 on over 3,000,000 confirmed cases of COVID-19, it was suggested that males are almost three times more susceptible to intensive care unit admission and nearly 1.4 times more vulnerable to mortality than females [18]. In the context of age and gender distribution in this study, males had a slightly higher prevalence than females; however, the ratio of males to females was 1.03: 1, which was not significantly different. The lack of gender association in this study indicates the susceptibility of the whole population to COVID-19. In line with this study, a recent systematic review and meta-analysis showed that men and women are not different in susceptibility to COVID-19 [19]. On the other hand, a noteworthy point in this study is that the rate of hospitalization in affected women, which was a little higher than in men, indicates the severity of COVID-19 in women, which can be justified by variables such as age and underlying diseases.

It was reported that most COVID-19 patients are 25-39 years old, and approximately 50% of cases are 25-64 years old [20]. Pooled analysis of 3 large-scale case studies in Wuhan, China, showed that all cases were more than 18 years of age [21]. In the single-center study of Nikpouraghdam *et al.* in Tehran, Iran, out of 2968 COVID-19 admitted patients, most cases were 50 to 60 years [22]. In another study in Iran in a multicentric setting, the age group of 50-59 years had the highest incidence of COVID-19 [23]. In this study, 63.3% of inpatients were in the 14-59 years group, which shows the high prevalence of this age group. However, 69.3% of identified patients with ≥60 years of age were hospitalized, which indicates the severity of the disease in this age group compared to other age groups. Similar to our results, in a systematic review of Hu *et al.*, most COVID-19 patients were elderly [19]. In another study by Liu *et al.*, elderlies were more susceptible to severe COVID-19 infection and intensive care unit admission [24]. In addition, in a study by Moradi *et al.* in Iran, it was observed that numerous negative outcomes were seen as consequences of COVID-19 infection in the elderly [25]. Therefore, more attention should be paid to the elderly with COVID-19 infections.

In this study, 30.64% of all COVID-19 patients and 45.73% of hospitalized patients had current underlying diseases. Among COVID-19 patients, diabetes and cardiovascular disease were the most common, with 10.1% and 9%, respectively. Choi *et al.* reported in their study that chronic cardiovascular, respiratory, and renal diseases, in addition to diabetes, are associated with increased costs of treatment, hospitalization, intensive care unit admission, and mortality [26]. In another study by Arman *et al.* in Iran, cancer, chronic lung diseases, and chronic neurologic diseases were associated with high risks of mortality in COVID-19 patients [27]. Thus, having an underlying disease is associated with more treatment measures and higher costs for the healthcare system. This issue should be taken into consideration in the management of COVID-19 patients.

In this study, the estimation of the time-dependent basic reproduction number for a total number of confirmed cases and hospitalized cases of COVID-19 in Jiroft showed that at the beginning of the epidemic, R0 was more than two, and after vast interventions in July, this rate dropped below one. The basic reproduction number is a critical concept in the epidemiology of communicable diseases, showing the potential of a pathogen to reach an epidemic phase [28]. R_0 is a warning measure for the transmissibility of an infectious disease, demonstrating the average number of new infections caused by an infected person in a thoroughly naïve population [29]. R_0 more than 1 indicates that the number of infected persons is increasing, and R_0 less than one may predict the stop of the infectious spread. Lee *et al.* reviewed 12 studies that assessed the basic reproductive number of COVID-19 from 1 January 2020 to 7 February 2020 and estimated that the average R_0 is 3.28 (median: 2.79; interquartile range: 1.16). In addition, the calculated R_0 was higher than the WHO estimation (R_0=1.95). This difference between R_0 estimations can be justified by different estimation techniques, including stochastic, mathematical, and statistical methods such as exponential growth and exponential growth [30]. However, with time and obtaining further data, a more accurate estimation can be achievable. As in the period of our study in Jiroft, R_0 fell below one, but since the beginning of September 2020, we have had an increasing trend of COVID-19 cases in Iran [20], and R0 reached>1 afterward. Considering the increasing trend of the disease in Iran, further studies are needed to identify the clinical and epidemiological aspects of COVID-19.

Conclusion

All age groups and genders are susceptible to COVID-19, while the severity of the disease is higher in people with underlying disease and the elderly. We estimated that R_0 at the beginning of the epidemic in March 2020 was more than two and after interventions in July 2020 reached under 1. However according to insufficient records and COVID-19 short onset time, our R_0 estimation is possibly biased.

Acknowledgments: The authors are pleased to thank the employees of the Health Department of Jiroft University of

Medical Sciences. The authors are pleased to thank the deputy for the research and technology of the Jiroft University of Medical Sciences Ethics Committee, which helped us to conduct the study.

Ethical Permissions: This study was conducted under permission of Jiroft Medical University ethical committee with the registration number of: IR.JMU.REC.1398.076. All individuals filled an informed consent and data were secured by the researcher in this study.

Conflicts of Interests: The authors have no conflicts of interest to declare for this study.

Authors' Contribution: Rezabeigi-Davarani E (First Author), Introduction Writer (16%); Nasiri N (Second Author), Introduction Writer/Methodologist/Original or Assistant Researcher/Discussion Writer/Statistical Analyst (13%); Kermani B (Third Author), Assistant Researcher/Discussion Writer (12%); Mohammadkhani M (Fourth Author), Discussion Writer (11%); Faryabi R (Fifth Author), Introduction Writer/Statistical Analyst (10%); Nakhaeizadeh M (Sixth Author), Statistical Analyst (9%); Meshayekhi V (Seventh Author), Introduction Writer/Methodologist/Original or Assistant Researcher/Discussion Writer/Statistical Analyst (8%); Daneshi S (Eighth Author), Introduction Writer/Methodologist/Original Researcher/Discussion Writer/Statistical Analyst (17%)

Funding/Support: None.

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