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Association of social, demographic, ecological factors, and underlying diseases with COVID-19 mortality rate: A cross-sectional study

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Abstract

Background: This study aimed to investigate the relationship between demographic, social, and ecological factors, as well as underlying diseases (diabetes, kidney, liver, and hypertension) with the COVID-19 mortality rate in the city of Kerman.

Methods: The present cross-sectional study was carried out on 200 COVID-19 survivors and 200 hospitalized deceased patients after infection to COVID-19 from March 2019 to March 2020. Logistic regression and Poisson regression were used to assess the relationship between demographic, social factors, underlying diseases, ecological parameters, and mortality rate.

Results: The COVID-19 mortality rate in the affected population (n = 6966 people) was 19.5%. The affected people were over 60 years old, male, Iranian, and married in more than half of the cases. A significant difference was observed between the two groups in terms of age ($P < 0.001$). However, there was no significant difference between hospitalized deceased patients and survivors in terms of social variables. Diabetes (OR = 1.79; 1.1 to 3.17), hypertension (OR = 1.6; 1.02 to 2.52), and liver disease (OR = 5.13; 1.05 to 24.99) had a significant effect on the mortality rate due to COVID-19 infection. The risk of COVID-19 death has significantly reached 0.96; in other words, decreased by 4% ($P = 0.03$), for a one-degree increase in the average rainfall during the studied period.

Conclusion: Finally, the prevalence of underlying diseases in the hospitalized deceased patients was more than that in the survivors. The results of the present study are expected to have preventive interventions and identify risk factors for mortality in patients hospitalized with COVID-19 and similar diseases.

Keywords: Prevalence, COVID-19, Diabetes, Liver diseases, Cross-sectional studies

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Introduction

The challenging and global spread of the coronavirus has made health researchers take measures to control the pandemic. One of these measures was to conduct extensive studies on its prevalence and relationship with some influencing parameters. In some studies, there is evidence of the influence of social and demographic factors (1), ecological factors (2,3), and underlying diseases (4) on contracting COVID-19 disease and the subsequent mortality. Monfared et al reported a high COVID-19 mortality rate in kidney transplant recipients (5). Emami et al investigated the epidemiological characteristics of hospitalized deceased patients and the mortality rate after the first peak of the disease in Fars province. The results showed that male gender, old age, and underlying diseases, especially diabetes, are common characteristics of COVID-19 patients hospitalized (6-8). Ahmadi et al investigated the climatological parameters affecting the COVID-19 prevalence in Iran. They found a direct relationship between population size and the prevalence of infection. Cities with low wind speed, humidity, and sunlight reported a higher rate of COVID-19 infection, which supports the survival of the virus. Several provinces including Gilan, Tehran, Alborz, Mazandaran, and Qom were more susceptible to the infection due to population size, intra-provincial movement, and high humidity compared to southern provinces (3). Considering the impact of social and ecological factors and the incidence

of underlying diseases on the spread of COVID-19 disease, subsequent mortality rate, and the importance of determining the role of these factors in implementing common preventive and therapeutic measures, the present study aimed to investigate the relationship between demographic, social, ecological factors, and underlying diseases with the COVID-19 recovery and mortality rates in the entire hospitalized patient population of Kerman.

Materials and Methods

Study area

The present cross-sectional study was conducted in Kerman city (30° 28' N 57° 08′ E) (Figure 1) from March 2019 to March 2020. The city of Kerman, the capital of Kerman province, is located in the southeast of Iran and an altitude of 1755 meters above sea level. This city is bordered by Zarand from the north, Mahan and Joopar from the south, Sirch from the east, and Bardsir from the west. According to the latest national census in 2016, the population of this city was 738 724 people in 240 km^2. Kerman has a semi-desert climate with relatively hot summers and cold winters. The average temperature in the cold and hot seasons is -8 °C and 37 °C, respectively. The average annual precipitation and relative humidity are 142 mm and 36%, respectively (9).

Data collection

The study population included COVID-19 patients hospitalized in Kerman city and diagnosed using the polymerase chain reaction (PCR) method from March 2019 to March 2020. The sample size was 200 hospitalized COVID-19 patients who died during the above-mentioned period and 200 COVID-19 survivors who were selected for 12 months from March 2018 to March 2019. Therefore, 17 people were considered for hospitalized people and 17 people were considered for people who died due to this disease in the study period. These people were selected through regular random sampling from the list taken from the health center, for example, 114 people were hospitalized in March 2018, of which one person was selected for every 6 people from the list of names taken from the health center. This method of calculation was observed in all 12 months.

The studied variables included demographic variables (gender, age, marital status, race, occupation, level of education, and smoking status), social (insurance status, type of residence building (apartment or house), approximate size of house, number of bedrooms, number of people living in the house, and number of COVID-19 patients hospitalized in the family), and underlying diseases (diabetes, hypertension, kidney, and chronic liver diseases), which were collected through the health center of Kerman Province and telephone interview. Checklists used to collect data are presented in Supplementary file 1.

The inclusion criteria were the cases of hospitalization infected by the COVID-19 in Kerman. There was no age limit. The exclusion criteria were outpatients and people who did not cooperate in providing the required information.

Ecological variables (temperature, humidity, and wind speed) were obtained from the meteorological organization of Kerman Province.

Then, the monthly average of the data was calculated. The number of people who died during a month was

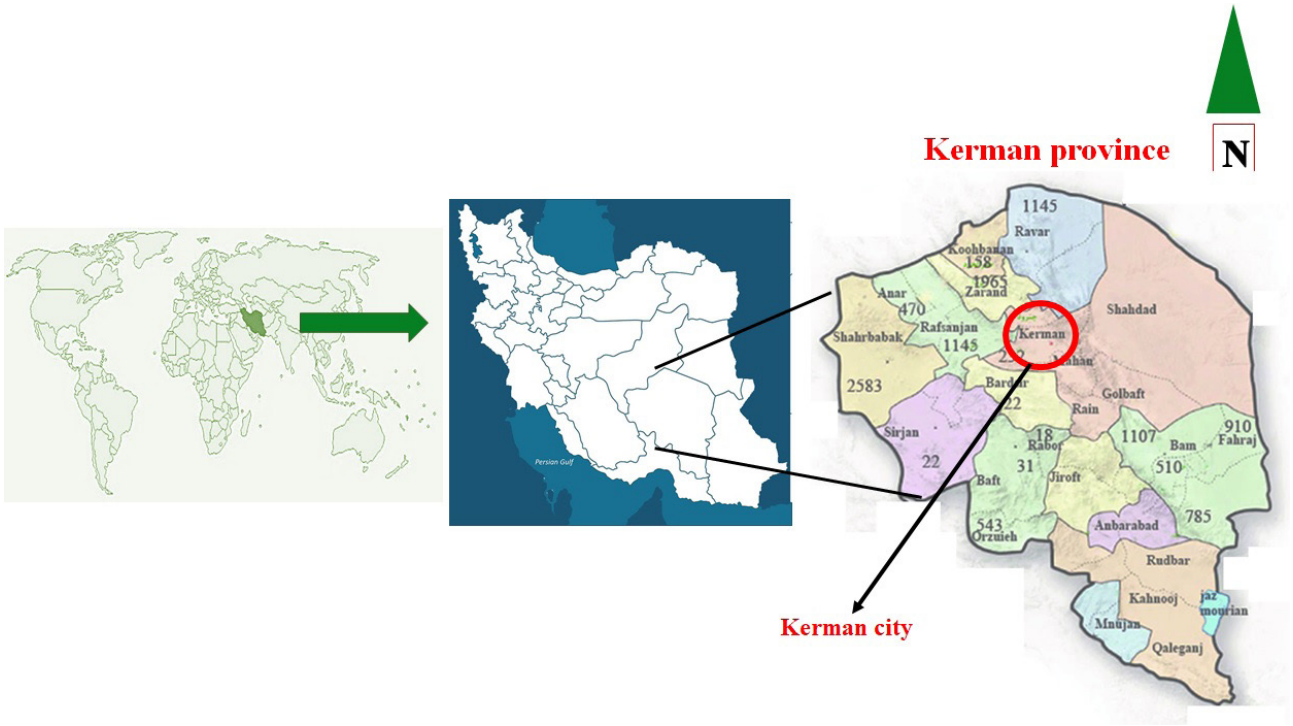

Figure 1. The study area

received from the health center system. The relationship between each of the ecological factors with the mortality rate in each month was measured using descriptive and analytical statistics. The status of the person infected with COVID-19 in terms of deceased or recovered was considered as a response variable. Recovery and mortality rates were calculated as response variables using Eq. (1):

$$Mortality\ or\ recovery\ rate(\%) = \frac{Mortality\ or\ recovery\ rates}{Hospitalized\ people\ with\ COVID-19} \times 100 \quad (1)$$ [1]

Data analysis

Data were analyzed using SPSS version 25. Poisson regression and incidence risk ratio (IRR) with 95% confidence interval (CI) were used to investigate the relationship between ecological variables and mortality rate. Univariate and multivariable logistic regression and odds ratios (ORs) with 95% CI were used to investigate the relationship between demographic and social parameters and underlying diseases and mortality rates. The statistical significance level was considered at $P<0.05$.

Results

The mortality rate

The COVID-19 mortality rate in the affected population (n = 6966) during the studied period was 19.5%.

Demographic factors

The relationship between demographic factors and the COVID-19 death via univariate and multivariate logistic regression analysis is shown in Table 1. There was a significant positive association between age > 60 years and COVID-19 death in both univariate (OR = 6.32; 2.27-17.58) and multivariate (OR = 6.76; 2.37-19.27) logistic regression analysis ($P<0.0001$). Other demographic variables had no significant effect on the COVID-19 death.

Social factors

The relationship between social factors and the COVID-19 death via univariate and multivariate logistic regression analysis is shown in Table 2. There was no significant association between these factors and COVID-19 death in both univariate and multivariate logistic regression analysis ($P>0.05$).

Underlying diseases

In the study period, 64.5%, 34.5%, 64%, and 5.5% of the studied patients suffered diabetes, hypertension, kidney and liver diseases, respectively (Figure 2). The relationship between social factors and the COVID-19 death via univariate and multivariate logistic regression analysis is shown in Table 3. There was a significant positive

Table 1. The relationship between demographic factors and the COVID-19 death via univariate and multivariate logistic regression analysis

Variable		Univariate logistic regression			Multivariable logistic regression		
		OR	95% CI	*P* value	OR	95% CI	*P* value
Age (y)	≤31	Ref	-	-	-	-	-
	31-60	2.33	0.83-6.56	0.1	2.46	0.85-7.11	0.09
	>60	6.32	2.27-17.58	<0.0001	6.76	2.37-19.27	<0.0001
Gender	Female	Ref	-	-	-	-	-
	Male	1.3	0.87-1.94	0.18	-	-	-
Race	Afghan	Ref	-	-	-	-	-
	Iranian	0.36	0.09-1.39	0.14	-	-	-
Marital status	Single	Ref	-	-	-	-	-
	Deceased spouse	1.18	0.52-2.72	0.68	-	-	-
	Divorced	1.18	0.32-4.41	0.79	-	-	-
	Married	1.21	0.6-2.45	0.59	-	-	-
Occupation	Unemployed	Ref	-	-	-	-	-
	Self-employed	1.17	0.67-2.04	0.56	-	-	-
	Employee	0.98	0.52-1.86	0.96	-	-	-
	Housewife	1.05	0.64-1.74	0.82	-	-	-
Level of education	Illiterate	Ref	-	-	-	-	-
	High school	1.08	0.63-1.89	0.76	-	-	-
	Diploma	1.24	0.73-2.11	0.41	-	-	-
	Associate degree	1.13	0.58-2.18	0.71	-	-	-
	Bachelor's degree	0.88	0.39-2	0.77	-	-	-
	Master's degree	1.08	0.26-4.56	0.9	-	-	-
Smoking status	Yes	1.45	0.97-2.16	0.06	-	-	-
	No	Ref	-	-	-	-	-

Table 2. The relationship between social factors and the COVID-19 death via univariate and multivariate logistic regression analysis

Variable		Univariate logistic regression			Multivariable logistic regression		
		OR	95% CI	*P* value	OR	95% CI	*P* value
Insurance status	Yes	0.82	0.44-1.52	0.53	-	-	-
	No	Ref	-	-	-	-	-
Number of bedrooms	1	2.81	0.49-15.85	0.24	-	-	-
	2	0.81	0.42-1.57	0.54	-	-	-
	3	1.35	0.73-2.49	0.32	-	-	-
	4	Ref	-	-	-	-	-
Type of residence building	House	1.47	0.95-2.28	0.07	-	-	-
	Apartment	Ref	-	-	-	-	-
The number of family members	≤2	0.91	0.49-1.67	0.77	-	-	-
	3-4	0.08	0.47-1.38	0.43	-	-	-
	≥5	Ref	-	-	-	-	-
House size (m^2)	80-120	0.55	0.24-1.24	0.15	-	-	-
	121-200	0.7	0.46-1.07	0.1	-	-	-
	>200	Ref	-	-	-	-	-
The number of COVID-19 patients hospitalized	1	0.81	0.11-5.85	0.83	-	-	-
	2	1.18	0.16-8.62	0.87	-	-	-
	3	1.18	0.22-14.75	0.57	-	-	-
	≥4	Ref	-	-			

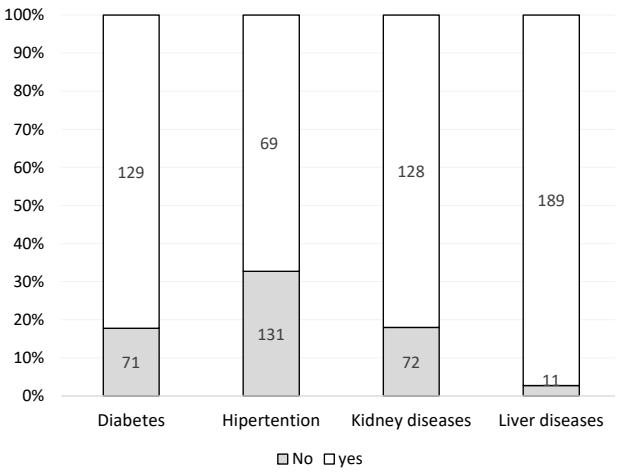

Figure 2. The number and percentage of COVID-19 patients hospitalized with underlying diseases

association between all underlying diseases included diabetes (OR = 1.8; 1.06-3.05; $P < 0.02$), hypertension (OR = 1.77; 1.16-2.70; $P < 0.008$), kidney disease (OR = 1.86; 1.1-3.14; $P < 0.02$), liver disease (OR = 4.66; 1.1-21.86; $P < 0.04$), and COVID-19 death in univariate logistic regression analysis. In terms of multivariate logistic regression analysis, there was a significant positive association between diabetes (OR = 1.8; 1.1-3.17; $P < 0.04$), hypertension (OR = 1.60; 1.02-2.52; $P < 0.04$), liver disease (OR = 5.13; 1.05-24.99; $P < 0.03$), and COVID-19 death.

Ecological factors

The relationship between the average of three ecological variables and the COVID-19 death via Poisson logistic regression analysis is shown in Table 4. There was a significant positive association between rainfall (OR = 0.96; 0.94-0.99; $P = 0.03$) and COVID-19 death. The trend of average values of temperature (°C), rainfall (mm), and wind speed (m/s) from March 2019 to March 2020 is reported in Figure 3. The number of patients hospitalized and deaths from March 2019 to March 2020 is illustrated in Figure 4.

Discussion

In the study period, the number of people infected with coronavirus and deaths was 1 786 265 and 61 649, respectively in Iran. The number of infected people and deaths were found to be 111 502 394 and 2 611 402 worldwide, respectively.

According to a study by Shamsalinia et al on the demographic and clinical characteristics of COVID-19 patients hospitalized admitted to hospitals in the west of Mazandaran, the COVID-19 mortality rate was reported to be 15% (10). Another study by Emami et al on the characteristics of deceased patients hospitalized with COVID-19 after the first peak of the disease in Fars province, showed that out of 3702 confirmed COVID-19 cases, 87 patients died and, therefore, the mortality rate was estimated to be 2.35% (6). The other study by Gozidehkar et al investigating the prevalence and risk factors for COVID-19 infection and mortality in patients referring to Shohadaye Ghaen Hospital in 2020, showed that out of 546 patients, 65 patients died, and the mortality

Table 3. The relationship between underlying diseases and the COVID-19 death via univariate and multivariate logistic regression analysis

Variable		Univariate logistic regression			Multivariable logistic regression		
		OR	95% CI	*P* value	OR	95% CI	*P* value
Diabetes	Yes	1.8	1.06-3.05	0.02	1.79	1.1-3.17	0.04
	No	Ref	-	-	-	-	-
Hypertension	Yes	1.77	1.16-2.7	0.008	1.6	1.02-2.52	0.04
	No	Ref		-	-	-	-
Kidney disease	Yes	1.86	1.1-3.14	0.02	-	-	-
	No	Ref	-	-	-	-	-
Liver disease	Yes	4.66	1.1-21.86	0.04	5.13	1.05-24.99	0.03
	No	Ref	-	-	-	-	-

Table 4. The relationship between the average of three ecological variables and the COVID-19 death via Poisson logistic regression analysis

Variable	IRR	95% CI	*P* value
Temperature (°C)	1.18	0.82-1.68	0.35
Wind speed (m/s)	1.04	0.92-1.18	0.49
Rainfall (mm)	0.96	0.94-0.99	0.03

IRR, incidence risk ratio.

rate was 11.9% (11).

The researchers attributed more mortality rates in the older age group to the weakened immune system and the higher frequency of underlying diseases and the more severe complications in this age group. The elderly group is the most vulnerable group and is admitted to ICUs more frequently due to their ignorance of and inability to fully comply with personal hygiene and self-care principles, loneliness and lack of support from the family, delayed referral to medical centers, improper nutrition, forgetfulness and unwillingness to take medicine. Also, the severity of the COVID-19 complications is much higher among the elderly people (12,13). According to the report of the American Center for Disease Control and Prevention (CDC), out of every 10 COVID-19 deaths, eight occurred in patients hospitalized aged over 65 years of age (14). In this regard, in a study by Gozidehkar et al, on the prevalence and risk factors of COVID-19 infection and mortality among patients hospitalized admitted to Shohadaye Ghaen Hospital in 2020, it was reported that out of 1124 people with an average age of 6.51 ± 5.24 years, 546 (48.6%) had positive RT-PCR result for COVID-19 and 65 people (11.9%) died. Body pain, cough, diarrhea, and shortness of breath symptoms were related to positive test results, and place of residence, diabetes, heart and lung diseases, age, and occupation were risk factors for developing COVID-19 infection, and ICU admission and age were regarded as risk factors for COVID-19 death (11). In a study by Dadgari et al, on some risk factors for COVID-19 in the middle-aged and elderly of Shahrood city, it was revealed this virus has a greater risk in the elderly and the risk of death increases in them with increasing age, especially since the elderly are biologically and socially at higher risk compared to other age groups (15). The results of a study showed that COVID-19 was the third cause of death in people over 45 years old and the second cause of death in people over 80 years (16). Evidence suggests that the elderly and disabled people are the main victims of this disease (17). The risk of COVID-19 death in men was more than that in women, which is consistent with the results reported by Chinese scientists in the largest study on the outbreak (18). Studies showed higher hospital admissions in American men (19). In a study by Golchin and Tavalaee on the cause of the difference in the severity of COVID-19 disease and subsequent death among women and men, it was reported that the prevalence of COVID-19 disease is almost equal between men and women; while the disease severity and the subsequent mortality rate are significantly higher in men than women. A set of genetic, immunological issues, differences in hormone secretion and lifestyle can be considered as factors for the difference in disease severity and mortality rate in both genders. Stronger innate and specific immune system in women, escape from X inactivation in immune-related genes, and the immunoenhancing effect of estrogen in women can be among the important factors contributing to the low mortality rate in COVID-19 women compared to men (7,20). In another study by Janjani et al on the risk factors affecting the death of COVID-19 patients, with an emphasis on intervenable factors, it was revealed that factors such as gender and lack of early hospitalization or a long wait time for hospital admission, occupation of hospital beds and ICU as well as the lack of equipment in hospitals were associated with increased mortality rate in these studies (21). Gozidehkar et al also stated that in addition to age, other demographic variables such as place of residence and occupation also played a role in contracting COVID-19 (11).

The results of the study by Golchin M, Tavalaee showed that smoking could be effective in the severity and mortality of COVID-19 disease (19). In a study by Nasrollahzadeh Sabet et al, on the mortality rate in COVID-19 patients hospitalized who had an underlying disease, it was reported a history of smoking in about 40% of cases (22). In a population-based cross-sectional study

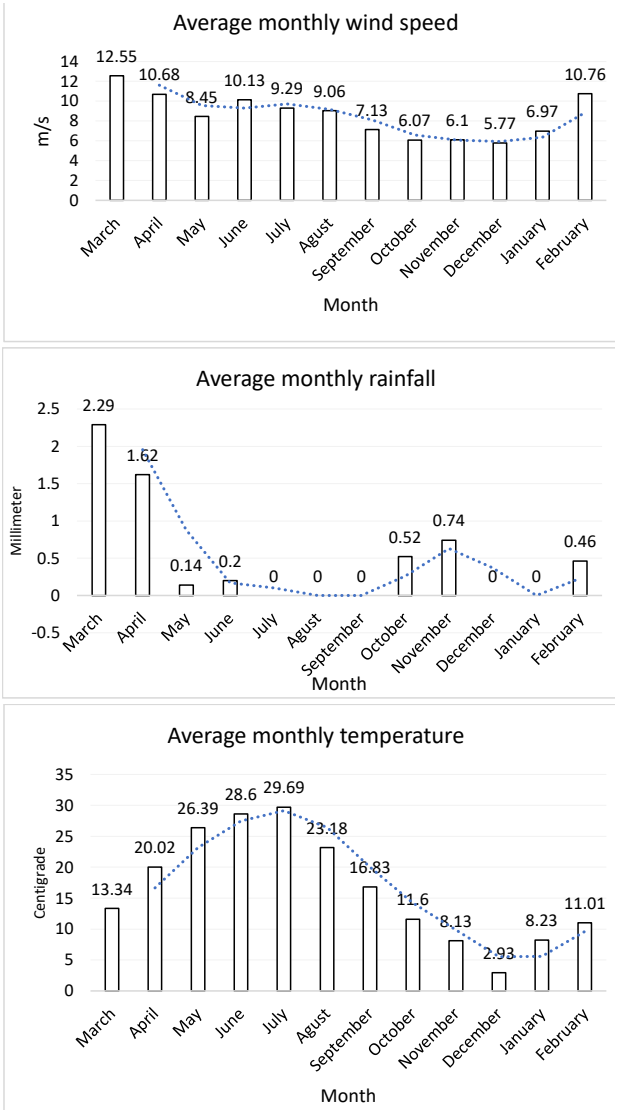

Figure 3. The trend of average values of temperature, rainfall, and wind speed from March 2019 to March 2020

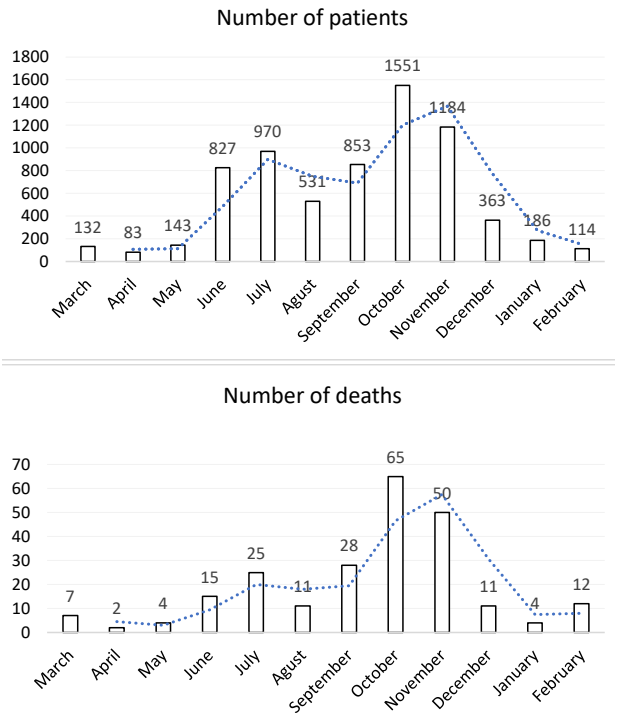

Figure 4. The number of patients hospitalized and deaths from March 2019 to March 2020

of seroepidemiology of COVID-19 in Yazd province, Mirjalili et al showed that the place of residence (urban/rural) plays a role in clinical manifestations and the mortality rate of COVID-19 patients hospitalized in the first pick of the disease in spring of 2020. This finding can be justified by referring to the access to healthcare facilities (23).

The coronavirus poses major health challenges, especially to people with cardiovascular disorders, diabetes, and hypertension as the underlying diseases. According to the studies, most of the COVID-19 patients suffer from the mentioned underlying diseases. The mortality rate in people with underlying diseases is reported to be higher than in others (24-26). Annually, many people die from these underlying diseases and they are considered important health problems. The emergence of COVID-19 and the subsequent anxiety had adverse effects on a person's health. Recent studies have reported that psychological factors, especially anxiety, affect heart rate and blood pressure, and also probably negatively affect the immune system (27). Hypertension, which is associated with other risk factors such as cardiovascular diseases and diabetes, can increase the COVID-19 risk (28). Moreover, diabetes can be considered a risk factor for the severity and progression of COVID-19. Previous studies have also shown that diabetes and cardiovascular diseases increase the incidence rate of SARS and MERS, which like COVID-19, are a type of acute respiratory syndrome, so that they increase SARS deaths by 11% and 8%, respectively. Moreover, MERS patients had underlying diseases such as diabetes and hypertension in more than 50% of cases and cardiovascular diseases in more than 30% of cases (29). Diabetes can increase the risk of immune system disorders. Many studies have shown that diabetes interferes with the immune system and leads to an increase in infections by disrupting the chemotaxis of neutrophils and the antibacterial activity of monocytes and phagocytosis. Similar studies also showed that 16% and 24% of patients with severe COVID-19 in China had diabetes (30,31) and hypertension (32), respectively. Although respiratory and immune systems are the main targets of COVID-19 disease, acute kidney damage and proteinuria have also been observed. For this reason, taking preventive measures against the occurrence and progression of acute kidney failure in COVID-19 patients has become a very important issue. COVID-19 management is even more challenging in patients with kidney disease because the pneumonia mortality rate in patients with chronic kidney disease is reported to be 14-16 times higher than in the general population (33). Some

studies also attributed the higher COVID-19 severity to immunodeficiency in patients with diabetes and concurrent diseases with diabetes such as cardiovascular, kidney and lung damage, and obesity (34). A cohort study in the United States showed that type-2 diabetes was associated with the risk of contracting COVID-19 (35). The results of a cohort study in England showed that diabetes and high body mass index (BMI) are associated with a higher chance of hospitalization due to COVID-19 (36). In addition to paying attention to diabetes, as a risk factor, in contracting COVID-19, the role of diabetes should also be considered important in contracting COVID-19 (37). Nevertheless, the risk of COVID-19 should be considered important in patients with diabetes. In this regard, the results from the articles published by the Chinese Center for Disease Control and Prevention showed people with cardiovascular and diabetes diseases, chronic respiratory diseases, hypertension, and cancer were respectively the most susceptible population to this virus (38). In a study titled ''clinical manifestations and mortality rate in COVID-19 patients with underlying disease", which was conducted on 1408 COVID-19 inpatients in Golestan, Hajar, Kanevadeh, and Bessat Hospitals of Tehran, Iran, Nasrollahzadeh Sabet et al (2020) showed that COVID-19 patients had a history of hypertension, diabetes and cardiovascular diseases in 1.24%, 7.21%, and 1.20% of cases, respectively (22). In a study titled ''Mortality risk factors for COVID-19 patients", Mirjalili et al (2021) also showed that cardiovascular disease, diabetes, chronic neurological disease, chronic lung disease, and malignancy increase the OR of death. Patients with a history of chronic lung diseases had an 83% higher risk of death compared to healthy people. Patients with diabetes had a 75% higher risk of death compared to healthy patients. Patients with a history of cardiovascular disease had a 99% higher risk of death compared to healthy people (23). In a study on the relationship between comorbid underlying diseases and the rate of COVID-19 ICU admission among elderly people admitted to Baharloo Hospital, Akhavizadegan et al reported that about 77% of the participants survived and 23% died. The OR of death in participants with two or more underlying diseases and ICU admission was 1.69 and 2.26 times higher than the elderly who did not have underlying diseases, respectively, which was statistically significant (39).

Weather conditions can potentially affect infectious diseases such as influenza, asthma, pneumonia, etc. Each of the weather elements, besides their positive effects, may also have negative effects on human health (40,41). Therefore, humans are affected by the surrounding temperature under any situation, so that climatic factors with favorable and sometimes unfavorable effects lead to changes in the human body such as hypothermia, flu, heart disease, stroke, asthma, etc. Medical studies show that various diseases become prevalent or disappear with the increase or decrease in the environmental temperature or with changing seasons. In some cases, changes in the natural environment directly create hazards. If the body temperature falls below 26 °C or above 40 °C, irreversible destruction and death will often occur, and cause biohazards or disease in some cases. Besides, many geographers believe that the number of deaths increases with deviation from optimal temperatures (18-25 °C). Also, the stressful effect of temperature on mortality has been proven by many researchers, that is, stress and heart diseases and subsequent deaths increase at temperatures beyond the human comfort zone (42).

Temperature and relative humidity (RH) can kill viruses in aerosols through evaporation. Studies also show that the COVID-19 virus has a longer lifespan at low temperatures. Some controlled studies on human nasal mucus and viral aerosols show that the COVID-19 virus degrades faster at higher relative humidity (RH). The common finding that virus survival is greater under relatively dry conditions is consistent with evidence from influenza, where transmission is optimal at low absolute humidity. UV radiation also appears to reduce the persistence of the virus. For example, the laboratory results show that the exposure to the coronavirus in conditions where the amount of ultraviolet radiation received is the same as that in autumn and winter, 90% disappears after 19 minutes, while the same amount is created in a shorter time, within 8 minutes in the summer season. While UV radiation appears to be the driver of virus persistence in sun-exposed areas, most transmission of COVID-19 occurs indoors, where the role of sunlight in regulating transmission may be limited (43).

In this regard, in a study on the climatological parameters affecting the spread of COVID-19 in Iran, Ahmadi et al showed a direct relationship between population sizes and intra-provincial movement with the spread of COVID-19 infection. Areas with low wind speed, humidity, and sunlight are exposed to high rates of infection that support virus survival (3). Jahangiri et al investigated the sensitivity and specificity of ambient temperature and population size on the rate of spread of COVID-19 in different provinces of Iran and concluded that several factors can affect the rate of transmission and survival of the coronavirus. Atmospheric temperature and population density can be considered significant transmissibility factors for coronavirus transmission (44). Bolaño-Ortiz et al investigated the spread of COVID-19, meteorological conditions, and air quality in the city of Buenos Aires, Argentina. They found a significant relationship between meteorological variables and air quality with COVID-19 cases, and the highest correlation was reported between temperature with infection cases (45).

According to the trend of average values of ecological factors from March 2019 to March 2020 in Figure 3,

the highest and the lowest temperature was reported in August (average = 29.69 °C) and January (average = 2.93 °C), respectively. The highest rainfall was reported in April with an average of 2.29 mm and the rainfall was zero in August, September, October, January, and February. The highest and the lowest wind speed was reported in April (average = 12.55 m/s) and January (average = 5.77 m/s), respectively.

Based on the number of patients hospitalized and deaths from March 2019 to March 2020 in Figure 4, the highest and the lowest number of COVID-19 cases were reported in November (n = 1551) and May (n = 83), respectively. The highest (n = 65) and the lowest (n = 2) COVID-19 deaths were reported in November and May. The increase in the COVID-19 deaths in November compared to other months can be attributed to the decrease in temperature and relative humidity at the beginning of the autumn season. In addition, the opening of some schools in October and religious ceremonies were also effective in increasing the number of deaths. On the other hand, the decrease in COVID-19 deaths in May can be attributed to the decrease in social activities in April due to the Nowruz holidays.

There was a lack of cooperation of some patients in giving information in the telephone interview, and in this context, continuous follow-up was done to receive information.

The present study not only investigated the relationship between ecological factors and mortality rate due to infection with COVID-19 for the first time in 2019 in Kerman but also examined the effects of other factors such as socio-demographic parameters and underlying diseases on the mortality rate due to infection with COVID-19.

The present study is a cross-sectional study that only determines the relationship but does not determine the causality. The results of the present study are expected to have an impact on the preventive interventions, and the identification of mortality risk factors in patients with COVID-19 can provide more effective interventions in the early stages of treatment and improve the medical approaches provided by the medical staff.

Conclusion

The present study investigated the relationship between demographic, social, and ecological factors and underlying diseases with COVID-19 deaths from March 2019 to March 2020 in Kerman, Iran. The COVID-19 mortality rate in 6966 affected people during the studied period was found to be 19.5%. A significant positive association was obtained between age > 60 years and COVID-19 death. The highest percentage of affected people were housewives and illiterate, and more than half of the affected population did not have health insurance. The mortality rate in smokers (55.5%) was higher than that in non-smokers. Diabetes, hypertension, and liver disease had a significant effect on the COVID-19 death. There was a significant positive association between rainfall and COVID-19 death. It is expected that the results of the present study will have an effect on preventive interventions, and the identification of mortality risk factors in COVID-19 patients hospitalized can provide more interventions that are effective in the treatment of early-stage patients and improve the medical approaches provided by the medical staff.

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Authors' contribution

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical issues

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Supplementary files

Supplementary file 1 contains used checklists in the study.

References

1. Sannigrahi S, Pilla F, Basu B, Basu AS, Molter A. Examining the association between socio-demographic composition and COVID-19 fatalities in the European region using spatial regression approach. Sustain Cities Soc. 2020;62:102418. doi: 10.1016/j.scs.2020.102418.

2. Snyder BF, Parks V. Spatial variation in socio-ecological vulnerability to COVID-19 in the contiguous United States. Health Place. 2020;66:102471. doi: 10.1016/j.healthplace.2020.102471.
3. Ahmadi M, Sharifi A, Dorosti S, Jafarzadeh Ghoushchi S, Ghanbari N. Investigation of effective climatology parameters on COVID-19 outbreak in Iran. Sci Total Environ. 2020;729:138705. doi: 10.1016/j.scitotenv.2020.138705.
4. Emami A, Javanmardi F, Pirbonyeh N, Akbari A. Prevalence of underlying diseases in hospitalized patients with COVID-19: a systematic review and meta-analysis. Arch Acad Emerg Med. 2020;8(1):e35.
5. Monfared A, Dashti-Khavidaki S, Jafari R, Jafari A, Ramezanzade E, Lebadi MK, et al. Clinical characteristics and outcome of COVID-19 pneumonia in kidney transplant recipients in Razi hospital, Rasht, Iran. Transpl Infect Dis. 2020;22(6):e13420. doi: 10.1111/tid.13420.
6. Emami A, Javanmardi F, Akbari A, Moghadami M, Bakhtiari H, Falahati F, et al. Characteristics of deceased patients with COVID-19 after the first peak of the epidemic in Fars province, Iran. Infect Ecol Epidemiol. 2020;10(1):1781330. doi: 10.1080/20008686.2020.1781330.
7. Hashemi M, Rajabi S, Eghbalian M, Sulibursk J, Nasab H. Demographic and anthropometric characteristics and their effect on the concentration of heavy metals (arsenic, lead, chromium, zinc) in children and adolescents. Heliyon. 2023;9(2):e13621. doi: 10.1016/j.heliyon.2023.e13621.
8. Malakootian M, Chavoshani A, Hashemi M, Amin MM, Shoshtari-Yeganeh B, Fadaei S, et al. Concentrations of urinary parabens and reproductive hormones in Iranian women: exposure and risk assessment. Toxicol Rep. 2022;9:1894-900. doi: 10.1016/j.toxrep.2022.10.001.
9. Malakootian M, Mohammadi A, Nasiri A, Sheikh Asadi AM, Oliveri Conti G, Faraji M. Spatial distribution and correlations among elements in smaller than 75 μm street dust: ecological and probabilistic health risk assessment. Environ Geochem Health. 2021;43(1):567-83. doi: 10.1007/s10653-020-00694-0.
10. Shamsalinia A, Useframaki M, Taslimi L, Jahangasht K. Demographic and clinical characteristics of COVID-19 patients in West Mazandaran hospitals. Journal of Caspian Health and Aging. 2022;7(1):58-69. doi: 10.22088/cjhaa.7.1.5. [Persian].
11. Gozidehkar Z, Gahani H, Davary A, Borna H. Prevalence and factors related to infection and mortality due to COVID-19 among patients of Shohada Ghaen hospital, Ghaen, Iran, 2020. J Birjand Univ Med Sci. 2021;28(4):375-84. doi: 10.32592/JBirjandUnivMedSci.2021.28.4.106. [Persian].
12. Jalali Farahani A, Swann J, Razi S, Mohammadi M, Amani J, Javadzadeh H, et al. Comparison of Clinical, laboratory and radiological findings in Iranian elderly and non-elderly patients with COVID-19. J Mar Med. 2021;2(4):216-25. doi: 10.30491/2.4.216. [Persian].
13. Li G, Hu R, Zhang X. Antihypertensive treatment with ACEI/ARB of patients with COVID-19 complicated by hypertension. Hypertens Res. 2020;43(6):588-90. doi: 10.1038/s41440-020-0433-1.
14. Hadinejad Z, Saleh Tabari Y, Sajadi Z, Talebi Ghadicolaei H. Clinical characteristics and risk factors of COVID-19 and related deaths in elderly patients. Iran J Ageing. 2021;16(1):128-39. doi: 10.32598/sija.16.1.658.2. [Persian].
15. Dadgari A, Mirrezaei SM, Talebi SS, Alaghemand Gheshlaghi Y, Rohani-Rasaf M. Investigating some risk factors related to the COVID-19 pandemic in the middle-aged and elderly. Iran J Ageing. 2021;16(1):102-11. doi: 10.32598/sija.16.1.3172.1. [Persian].
16. Woolf SH, Chapman DA, Lee JH. COVID-19 as the leading cause of death in the United States. JAMA. 2021;325(2):123-4. doi: 10.1001/jama.2020.24865.
17. Andrew MK, McElhaney JE. Age and frailty in COVID-19 vaccine development. Lancet. 2021;396(10267):1942-4. doi: 10.1016/s0140-6736(20)32481-8.
18. The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) - China, 2020. China CDC Wkly. 2020;2(8):113-22.
19. Stokes EK, Zambrano LD, Anderson KN, Marder EP, Raz KM, El Burai Felix S, et al. Coronavirus disease 2019 case surveillance - United States, January 22-May 30, 2020. MMWR Morb Mortal Wkly Rep. 2020;69(24):759-65. doi: 10.15585/mmwr.mm6924e2.
20. Golchin M, Tavalaee M. Evaluation of difference of severity and mortality of COVID-19 disease in terms of gender: a review paper. Feyz. 2021;25(4):1118-29. doi: 10.48307/fmsj.2021.25.4.1118. [Persian].
21. Janjani H, Aghaei M, Yunesian M. Risk factors affecting the mortality of COVID-19 patients: impacts of modifiable factors. Iran J Health Environ. 2021;14(2):363-78. [Persian].
22. Nasrollahzadeh Sabet M, Khanalipour M, Gholami M, Sarli A, Rahimi Khorrami A, Esmaeilzadeh E. Prevalence, clinical manifestation and mortality rate in COVID-19 patients with underlying diseases. J Arak Univ Med Sci. 2020;23(5):740-9. doi: 10.32598/jams.23.cov.5797.1. [Persian].
23. Mirjalili M, Dehghani M, Raadabadi M, Dehghani A. Death risk among COVID-19 patients in Yazd, Iran: a hospital-based case-cohort study. J Mil Med. 2021;23(3):274-82. doi: 10.30491/jmm.23.3.274. [Persian].
24. Zhou P, Yang XL, Wang XG, Hu B, Zhang L, Zhang W, et al. A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature. 2020;579(7798):270-3. doi: 10.1038/s41586-020-2012-7.
25. South AM, Diz DI, Chappell MC. COVID-19, ACE2, and the cardiovascular consequences. Am J Physiol Heart Circ Physiol. 2020;318(5):H1084-90. doi: 10.1152/ajpheart.00217.2020.
26. Nasab H, Mirzaee M, Hashemi M, Rajabi S. Measurement of urinary triclocarban and 2,4-dichlorophenol concentration and their relationship with obesity and predictors of cardiovascular diseases among children and adolescents in Kerman, Iran. J Environ Public Health. 2022;2022:2939022. doi: 10.1155/2022/2939022.
27. Pfefferbaum B, North CS. Mental health and the COVID-19 pandemic. N Engl J Med. 2020;383(6):510-2. doi: 10.1056/NEJMp2008017.
28. Ran J, Song Y, Zhuang Z, Han L, Zhao S, Cao P, et al. Blood pressure control and adverse outcomes of COVID-19 infection in patients with concomitant hypertension in Wuhan, China. Hypertens Res. 2020;43(11):1267-76. doi: 10.1038/s41440-020-00541-w.
29. Park JE, Jung S, Kim A, Park JE. MERS transmission and risk factors: a systematic review. BMC Public Health. 2018;18(1):574. doi: 10.1186/s12889-018-5484-8.
30. Guo W, Li M, Dong Y, Zhou H, Zhang Z, Tian C, et al.

Diabetes is a risk factor for the progression and prognosis of COVID-19. Diabetes Metab Res Rev. 2020;36(7):e3319. doi: 10.1002/dmrr.3319.
31. Pickup JC, Crook MA. Is type II diabetes mellitus a disease of the innate immune system? Diabetologia. 1998;41(10):1241-8. doi: 10.1007/s001250051058.
32. Schiffrin EL, Flack JM, Ito S, Muntner P, Webb RC. Hypertension and COVID-19. Am J Hypertens. 2020;33(5):373-4.
33. Eskandarian R, Alizadeh Sani Z, Behjati M, Zahmatkesh M, Haddadi A, Kakhi K, et al. Identification of clinical features associated with mortality in COVID-19 patients. medRxiv [Preprint]. April 20, 2021. Available from: https://www.medrxiv.org/content/10.1101/2021.04.19.21255715v1.
34. Zhou Y, Chi J, Lv W, Wang Y. Obesity and diabetes as high-risk factors for severe coronavirus disease 2019 (COVID-19). Diabetes Metab Res Rev. 2021;37(2):e3377. doi: 10.1002/dmrr.3377.
35. Gu T, Mack JA, Salvatore M, Prabhu Sankar S, Valley TS, Singh K, et al. Characteristics associated with racial/ethnic disparities in COVID-19 outcomes in an academic health care system. JAMA Netw Open. 2020;3(10):e2025197. doi: 10.1001/jamanetworkopen.2020.25197.
36. Holman N, Knighton P, Kar P, O'Keefe J, Curley M, Weaver A, et al. Risk factors for COVID-19-related mortality in people with type 1 and type 2 diabetes in England: a population-based cohort study. Lancet Diabetes Endocrinol. 2020;8(10):823-33. doi: 10.1016/s2213-8587(20)30271-0.
37. Marhl M, Grubelnik V, Magdič M, Markovič R. Diabetes and metabolic syndrome as risk factors for COVID-19. Diabetes Metab Syndr. 2020;14(4):671-7. doi: 10.1016/j.dsx.2020.05.013.
38. Gralinski LE, Menachery VD. Return of the coronavirus: 2019-nCoV. Viruses. 2020;12(2):135. doi: 10.3390/v12020135.
39. Akhavizadegan H, Aghaziarati M, Roshanfekr Balalemi MG, Arman Broujeni Z, Taghizadeh F, Akbarzadeh Arab I, et al. Relationship between comorbidity, chronic diseases, ICU hospitalization, and death rate in the elderly with coronavirus infection. Iran J Ageing. 2021;16(1):86-101. doi: 10.32598/sija.16.1.3161.1. [Persian].
40. Omidvar K, Shahaeian S, Amiri Esfandegheh M. Relation between concentration of pollutants and some climatic parameters on cardiovascular and respiratory disease mortality in Shiraz. J Shahid Sadoughi Univ Med Sci. 2020;28(3):2467-78. doi: 10.18502/ssu.v28i3.3744. [Persian].
41. Nasab H, Mirzaee M, Ebrahimpour K, Hashemi M. Association of urinary triclosan and methyl-triclosan levels with predictive indicators of cardiovascular disease and obesity in children and adolescents in 2020 (case study: Kerman, Iran). Environ Health Eng Manag. 2021;8(3):187-95. doi: 10.34172/ehem.2021.22.
42. Mayvaneh F, Akbari E, Baaghideh M. The relationship between thermal comfort indices and mortality from heart disease. Med J Mashhad Univ Med Sci. 2015;57(8):932-42. doi: 10.22038/mjms.2015.3701. [Persian].
43. Weaver AK, Head JR, Gould CF, Carlton EJ, Remais JV. Environmental factors influencing COVID-19 incidence and severity. Annu Rev Public Health. 2022;43:271-91. doi: 10.1146/annurev-publhealth-052120-101420.
44. Jahangiri M, Jahangiri M, Najafgholipour M. The sensitivity and specificity analyses of ambient temperature and population size on the transmission rate of the novel coronavirus (COVID-19) in different provinces of Iran. Sci Total Environ. 2020;728:138872. doi: 10.1016/j.scitotenv.2020.138872.
45. Bolaño-Ortiz TR, Pascual-Flores RM, Puliafito SE, Camargo-Caicedo Y, Berná-Peña LL, Ruggeri MF, et al. Spread of COVID-19, meteorological conditions and air quality in the city of Buenos Aires, Argentina: two facets observed during its pandemic lockdown. Atmosphere. 2020;11(10):1045. doi: 10.3390/atmos11101045.