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Spatial Distribution of COVID-19 in Shahroud, Iran Using GIS

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Abstract

Background: The highest incidence rate of covid-19 in Iran was reported from Shahroud County. This study was conducted by geographic information systems (GIS) to determine the geographical distribution of Covid-19 in 60 days.

Study design: A cross-sectional study **Methods:** This study was conducted in counties covered by Shahroud University of Medical Sciences, namely Shahroud and Mayami, from February 20, 2020 to April 18, 2020. The GIS can better show the spread of epidemics. This software indicates geographical distribution of disease spread and is very helpful in controlling the epidemics. Therefore, maps of spatial distribution and risk of infection to COVID-19 were prepared in different regions of Shahroud county using Arc-GIS software to better implement health policies.

Results: During this sixty-day period, 529 confirmed cases were detected, of which 51% were men and the average age was 55 years. The maps showed high-risk to risk-free regions. Shahroud and Bastam cities were known as the coronavirus hot spots. The eastern region of Shahroud has the highest number of cases but some high risk areas are spread throughout the Shahroud city due to high infectivity of virus. Risk-based time maps indicated a reduction in the risk of infection at the end of the research period due to some mitigation and suppression strategies.

Conclusions: Shahroud and Bastam are the most dangerous cities that, the number of patients and dissemination has decreased over time because of tracking definite patients and people in contact with them and implementation of preventive care.

Keywords: COVID-19, geographic information systems (GIS), Shahroud, Iran

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1. Introduction

Coronaviruses have attracted the global attention due to the recent emergence of a highly pathogenic human coronavirus in China[1]. The World Health Organization has considered COVID-19 as a pandemic and a public health emergency with an international concern due to its widespread distribution in the world[2-4].

Person-to-person transmission has been confirmed in the disease; and asymptomatic individuals have been identified as potential sources of infection[4]. Disease caused by COVID-19 is transmitted by respiratory droplets and close contact[4, 5]. According to the statistics released by the WHO, more than 7 million people globally were infected with the disease, and more than 400,000 died of it until June 21, 2020. the United States and Europe are at the forefront of number of deaths and patients[6]. The first confirmed cases of COVID-19 infections were reported on 19 February 2020 in Iran. This disease up to Jun 1, 2020, had caused 154,445 cases and more than 7,878 death in Iran. The highest covid-19 incidence in Iran was reported from Semnan province and Shahroud County[7]. So far, like other countries, the risk factors associated with COVID-19 morbidity and mortality are still not completely understood in Iran. Therefore conduct the studies in individual, molecular and ecological levels to identify the covid-19 risk factors are necessary.

The use of geographic information systems (GIS) has been taken into consideration by health policymakers. This software indicates the geographical distribution of disease and is very helpful in controlling the epidemics[8, 9]. Observing and reporting high-risk regions can be contributory in making decisions and providing solutions, allocating resources, and warning people about maintaining and implementing individual and social health measures.

Regarding to, the determination of the geographical distribution of incidence/prevalence of diseases is very important in order to formulate a hypothesis about risk factors and generating accurate maps of disease risk in the area for the purpose of better resource allocation. Therefore, the present study was conducted by GIS to determine the geographical distribution of covid-19 and identified high risk regions in Shahroud and Mayami during 60 days.

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2. Materials and methods

This cross sectional study was conducted in counties covered by Shahrud University of Medical Sciences, namely Shahroud and Mayami, from February 20, 2020 to April 18, 2020 using the Arc-GIS software. Shahroud and Mayami counties lies between latitudes 36.40° N and longitudes 55.01° E; and includes 52% of the area and 43% of the population of Semnan province (about 302015 people). Figure 1 shows the geographical location of Shahrud and Mayami in Semnan province.

The present study investigated the incident cases of COVID-19 and geographical distribution of the risk of disease over periods of ten days. All patients suspected of COVID-19, who were treated as outpatients or were admitted at hospitals, were investigated. All investigated cases had positive Real-time reverse transcriptase polymerase chain reaction (RT-PCR) test on throat or nasopharynx swabs. Demographic characteristics of patients such as age, sex, residential address, and dates of first positive PCR test were by trained interviewers into comprehensive software for COVID-19.

The recorded data were transferred to Arc-GIS ESRI-V10 after accurate time and place classification in Excel 2013. Information layers included a layer of points relating to patients' addresses, layer of points relating to health centers, layer of points relating to location of towns and villages, information layer of main and back roads, boundary layer, as well as layer of points relating to the distribution of COVID-19 Arc-Catalogue module was used by the help of analytical package IDM in the geographical distribution of the occurrence of COVID-19 and determining the rate of risk in each region and visualizing the risk of disease in different regions of two counties by masking the information layer of dispersion of people in each region at the desired boundary layer. The analysis of distribution and high-risk regions took place after preparing the geographical images, number of incident cases in each region, and risk of infection.

The risk map of COVID-19 in different regions of Shahroud city was prepared separately.

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2. Results

According to the data, 472 (89.2%) and 57 (10.8%) out of 529 reported cases in 60 days of outbreak were from Shahroud county and Mayamey county, respectively. The average age of patients is 55.3 years, of which 271 cases were male (51%)

Figure 2 shows the risk of coronavirus in different regions of Shahroud and Mayami counties based on the number of patients reported in different regions. The maximum number reported was 363 in Shahrud and 38 case in Bastam, which are known as the coronavirus hot spots in the county. In other cities and villages, there were between 1 to 12 cases of COVID-19, but no case was reported in some regions up to date of submission of the present study.

The risk of infection in any city or village can be found according to the map legend. The blue areas on all maps indicate cities or villages with no reported case of COVID-19.

Figure 3 shows the high-risk and low-risk regions for risk of COVID-19 in Shahroud city. High risk areas are spread throughout the Shahroud city but the eastern region of Shahroud has the highest number of cases.

Time series for COVID-19 are presented as a video in supplementary. Figure 4 (a-f) shows the risk of infection in different regions of both counties from February 20, 2020 to April 18, 2020 in ten-day intervals (map of “a” and “f” are the first ten days and sixth ten days respectively). These risk-based time maps indicate how the risk of COVID-19 in two cities is increasing in ten-day intervals and then decreasing at the end of the research.

Discussion

In this study, Shahroud and Bastam cities were high-risk regions that need more rigorous prevention. The incidence of the disease is higher in Bastam. According to the university registration system, the first definite positive cases also reported from Bastam, where, according to the residents of this city, had a lot of traffic with the first positive cases in Iran, namely Qom.

The risk of covid-19 in the Mojen, Qaleh Now-e Kharaqan, and Hoseynabad-e Kalpush, followed by Mayami, Khij, and Nardin were in the next levels respectively.

Based on our study findings, the eastern region of Shahroud had the highest number of cases with COVID-19. Therefore, it seems that compared to other parts of the city, this region had the

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highest risk of COVID-19. This may be due to the fact that most residents of eastern Shahroud have low socio-economic conditions compared to other parts of the city, and this may delay the referral of patients with COVID-19 to health centers. Also, it seems the disease to have spread to other areas in Shahroud due to high infectivity of virus so, attention to this disease and preventive measures should be considered everywhere.

The risk of COVID-19 in two cities first is increasing in ten-day intervals and then decreasing at the end of the research period due to restrictions on travel, social distances, and other mitigation and suppression strategies implemented in Shahroud**.** Also, we can find how the disease is spread within a certain range up to a radius of 200 km from the center of observation of the first cases of COVID-19.

The extent of risk and number of cases COVID-19 in Shahroud are very high in terms of population and area, and this is clearly seen in ten-day periods and is probably due to close contacts between individuals and families.

The highest spread of the disease in cities of shahroud and Mayami has been in the third and fourth ten days, but this trend is reversed in the fifth and sixth ten days, especially in the sixth ten days.

Therefore, this trend was shown that integrating the activities of the health, treatment, and research sectors in Shahroud university medical sciences and implementation of preventive care decreased the extent of disease dissemination. It is easy to cope with COVID-19 by active tracing individuals in contact with the definitive cases quickly, isolation of cases, the same thing that was done at Shahroud University[10].

The geographical distribution of COVID-19 has been examined in many studies and its prevalence, risk, number, and density have been depicted with GIS in different regions of the world[11, 12]. Comparing the maps presented in the study with time series presented in other regions of the world [9, 11-13] indicates the fact that the disease can spread quickly and easily in a short period of time by infected people, who are unaware of their disease, or due to neglecting personal and social hygiene. However, to the best of our knowledge, there was no other study on the geographical distribution of COVID-19 in Iran, and the results of the present study were not comparable to similar studies.

The present study conducted based on available data over a short period of time; hence, we couldn't investigate the relationship of some health recommendations such as staying at home, restrictions on travel, and social distancing with covid-19. However, if we have access to this information, we can examine their relationship with COVID-19 in each region. As the last limitation, we did not consider the population of different regions in the calculation of risk; and the risk calculation was based only on the number of cases in each region that seemed to be enough in terms of policy-making and interventions. In fact, most of the blue regions in maps of Shahroud and Mayami were uninhabited and did not mean that there was no disease.

Conclusion

Shahroud and Bastam are among the most dangerous cities that over time, the number of patients and disease dissemination has decreased because of tracking definite patients and people in contact with them. Controlling and preventive measures of COVID-19 could largely control the epidemic in Shahroud, but there are still hotspots in different regions of Shahroud and some regions of Mayami and Shahroud counties that should be taken into consideration for more control.

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Conflicting Interests: The Authors declare that there is no conflict of interest.

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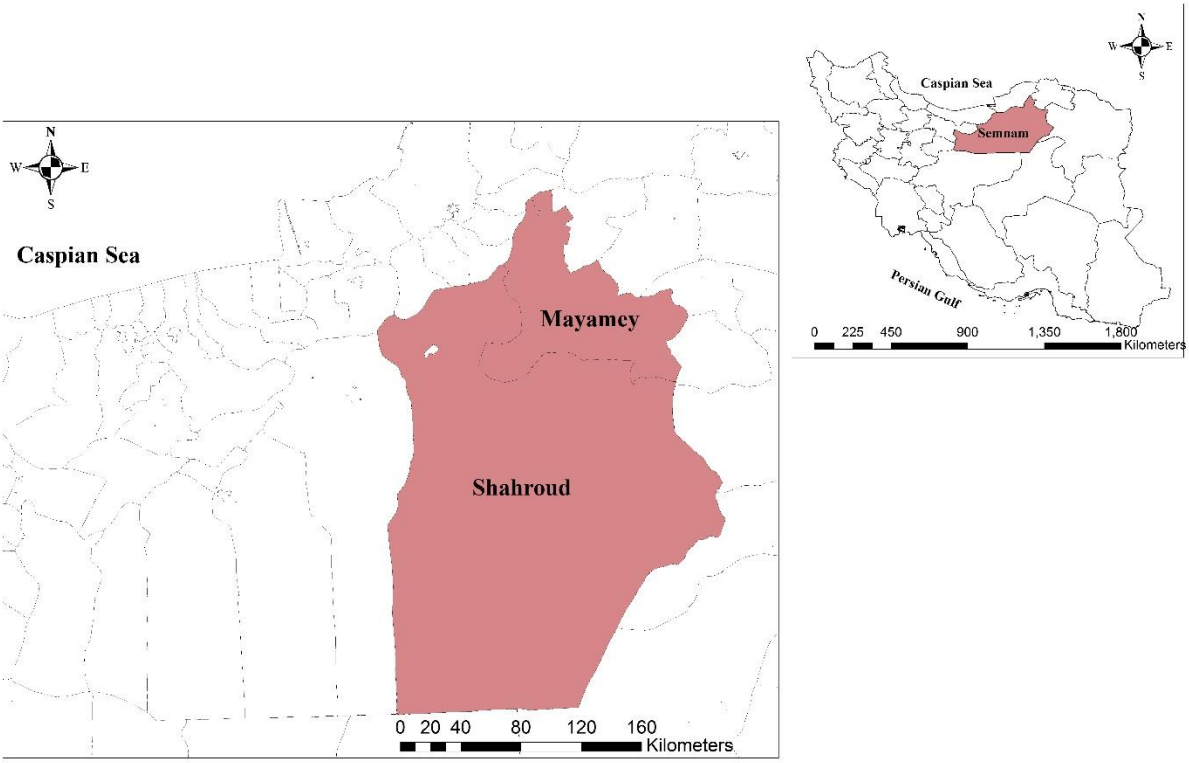

Fig 1. Geographical location of Shahroud and Meyamey in Semnan province

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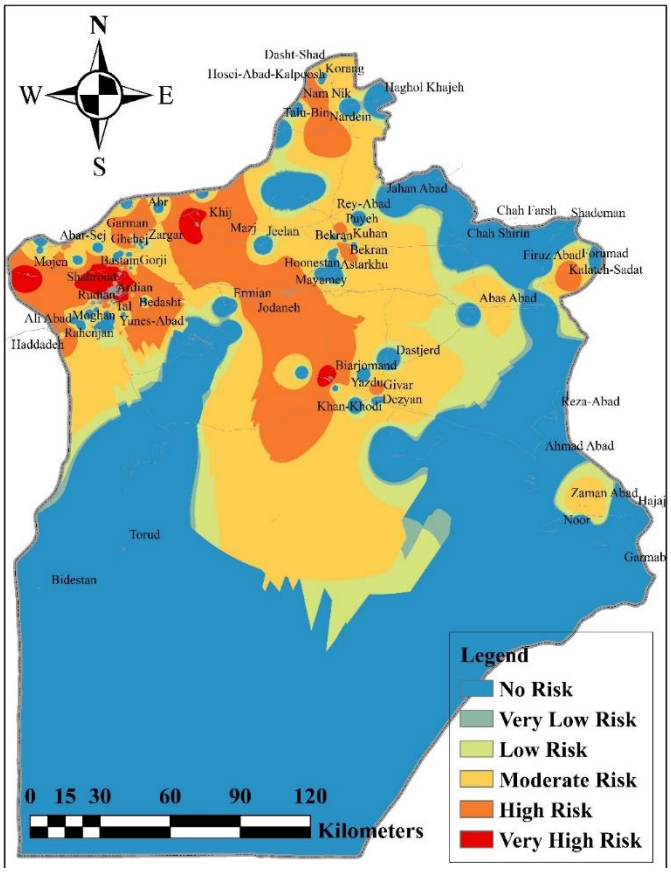

Fig 2. The risk map of COVID-19 in different regions of Shahroud and Mayami counties

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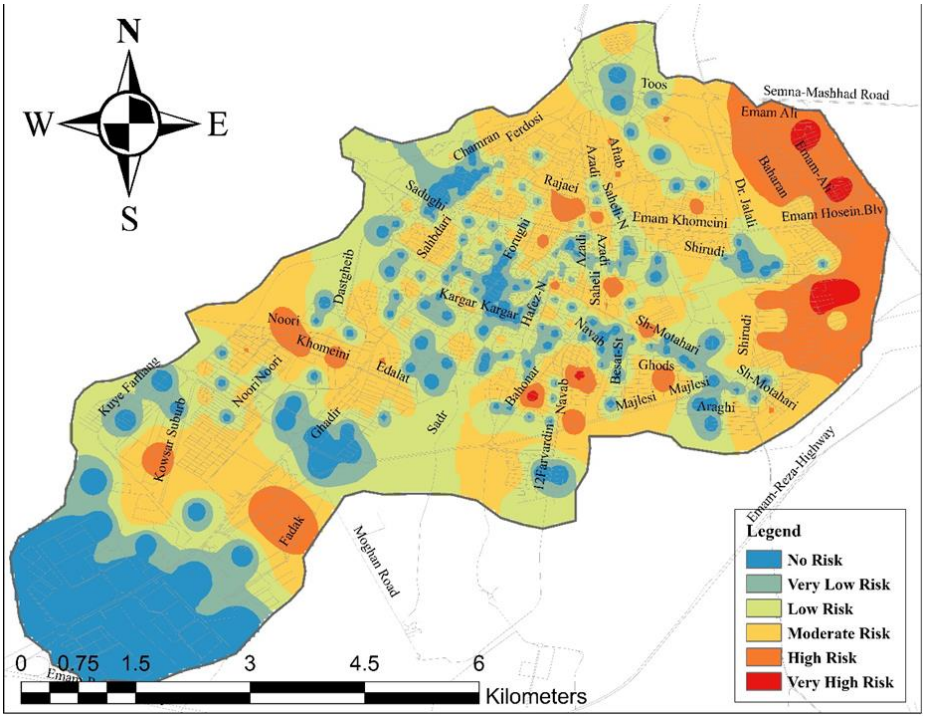

Fig 3. The risk map of COVID-19 in different regions of Shahroud city

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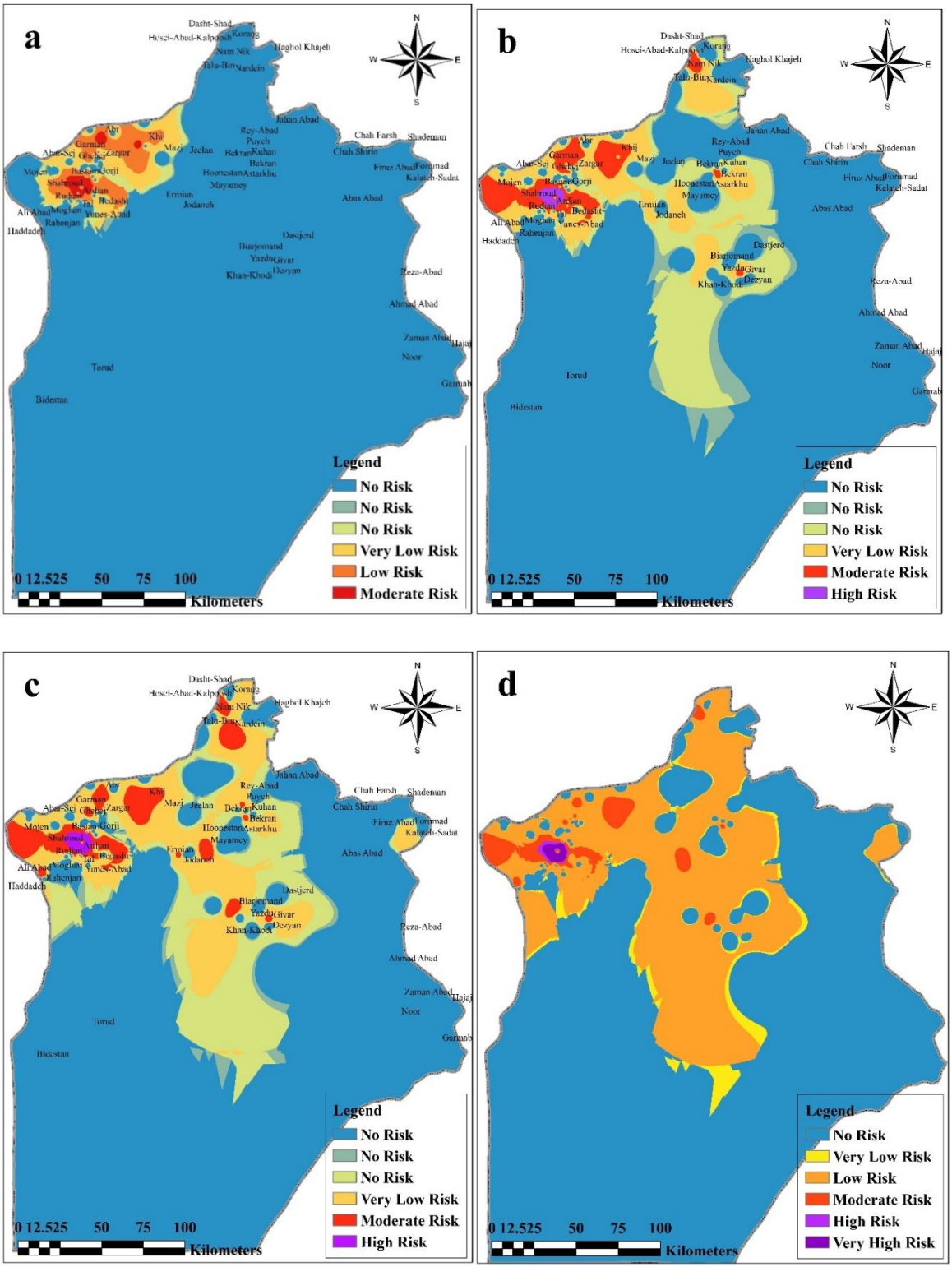

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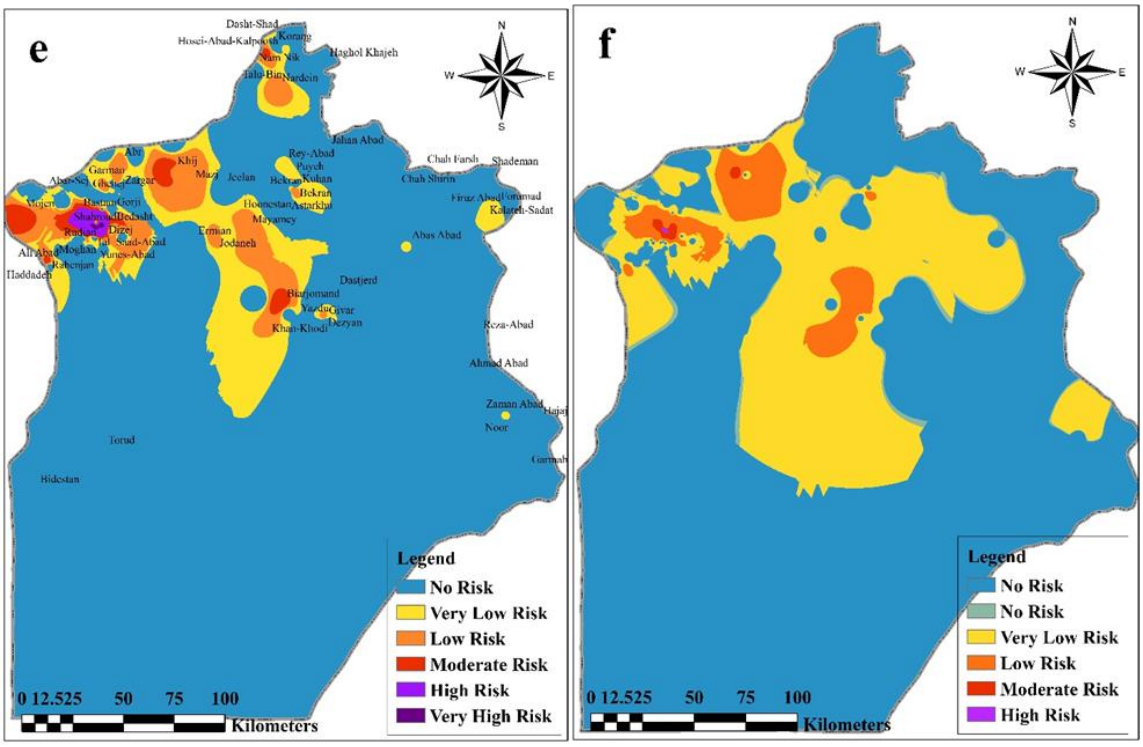

Fig 4. The risk map of COVID-19 in different regions in a period of 60 days as ten-day intervals (a-f)