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The Effects of Personal, Environmental, and Genetic Factors on Epidemic of Coronavirus Disease-19: A Review of the Current Literature

Salar Bakhtiyari[1], Amin Mirzaei[2], Mohsen Jalilian[2], Sajad Mazlomi[3], Heshmatollah Nourmoradi[3,4]*, Hojatollah Kakaei[5]

[1]Department of Clinical Biochemistry, School of Medicine, Ilam University of Medical Sciences, Ilam, Iran; [2]Department of Public Health, School of Health, Ilam University of Medical Sciences, Ilam, Iran; [3]Department of Environmental Health Engineering, School of Health, Ilam University of Medical Sciences, Ilam, Iran; [4]Biotechnology and Medicinal Plant Research Center, Ilam University of Medical Sciences, Ilam, Iran; [5]Department of Occupational Health Engineering, School of Health, Ilam University of Medical Sciences, Ilam, Iran

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***Correspondence:** Dr. Heshmatollah Nourmoradi, Biotechnology and Medicinal Plant Research Center, Ilam University of Medical Sciences, Ilam, Iran. E-mail: ilam_nourmoradi@yahoo.com
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Abstract

Coronavirus disease (COVID)-19 is a viral disease that broke out in late 2019 in Wuhan, China. The World Health Organization has been forced to declare a public health emergency due to the global outbreak of COVID-19. The concerns about the COVID-19 disease are the rapid increase in the number of patients as well as the number of deaths compared with severe acute respiratory syndrome disease. Given that there is a remarkable variability amongst people for COVID-19 infection, there really is the possibility that there will be genetic and environmental effects, it is a need for their role to be fully clarified as soon as possible. Numerous studies have been performed on the on the stability of COVID-19 virus in different environmental conditions including temperature and humidity. In this study, we aimed to discuss in detail the benefits and effects of these factors on COVID-19. Some studies have confirmed the relationship between environmental conditions and disease transmission and others have rejected. Furthermore, not all COVID-19 exposed people are infected and not all infected patients develop severe respiratory complications. It is quite likely that these disparities are genetically mediated, in part. People who may be occupationally exposed to this virus may be due to different reasons, including lack of health, lack of knowledge and attitude, and working conditions. Reducing human-to-human contact by increasing the level of public health in the community as well as maintaining social distance plays a key role in prevention of COVID-19 disease. However, many aspects of COVID-19 are still unknown and require further and extensive studies.

Introduction

In December 2019, in Wuhan, China, a virus was first identified that was named Coronavirus (CoV) Disease (COVID)-19 because it was caused by the severe acute respiratory syndrome (SARS)-CoV-2 virus. The World Health Organization (WHO) Director-General announced on January 30, 2020, that the outbreak of COVID-19 is a global concern [1], [2], [3]{Sohrabi, 2020 #1}. Evidence recommends that COVID-19 is mainly transmitted through close contact with infected individuals through bodily secretions including nasal fluid, saliva, and respiratory droplets spread by speaking, sneezing or coughing [2], [4], [5]. The most commonly reported symptoms of the disease include fever, dry cough and fatigue, and in fewer frequent cases, headaches, diarrhea, shortness of breath, and sore throat [5], [6], [7], [8], [9].

Study Strategy

The compilation of this review study was carried out in April 2020. To find the related published papers on the effect of personal and environmental conditions and genetics on COVID-19, the recent electronic documents from Google, PubMed, Google scholar, Elsevier, and Scopus were applied. Various key words, including COVID-19, environmental condition (air temperature and humidity), water, wastewater, solid waste, food, genetics, personal health, occupations, and disinfection, were used to investigate the study.

Epidemiologic Characteristics of the COVID-19

The WHO report no108 on COVID-19 global situation on June 14, 2020, was demonstrated that 216 countries had reported confirmed COVID-19 morbidity. At the time of the report, the total number of cases and death were 27,486,960 and 894,983, respectively [10].

CoV is a single-stranded RNA virus resembling a crown under electron microscopy (due to the presence of spike glycoproteins on the envelope), which is divided into four genres including alpha, beta, gamma, and delta CoV. The SARS-CoV and SARS-CoV-2 (COVID-19) genomes have about 80% identity and belong to the beta genre and cause symptoms such as fever, malaise, dry cough, and acute respiratory response [11]. This newly discovered CoV is associated with the recent outbreak of pneumonia in humans and probable bat origin [12].

The diameter of COVID-19 is around 60–140 nm and has a spherical or oval and often pleomorphic form. It is sensitive to heat and ultraviolet rays like other CoVs. In addition, using lipid solvents including ethanol, ether (75%), chlorine-containing disinfectant, chloroform, and peroxyacetic acid, this virus can be effectively eliminated [13].

The median incubation period of COVID-19 from exposure to the first symptoms was reported in Qian *et al*., Xu *et al*., Guan *et al*., and Singhal studies for 3, 4, 4, and 5 days, respectively [6], [7], [8], [14]. Symptoms in most people are mild and, in some cases (often elderly), the symptoms are severe and it is also asymptomatic in most people [8]. The median age of patients was reported in studies of Xu *et al*., Sun *et al*., and Guan *et al*., studies were reported 41, 46, and 47 years, respectively.

The overall case-fatality rate has been reported at between 2% and 3.4% [8], [11], [12], [15]. Mortality is higher in the elderly and in cardiovascular, diabetic, cancerous, or chronic respiratory patients and is very low in children [3], [15]. Although the fatality rate of COVID-19 is lower than its two ancestors the SARS-CoV and Middle East respiratory syndrome CoV (MERS-CoV); however, it is much faster to spread [8]. Estimates of contagiousness of COVID-19 (R_0) has been reported in some studies ranging from 1.5 to 5.2 [5], [16], [17]. R_0 is defined as "the average number of people who will contract a disease from one contagious person" [5], [18]. However, within the closed environments as well as in high-density environments such as hospitals, where contact between people is getting closer, the R_0 of COVID-19 has been estimated to be significantly higher (estimates ranging from 5 to 14) [5], [19], [20], [21]. However, with the enhancement of healthcare and increasing public health in the community, the R_0 will decline [17].

Genetic Susceptibility to COVID-19 Infection

In the case of COVID-19, what is controversial for researchers and clinicians is that not all COVID-19 exposed people are infected and not all infected patients develop severe respiratory complications. Although the exact mechanisms behind these dramatically different infection outcomes remain to be elucidated, it is quite likely that these disparities are genetically mediated, in part [22].

For entering into the host cells, many viruses use multiple alternative receptors. The study by Lu *et al*. showed that SARS-CoV and SARS-CoV-2 have similar receptor binding domain structures. Further studies showed that these viruses use the same receptor for entering the cells. This receptor is angiotensin-converting enzyme 2 (ACE2) and is involved in the pathogenicity of SARS-CoV and SARS-CoV-2 [12], [23].

The previous studies have shown that the expression level of ACE2 is influenced by age, sex, and smoking. Thus, the pathogenicity of COVID-19 varies in different populations and races. Zhao *et al*. (preprint) showed the predominant expression of ACE2 in Asian men, which might be one of the possible reasons for the higher prevalence of COVID-19 in this subgroup of patients compared to the women and patients of other populations [24].

In a study of Asian and Caucasian people by Cai (preprint) was shown that there was not any significant difference in ACE2 expression between these groups. Furthermore, ACE2 expression was not affected by sex and age. However, it was significantly higher in smokers than non-smokers of Asian ethnicity [25]. Some studies reported that there was no significant relationship between smoking and the prevalence or severity of COVID-19 [7], [26].

In a study on critically ill patients with COVID-19 by Yang *et al*., it was found that more men were affected (67%) than women [27]. Of the 1099 patients with COVID-19 hospitalized in 30 hospitals in China, 58% were reported to be men [7]. In contrast, one study of 140 patients with COVID-19 reported the equal sex distribution [26].

Different immune responses to pathogens can be due to genetic differences between individuals. When the immune system is compromised, the SARS-CoA-2 can spread in the body and cause extensive damage to tissues that have high expression of the ACE2 gene such as the lung, intestine, and kidney. Innate inflammation that is largely mediated by pro-inflammatory macrophages and granulocytes is induced by the lung damaged cells. Lung inflammation is the main complication of COVID-19 infection at the severe stage [28]. Accordingly, it is very critical to identify human leukocyte antigen (HLA) molecules that have increased binding specificities for peptides of SARS-CoV-2 presented on the antigen-presenting cell surface. Given that there are no related data available so far, we can obtain some information from the work of researchers on SARS-CoV. Several studies have shown the association between HLA polymorphisms and the susceptibility of SARS-CoV, such as HLA-DRB1*1202, HLA-B*0703, HLA-B*4601 [29], and HLA-Cw*0801 [30] and some polymorphisms related to the protection from SARS infection including HLA-A*0201, HLA-Cw1502, and HLA-DR0301 alleles [31]. This information will be very advantageous for the treatment of COVID-19. Together, to identify the mechanism of COVID-19 pathogenicity and the environmental and genetic factors affecting the prevalence and severity of the disease, many studies should be conducted in different populations and races around the world to determine the effects of age, sex, genetic background, and environmental factors on this disease.

The Effect of Environmental Condition (Temperature AND Humidity) on Spread of COVID-19

Several studies have been conducted on the effects of environmental conditions such as ambient temperature and humidity on the stability of the COVID-19 virus. Some of these researches have considered the association between the environmental factors to be effective, and other studies have not found a relationship between these factors and COVID-19 virus transmission and spread. Wang *et al*. (2020) concluded that environmental conditions such as humidity and air temperature play an important role in the spread of disease. Based on this study, the prevalence of the disease was higher in countries with the lower humidity and temperature (Iran and South Korea) than other countries with higher humidity and temperature (Singapore and Thailand) [32]. This finding can due to the high viral stability in the cold weather and the susceptibility of the host immune system to cold air and low humidity [32]. There was also such a trend for the SARS virus [33].

Sajadi *et al*. study (2020) showed that COVID-19 morbidity will decrease in countries above 30°C during the coming months and summer due to rising temperatures. The disease in the tropics may also cause seasonal peaks and in the southern hemisphere may cause outbreaks in the months ahead. In temperate regions, it may lead to outbreaks in late fall and winter. Extensive health care can prevent summer outbreaks in the tropical and southern hemisphere [34].

Wang *et al*. (2020) study on the effect of ambient temperature on the COVID-19 disease transmission in 34 Chinese provinces and 26 countries showed that ambient temperature had significant effects on the disease transmission rate. The study indicated that by reducing the air temperature, the transmission of the disease was increased. According to this study, when the air temperature reaches 30°C, the cumulative number of cases increases by only 3.38, indicating that the COVID-19 virus is sensitive to ambient temperature [35]. There is also a pattern in the spread of other viral diseases, such as the flu. The prevalence of influenza is high from May to September in the Southern Hemisphere and November to March in the Northern Hemisphere where temperatures are low [36]. Other studies have also shown that the prevalence of swine flu is also increased at low air temperature and humidity [37]. Studies on SARS disease also showed that increasing air temperature and humidity from 22 to 25°C and 40–50% to 38°C and 95%, increase the activity of the virus on the surfaces from 5 days to near zero, respectively [33]. In other studies, it was proved that low temperature and humidity had a significant effect on the survival rate of other CoVs, such as MERS [38]. In a study by Bu *et al*. (2020) on the effect of air temperature and humidity on the COVID-19 virus, it was found that temperatures of 13–19°C and humidity of 50–80% were considered as suitable conditions for survival and spread of the disease [39]. Oliveiros *et al*. (2020) on the effect of ambient temperature and humidity on COVID-19 concluded that doubling time was directly and inversely correlated with ambient temperature and humidity, respectively [40]. For this reason, the spread of the disease is expected to slow in the spring and summer of the northern hemisphere. It is also expected that by 20°C increasing the air temperature, the doubling time will be delayed to 1.8 days. These factors account for 18% of the variation in disease doubling time. The other 82% may be connected to personal health measures, population bulk, commuting, and people's customs [40]. Other studies have shown that environmental conditions including temperature and humidity alone do not essentially result in decreasing the number of COVID-19 cases without rigid health interventions [41]. In the study by Cai *et al*. (2020), we reported that there was no relationship between daily ambient temperature and growth rate of COVID-19 epidemic [42]. Poirier *et al*. (2020) stated that high humidity and temperature did not diminish the spread and survival of COVID-19 virus. According to a study conducted in China, Iran, Italy, Japan, and South Korea, the environmental conditions (temperature and humidity) did not appear to affect the number of COVID-19 cases [43]. It seems more extensive studies are needed to prove the effects of environmental conditions (temperature and humidity) on the stability and spread of COVID-19 virus.

The Effect of Water, Wastewater, Solid Waste, and Food on Spread of COVID-19

The risks of COVID-19 transmission through human wastewater (feces) are very low. However, scientific studies have confirmed the presence of viral RNA fragments in human feces [44], [45] and in a study using virus culture from the human stool, viral RNA has also been detected[46]. However, so far, no studies have confirmed the oral-fecal transmission of the virus [47]. In the wastewater containing COVID-19 virus, wastewater treatment plants (especially in the disinfection part) effectively inactivate the virus [48]. Washing hands with soap and water for at least 20 s is a necessity if contact with the stools of suspected or ill persons occurs. Washing hands with soap and water for at least 20 s is sufficient if contact with the stools of suspected or ill persons. Furthermore, given that the feces of COVID-19 persons are considered as biohazard, the people responsible for stool disposal, especially in hospitals, should be provided with masks, gloves, and protective equipment [47]. The COVID-19 virus is a virus with a fragile outer membrane. Membrane viruses are usually low resistant to environmental conditions, especially disinfectants such as chlorine and ozone. The inactivation time of membrane viruses is much lower than of non-membrane viruses [47]. While the presence of virus in drinking water is possible, no studies have been conducted on the presence and transmission of COVID-19 virus in surface and ground waters. As sodium hypochlorite solution can inactivate COVID-19 virus on the surfaces, it seems that in drinking water containing disinfectants, the virus inactivation can rapidly occur. For this reason, the risk of virus transmission through drinking water is very low. Operational measures including water disinfection and proper storage in clean containers can be helpful to prevent virus transmission from contaminated water. For effective disinfection of drinking water containing the virus, it is recommended that the chlorine concentration should be ≥0.5 mg/L with a minimum contact time of 30 min and a pH of <8 [49]. If treated drinking water is unavailable, household water purifiers with nanofilter, ultrafilter and reverse osmosis membranes or ultraviolet radiation can be effective to inactivate the virus. Water boiling and solar radiation can also remove the virus from potable water [47].

Hospital waste management plays a key role in the control of the COVID-19 epidemic and includes separation, collection, and disposal [50]. Hospital waste management should be healthily conducted. The absence of proper management at each stage can result in developing the disease among staff, patients, and also people. The waste generated in the COVID-19 patient's wards should be considered as highly infectious. For this reason, separation is not required for disposing of COVID-19 patient's waste and should be considered as completely infectious. These wastes should be collected in lid standards containers. Hospital waste management workers should be fully equipped with glove, hat, gown, boot, and face shield (mask). The waste collection period at COVID-19 patients' wards was daily (24 h) carried out in China during the disease epidemic time [51]. One of the best ways for the disposal of hospital wastes to prevent the release of COVID-19 virus is incinerators which have a great role in the destruction of biological agents [51]. According to a study by Rafiee *et al*. (2016) on hospital waste management, the use of hydroclave, as well as autoclave, has been suggested as two suitable options for the control of waste infection [52]. So far, no study has been reported on the transmission of COVID-19 virus by hospital wastes [47]. Epidemiological evidence suggests that the zoonotic transmission of the virus occurred in December 2019 at the Wuhan's Huanan Wildlife Market. Molecular researches have also reported that the COVID-19 virus is very similar to the CoV isolated from the horseshoe bat [53]. Therefore, the zoonotic transmission of the virus from animals to humans is possible. Unlike other foodborne viruses such as norovirus and hepatitis A that causes food-borne viral gastroenteritis, COVID-19 virus causes severe respiratory infection. It has been no documents about the food-borne transmission of COVID-19 [54].

COVID-19 and Occupations

In addition to healthcare workers, a large number of people in various professions including industry, agriculture, public services, traffic police, staff public transport, and taxi drivers are at risk for COVD-19 [55], [56], [57], [58]. In 2018, the Bureau of Labor Statistics (BLS) estimated the total number of employees in the United States at 144.7 million. Of these, 18.4% (26.669.810) at least once a month and 10% (14.425.070) at least once a week are exposed to the pathogen [59], [60]. There are 150 million international migrant workers worldwide. About 95% of them are resident in the five WHO regions where COVID-19 has been confirmed [61]. The employment rate for 2018 in the Central and West Asia region was 58.3% [62].

To reduce the prevalence of COVID-19 in businesses, workers, and the general public, it is important that all employers plan to counter COVID-19. The amount of occupational exposure risk depends largely on the type of industry; however, to help employers, Occupational Safety and Health Administration (OSHA) has divided job duties into four levels of risk: Very high-risk, high-risk, medium-risk, and low-risk. Most American workers are likely to be at low or medium exposure levels. In the very high-risk group is occupation such as healthcare workers (e.g., doctors, nurses, paramedics, sampling laboratories, and morgue staff performing autopsies). The high-risk group includes occupations such as healthcare and support staff (people who need to enter the patient room), medical transport staff (ambulance operator), and cold storage staff involved in preparing the bodies of suspected COVID-19. In the middle-risk group is that who need frequent or close contact (e.g., less than 6 feet) with people who may be infected with COVID-19 (Staff with international jobs). Finally, there are low-risk (precautionary) groups in the business that have the least amount of job contact with people and other colleagues [63].

Since the transmission features of COVID-19 have not yet been fully identified, the WHO recommends wearing masks for all occupations in public and crowded environments [64], [65], [66], [67]. Although no study to date has compared the efficacy of N95 masks and surgical masks in preventing influenza or other respiratory infections in healthcare workers, almost all practitioners recommend the use of N95 masks to protect *against droplet* transmission from *coughs and sneezes* of COVID-19 patients [68].

Basic Approaches for the Prevention and Control of COVID-19 Disease

The reviewed studies generally suggest two main approaches for preventing and controlling COVID-19, including promoting public health and maintaining social distance [2], [3], [5], [16], [69]. Preventive measures should be taken by everyone everywhere, including homes, workplaces, hospitals, schools, universities, shopping centers, mosques, churches, and temples. [2], [4], [5], [16], [70].

Quarantine is a very important strategy to prevent infected individuals from contacting healthy people, especially in the early stages of COVID-19 disease. The results of past studies point to the high significance of quarantine in cutting off the COVID-19 disease transmission chain. Accordingly, solutions such as quarantine travelers, who enter the country from high-risk areas, banning intercity travel and restricting intercity movement, closing or postponing school activities, churches, mosques, and workplaces, can be very effective in preventing and controlling of COVID-19 disease [2], [3], [5], [16], [70], [71].

Effect of Disinfectants on COVID-19 Virus

Detailed information about the level of resistance of COVID-19 in the environment is not available, but it seems to behave like other CoVs [72]. Recent studies have shown that the resistance of human CoVs such as SARS-CoV, MERS, and other endemic human CoV, is varied in different surfaces (from 2 h to 9 days) [72], [73]. The survival time of these viruses is affected by many factors such as surface structure, temperature, relative humidity, and type of virus species so that on inanimate surfaces such as metals, glass, and plastics can survive up to 9 days [72], [73].

Unfortunately, there is little information about the suitable disinfectant for confrontation to COVID-19. However, experts believe that effective disinfectants on other CoVs can also be effective to inactivate COVID-19 virus. There is a wide range of disinfectants for surface disinfection. Ethanol 62–71%, hydrogenperoxide 0.5%, and sodium hypochlorite 0.1% can effectively disable the CoVs during 1 min [74]. The WHO believes that a wide range of disinfectants is effective for enveloped viruses such as COVID-19 virus. At present, 70% ethyl alcohol recommends for disinfection of small areas between uses such as reusable equipment (e.g., thermometer). Sodium hypochlorite at 0.5% (equivalent 5000 ppm) is recommended for disinfection of surfaces [72].

The efficiency of other disinfectants such as 0.05–0.2% benzalkoniumchloride or 0.02% chlorhexidinedigluconate was negligible [74]. Ultraviolet (UV)-C has a high ability to deactivate viruses, bacteria, and fungi in an aerosolized form [73]. A study showed that irradiation with UV for 60 min on several CoVs that were cultivated on the medium resulted in a lack of viral growth [74]. Quaternary ammonium compounds are able to remove the odor and have extensive biocidal and sporostatic activities [73]. To wash the clothes, the washing machine contains laundry detergent with a temperature of 60–90°C is recommended. If this is not possible, immerse the clothes in warm soapy water in a large container and use a stick to stir. After the drain of water and soap, it will be submerged in 0.05% chlorine for 30 min then drain, rinse, and dry in sunlight [47]. Ambulances and vehicles for the transport of suspicious cases should be cleaned and disinfected properly. For washing and disinfection, it should be cleaned first by household soap or detergent and then performed by 0.5% sodium hypochlorite as a disinfectant [75].

Conclusion

COVID 2019 is a pandemic with very high transmission power. Several studies have been conducted on the effect of genetic and environmental factors (temperature and humidity) on COVID-19 transmission rate. Some of these studies have confirmed the relationship between environmental conditions and disease transmission and others have rejected. It seems more widespread studies are needed to prove the effects of factors on the stability and spread of COVID-19 virus. Not all COVID-19 exposed people are infected and not all infected patients develop severe respiratory complications.

It is quite likely that these disparities are genetically mediated, in part. Because SARS-CoV-2 enters the cells through ACE2, by examining more cases from different genetic backgrounds and ethnicity and worldwide, ACE2 expression variation can be precisely analyzed and compared to establish whether it contributes to susceptibility to COVID-19 across the different subgroups. The number of people due to the occupation may be exposed to this virus are very high and, in many cases, may be due to different reasons, including lack of health, lack of knowledge and attitude, working conditions, and different safety culture. Reducing human-to-human contact by increasing the level of public health in the community as well as maintaining social distance plays a key role in prevention and control of COVID-19 disease. However, many aspects of Covid-19 are still unknown and require further and extensive studies.

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