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Computerized intelligence and mathematical models for COVID-19 management: A short communication

Reza Gerami[1], Ramezan Jafari[2], Amin Saburi[3], Tina Zeraati[4,5], Mostafa Ghanei[3*], Elham Sabouri[6*]

[1] Department of Radiology, Faculty of Medicine, AJA University of Medical Sciences, Tehran, Iran
[2] Radiology Department, Faculty of Medicine and Chemical Injuries Research Center, Baqiyatallah University of Medical Sciences, Tehran 18151777, Iran
[3] Chemical Injuries Research Center, Systems Biology & Poisonings Institute, Baqiyatallah University of Medical Sciences, Tehran, Iran.
[4] Medical Genetics Research Center, Mashhad University of Medical Sciences, Mashhad, Iran
[5] Renal transplantation Complications Research Center, internal medicine, Mashhhad, Iran
[6] Student research committee of Mashhad University of Medical Sciences, Mashhhad, Iran.

Corresponding Author:
Mostafa Ghanei: Chemical Injuries Research Center, Systems Biology & Poisonings Institute, Baqiyatallah University of Medical Sciences, Tehran, Iran. Email: mghaneister@gmail.com
Elham Sabouri: Student research committee of Mashhad University of Medical Sciences, Mashhad, Iran. Email: e.sabouri@ymail.com

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Abstract

The onset of COVID- 19 pandemic has resulted in the transition from conventional face-to-face health care strategies to computerized approaches, considering distances, the importance of quarantine, and early diagnosis and management. As far as the rapid management of the infection is concerned, the telemedicine approach appears beneficial. The use of telemedicine is thought to decrease the risk of cross-contamination. Moreover, it provides access to the healthcare for remote locations. The healthcare staff can use computational analyses to get rapid access to accurate epidemiological and laboratory data. The risk assessment provided by the mathematical models seems essential for deciding in regards to prognosis and management. We aimed to explore the breakthrough of telemedicine regarding the pandemic, in addition to a discussion on the related problems and challenges.

Keywords: COVID-19, Remote consultation, Telemedicine, Delivery of health care

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Introduction

The growing trend is for the management of COVID-19 owing to its extensive spread across the world. Additionally, the unknown aspects of the disease and controversial ideas of choosing the appropriate management lead to a difficult deciding process amongst healthcare staff. Currently, the most common practices in treating the disease consist of supportive management and relieving clinical manifestations, such as respiratory support with oxygen therapy and mechanical ventilation[1]. Evidenced-based guidelines are being daily updated, and they suggest novel treatment protocols for proper management, including antiviral medications, plasma compounds, monoclonal antibodies, corticosteroids and antithrombotic agents[2]. In addition to the treatment options mentioned above, a considerable number of healthcare systems worldwide are attracted to the use of telemedicine to provide a more effective and faster management strategy[3]. It is also expected that the expanding role of telemedicine not only will not lose its importance at the end of the pandemic, but also it will become more popular[4-6]. Telemedicine, also known as telehealth, is a combination of engineering and medical activity, involving electronic communication in addition to considering distances[7]. The authors review the advantages of using telemedicine in the case of infection management emphasizing COVID-19. Additionally, the main challenges regarding the issue are discussed.

Factors influencing the management and possible delayed management

Since the infections can have diverse serious complications, including impaired function of the kidney , liver, brain, coagulation system, lung, cardiovascular system (including myocarditis, cardiomyopathy, and ventricular arrhythmias), early diagnosis and management play an essential role in saving people's lives and improving the prognosis[8,9]. The most important challenges in early management of pandemic diseases are related to two major categories, protocols and supply[10]. Protocols include various factors from the first steps of patient detection and later risk stratification for hospital admission and intensive therapy. Severe manifestations may progress rapidly in the absence of an inclusive data system with online recorded patient information and an effective patient tracking protocol.

The healthcare systems are now meeting the challenges of supply shortages and delays in delivering facilities and medications to health centers. Accordingly, they may encounter an increased mortality rate. Furthermore, patients seeking healthcare due to other health problems are reported to miss the appropriate care because of their fear of entering the hospitals[11]. The delay in management has great influence on prognosis and outcome of the disease for infected patients[12]. Early management and treatment can decrease the rate of severe complications such as cardiac injury, sepsis, shock, acute kidney injury, multiorgan failure, hypercoagulable states, and neurological complication, leading to lower mortality rates and better outcomes for the disease.

The role of computational intelligence in healthcare system management of the COVID-19

First, it is essential to have a complete data collection system in every health center, clinic and hospital, etc. Correspondingly, an online interacting dashboard for data recording, and analyzing with a computational infrastructure seems necessary[13]. Onset dates, demographics, confirmation dates, dates of symptoms onset, symptoms and signs and number of recoveries should be included in the dataset[13]. The data provide the opportunity for planning, modeling and studying different features of the disease[13]. Also, it is a good guide for informing people, policymakers, funders, and governmental organizations[13]. All different features of a new pandemic disease should be assessed to achieve the best way of controlling the spread of the disease, and managing the complications[14].

The rate of virus transfer is usually assessed based on the R0 parameter (basic reproduction number). R0 is a key threshold quantity that is related to viral transmissibility. It is defined as the average number of people who were infected due to contact with a sick person in an entirely exposed population. The values are ranging from <1 to 1. When R0 value exceeds 1, it means that the infected cases rise exponentially which leads to the epidemic. WHO initial estimation on Jan 23, 2020 showed R0 values of 1.4–2.5 for SRAS-CoV-2 while R0 of 3.3–5.5 was reported in the early phase of the outbreak. This value is a little higher than SARS-CoV which showed R0 of 2–5 [15].

With the aforementioned data system, the R0 can be calculated for different areas and health care systems, defining the epidemiologic pattern of the disease spread. In addition, these models with tracking systems provide the opportunity for healthcare system to assess the viral shedding patterns in the society and highlight areas with higher prevalence of the disease[16]. The reliability and accuracy of epidemiological, clinical, and laboratory data early in an epidemic is understood to have a crucial role, helping the public health so as to provide a better deciding strategy[13].

The mathematical models designed by computational intelligence can arm healthcare system with various analysis that are critical in regards to their final decision. These models can sort patients by their physical and laboratory features and comorbidities. Using the computational analyses, most common risk factors, laboratory findings and prognostic factors can be analyzed to achieve comprehensive models beneficial for decision-making in regards to the diagnosis, laboratory findings, and prognosis[17]. Mathematical models appear useful to set diagnostic, management, prognostic, and epidemiologic models to ease the deciding process for healthcare workers and governments about diagnosis, prognosis, management, and control of the disease. According to the findings of recent research studies, age > 65 years, preexisting concurrent conditions such as cardiovascular disease, hypertension, diabetes, chronic respiratory disease, immunodeficiency, cancer, and obesity have appeared to be the most relative Risk factors for severe COVID-19 [18]. The known factors can be used for risk stratification of the patients and deciding about necessary actions.

Major laboratory findings in COVID-19 patients identified by meta-analysis include leukopenia, leukocytosis, decreased albumin levels, increased levels of C- reactive protein, lactate dehydrogenase (LDH), creatinine kinase, and bilirubin, and a high erythrocyte sedimentation rate (ESR)[19]. There are agreements on the strong association between myalgia and the increased levels of creatine kinase and lactate dehydrogenase[18]. These laboratory findings are also helpful in diagnostic and prognostic models in defining the risk of being infected with the virus or developing a severe disease for every patient[20]. The most frequently used prognostic factors include comorbidities, age, sex, lymphocyte count, C reactive protein, body temperature, creatinine, and imaging features[21]. They are helpful in measuring the prognosis of patients and detecting the patients who seek intensive care. Using computational intelligence, the most important factors influencing prognoses, such as gender, age, CRP, creatinine, and comorbidities, can be precisely assessed. Accordingly, the healthcare staff can easily decide whether a patient needs admission to the hospital ward or to the intensive care unit[21].

Respiratory decompensation is the most common complication of COVID-19. Computational intelligence can use the patient information in their records and estimate the risk of respiratory decompensation in patients[22]. So, physicians can use these risk stratification models to decide which patient should be admitted to intensive care unit. In addition, these models can analyze information on admitted patients to compute the threshold of intubation for patients with respiratory failure and at what level the prognosis will be better. Another application is defining the indications for thromboembolic prophylaxis, as thromboembolism is one of the most common complications of infection with COVID-19[23].

For all patients with indications of taking tests, healthcare workers should record their ID number and information, insurance number, credit card number and all other identifying information to make opportunity for healthcare and government to follow the patient's actions during the quarantine period[24].

The final diagnosis of the COVID-19 infection is usually followed by risk stratification into the health center. According to the management models designed by computational intelligence, all patients should be divided in two groups[25]. First, the patients with positive tests and mild symptoms who only seek supportive care at home, and second, patients with positive tests plus severe clinical manifestations who must be admitted. Information about the patients in both groups should be analyzed with computational intelligence as which subgroup they should enter. (Fig.1)

Patients in the first group are categorized into three groups through bioinformatics models, including low risk, moderate risk and high risk of progressing to severe disease. Patients with a low risk of progression to severe condition, such as patients with positive test results and no risk factors, do not need to be followed, health workers can inform them about red flags and ask them to present to hospitals if any of the red flags develop[26]. The second group is the patients with only one risk factor, needed to be followed through the telemedicine system two or three times a week, and ask them about their physical condition, clinical signs, and symptoms, and if their condition had deteriorated or not[27]. High-risk group consists of patients with various risk factors, including old age or chronic diseases. The patients should be assessed every day according to their clinical condition and the essence of admission.

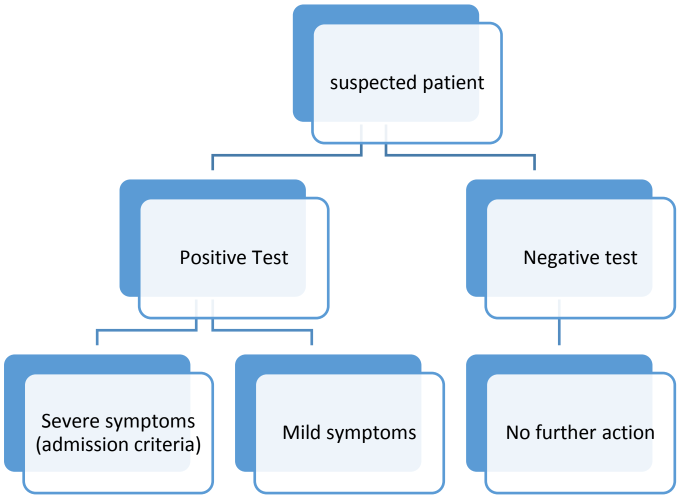

Figure 1. Approach to a patient with suspected history and physical examination of COVID-19.

All three above-mentioned groups of patients with positive tests should be advised to stay at home for 14 days; in addition to avoiding public places, such as markets or offices. Governmental organizations can track patients' quarantine through their data[28]. For instance, the patient uses their credit card, ID card, or insurance in any place during quarantine, government personnel can detect them. Patients with positive tests and clinical manifestations consistent with admission criteria should be assessed at the time of admission, and their information should be recorded in the online tracking system[29]. This system should be online, accessible, and daily updated to provide dynamic follow-up of patients for health workers, especially doctors.

Additionally, we suggest that health workers frequently assess admitted patients and update the tracking system with patients' information on their physical examination, including oxygen saturation, heart rate, and their clinical condition. Also, all machines and facilities should be online to automatically deliver patients data to tracking system. Using this information, health workers can perform computational analysis on them and assess different approaches to different patients and also define a general treatment protocol for healthcare system. The aforementioned data can be applied in the risk stratification system for defining the severity of patient's condition and a general treatment guideline.

These mathematical models can compute risks of complications in patients according to recorded daily data acquired from automatic online machines. For instance, in patients who develop tachycardia with decreased oxygen saturation, assessing pulmonary thromboembolism is indicated[30]. So, this online system can announce healthcare staff, especially doctors to perform diagnostic methods including CT angiography or laboratory tests. These models can be applied for all complications of COVID-19 to be detected early and prevented.

The computational analysis may be useful to assess the overall prognosis of the disease in different hospitals, areas, cities, and states. If poor management is reported in a particular hospital or health center, then healthcare system can be informed and assess the factors deteriorating patients management there. Then, if the deteriorating factor is reversible or removable, the healthcare system can intervene immediately to remove that factor and improve the prognosis[31]. These factors include viral mutation, treatment guidelines, medicine distribution or availability, management and administration of health protocols, etc. For instance, if a new viral strain is detected in an area, which is drug-resistant or more invasive compared to other strains, healthcare system can report the area to governmental organizations and ask for total area quarantine, preventing the spread of that strain[32].

In addition, healthcare providers can perform clinical trial studies on the frequently updated data of patients derived from their health records in tracking systems, to find the most effective treatment protocols or medications on the patient's prognosis and report them to management systems, making decisions about effective protocols for whole country. This inclusive data system provide access to all recorded information of COVID-19 patients to healthcare system with computational analyses and effective feedback to the performance of health organizations and different approaches and protocols[33,34].

The role of computational intelligence in assisting government disease management

If a governmental and managerial system wants to be qualified and prepared to rise to the challenge of encountering a considerably contagious disease like COVID-19, an inclusive, online,and open-access data system is needed from the primary screening to the follow-up of cured patients. This system must be accessible for all health care providing organizations, including governmental and non-governmental ones, to record related data in the tracking system. All information about patients, including identity information, laboratory tests, imaging results, history of contact, and clinical manifestation should be recorded in this system to provide the opportunity of tracking and following patients in the process of disease control and management and preventing the spread of infection.

Governmental and managerial organizations can access the data and use mathematical analysis to assess the condition of different areas in terms of the number of infected patients, the number of positive tests, transmission and commuting, high-risk contacts, admission of infected patients in public places and public transportation using the data registered in tracking system, such as ID numbers, credit card numbers, insurance numbers, etc[6]. Governmental organizations responsible for controlling pandemic disease can have access to patients' transportation and contacts, assess people's commitment to governmental protocols, and quarantine or locked down in the pandemic situation[35]. For instance, if an infected patient is ordered to be quarantined at home for 14 days but uses their credit card in a shopping center or supermarket, governmental organizations can detect this disobedience and consider the patient for governmental punishment due to their inappropriate behavior in society.

Governmental punishments are supposed to be as severe as deprivations from municipal services or cash fines to encourage all citizens to obey health protocols and defined quarantine periods[36]. According to the provided data in the suggested tracking system, the epidemiologic analysis will be possible for governmental organizations to achieve patterns of disease spread, routes of transmission, and society involvement in different geographical areas. These patterns will mark high-risk areas, emphasizing the necessity of investigating causative problems, like inefficient health management, insufficient equipment or medications, inappropriate surveillance on executing health care protocols and locked-down laws.

Detection of aggravating factors followed by removing them is a major step in controlling pandemic diseases. Since all state, city, and health managers have access to disease mappings resulted from computational intelligence, in cases of increased infected patients in an area, it is not necessary to quarantine a whole state or city, instead performing locked-down rules just in the high prevalence area will be sufficient. Therefore, the governmental managers can perform Public health interventions, such as home quarantine after infection, restricting mass gatherings, travel restrictions, and social distancing[1], so economic burden and mobility restrictions will be decreased to the minimum amount together with prevention from disease spread.

Conclusion:

The COVID-19 outbreak is improving the landscape of telemedicine at a swift pace. Well-designed telemedicine services seem to be capable of providing affordable, applicable, and robust epidemiological and clinical data. Therefore, both governmental organizations and health-care systems are seeking the use of telemedicine so as to provide the most effective and rapid management strategies.

In conclusion, it is noted that tele-COVID management has been associated with highly positive outcomes, not only in setting the strategies to limit the spread of COVID-19, but also as regards leading to thorough and convincing management strategies. However, its potentialities are yet to be understood. It is strongly recommended that future research studies should emphasize powerful and innovative telematics approaches and telecommunication.

Review Highlights

What Is Already Known?
As COVID is a newly appeared condition throughout the world, and developed pandemic in a short period of time, there were no chance gathering whole data regarding telemedicine

What Does This Study Add?
According to the assessments done, several policies suggested in the management of COVID patients through telemedicine.

Ethics approval and consent to participate
not applicable

Consent for publication
not applicable

Availability of data and materials
Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Competing interests
The authors declare that they have no competing interests

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Authors' contributions
ES: data collection and manuscript drafting, AS: study design TZ: data collection and manuscript reviewing. RG and MG contributed to the development of the study. All authors read and signed the final paper.

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Conflicts of interest
The authors declare no conflict of interest.

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