Identifying and combating the Covid-19 pandemic using Artificial Intelligence

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Abstract

Introduction: In late 2019, a large number of people across the globe became infected after an outbreak, a pandemic, and an epidemic following COVID-19 spread. To this end, researchers in various fields seek crisis management and solutions to control issues. The new coronavirus's transmission potential has drawn experts' attention to using artificial intelligence to identify and combat this epidemic. The term artificial intelligence (AI) refers to a software that is capable of decision-making in addition to data analysis.

Method: For this review, we searched *artificial intelligence, epidemic, and COVID-19* keywords in PubMed, SID, Scopus, ScienceDirect internet databases, and Google Scholar search engine. After applying inclusion and exclusion criteria to 37 articles, 11 were selected for review.

Result: The studies mentioned the description of artificial intelligence and its application in medicine, coronavirus and its symptoms and mode of transmission, the benefits of using artificial intelligence in the corona pandemic crisis, aid in the rapid diagnosis, treatment monitoring, epidemiology, and tracking infected areas, drug system management, reduction the workload of medical staff, methods for a definitive diagnosis of COVID 19 based on artificial intelligence and laboratory programs with an emphasis on artificial intelligence. Artificial intelligence can assist in rapid diagnosis, monitoring of COVID-19 patients,

developing treatment, facilitating research, prevention, and designing drugs and vaccines. Artificial intelligence-based software uses designed intelligent networks to mimic human thought processes.

Conclusion: Artificial intelligence can recognize patterns beyond defined rules, allowing it to analyze large quantities of information that humans cannot manage. AI-based software provides the possibility of identifying suspected Covid-19 cases with the least amount of contact between medical personnel and patients. Moreover, it monitors the progress of the treatment.

Keywords: Artificial Intelligence, Pandemic, COVID-19, Coronavirus

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Introduction

In late 2019, following the emergence and spread of the new coronavirus (SARS-COV-2) in Wuhan, China, the virus spread rapidly worldwide, resulting in the COVID-19 pandemic. Currently, it has impacted the entire globe. COVID-19 has been causing an increasing number of patients and deaths daily, with few regions in the world escaping its impact. This pandemic is still not under control, requiring the use of the most advanced technologies to manage it (1).

Hospitals and all healthcare services providers have been receiving a large number of suspected cases of COVID-19 infection. One of the problems is the need for more medical personnel, additional facilities, and devices for COVID-19 diagnosis. Also, an increase in the volume of samples, test requests, and personnel fatigue led to various systemic and non-systemic errors in diagnosis and treatment. As the COVID-19 pandemic continues to spread, we need new methods to reduce the workload and increase accuracy in the various stages of this disease (2).

A method for utilizing artificial intelligence for the coronavirus is data analysis, enabling real-time monitoring of the disease's spread. With the experience of epidemic outbreaks and previous pandemic outbreaks, reducing the analysis time is essential, and free and open access to the datasets is necessary in the case of COVID-19, which allows mathematical modeling and artificial intelligence to be combined (3).

We can predict the spread of a virus using computational techniques. In addition, data collected through social networks and other unconventional data may provide insight into the early epidemiological history of the outbreak. Using non-traditional datasets, researchers can better understand the relationship between disease prevalence and community health literacy, healthcare-seeking behaviors, and health resource utilization. Especially in the early stages of the outbreak, real data and data flow can assist in designing and implementing effective public health measures (4,5).

Another use of these techniques is to predict the number of new suspected or confirmed cases of COVID-19. However, a remaining challenge that public health authorities should pay special attention to is the accuracy and validity of the collected data, i.e., their reliability for processing and modeling (6). Training, validation, and continuous learning are three fundamental principles in the healthcare system. A correct and prompt diagnosis is an essential therapy component, and artificial intelligence can reduce errors and shorten diagnosis times (7).

This review study investigates how artificial intelligence can be used to detect and control the COVID-19 pandemic.

Method

This review article has been performed by searching artificial intelligence, epidemic, and COVID-19 keywords, in PubMed, SID, Scopus, and ScienceDirect internet databases as well as google scholar search engine from the end of December 2019 to the end of October 2021. December 30th, 2019, was selected because it coincided with the onset of the COVID-19 epidemic. English-language articles were included in this study. We excluded irrelevant and repetitive articles and those without access to the complete text. From 37 articles, we selected 11 that cited the use of artificial intelligence to identify and prevent the spread of COVID-19.

Result

1. Artificial intelligence

Today, as knowledge fields have expanded and decision-making has become more complex, information systems, especially artificial intelligence systems, are becoming increasingly important in supporting decision-making processes (8). The term artificial intelligence refers to systems capable of displaying intelligent behaviors and reactions similar to those of humans. This includes simulating human reasoning and thought processes, identifying complex situations and responding effectively, learning, acquiring knowledge, and reasoning for solving problems (8–10). As medical knowledge has expanded and decision-making regarding diagnosis and treatment has become more complex (in other words, human life), decision-support systems in medicine have gained attention among experts. Meanwhile, there has been an increase in the use of intelligent systems in medicine (11,12). The impact of various intelligent systems on medicine has been studied nowadays (13–18). Despite their numerous advantages, these systems face various challenges in medicine. Several steps involved in the performance of artificial intelligence-based systems are illustrated in Figure 1. The main advantage is that experts and intelligent systems can control and monitor these systems' performance. Before confirming and documenting the final result, it is also possible to investigate the feedback and operation of the artificial intelligence system under the influence of various factors. The defined control can be reevaluated, and the intelligent system can automatically resolve errors and problems (19).

2. Using intelligent systems in medicine

In artificial intelligence systems, structures, components, and capabilities contribute to enhanced decision-making abilities. Consequently, their use in medicine has been widespread, and we will discuss some of them. Another study used artificial intelligence to diagnose headache types. The evaluation showed that this system could correctly diagnose 94.4% of migraine types (including tension headaches) and 93% of daily headaches. The overall diagnostic accuracy of this system was 89% (20). Furthermore, a study used the systems to diagnose and classify arrhythmic and ischemic heartbeats. The study showed 90.4% accuracy in detecting ischemic beats and 94.4% in diagnosing arrhythmic beats (21).

In another study, artificial intelligence was used to improve the quality of first aid. According to its results, the group using the system performed better in almost all tasks, ranging from 3.8 to 70.1% (22).

In another study, a neural network was employed to diagnose and differentiate types of strabismus. This system is web-based (www.strabnet.com), and the physician can simply enter patient information into the system following an examination. The evaluation of this system has shown that its accuracy is 100% for real data (23).

In another study, artificial intelligence determined and optimized treatment variables for new patients. According to the study results, 96% of the radiation therapy programs recommended by the system were acceptable compared to the treatment performed by the dosimetrist (24).

Artificial intelligence can be used to identify types of cancers, predict survival rates, analyze cancerous tissue biopsy results, and predict recurrence and metastasis in other body organs, allowing better management (25). For example, a study found that artificial intelligence can distinguish benign from malignant breast cancers without a biopsy with 70% accuracy (26).

3. Coronavirus

Coronaviruses are a group of viruses belonging to the *Coronaviridae* family which cause respiratory tract infections in birds and mammals (27). These viruses can cause some types of the common cold to more severe diseases such as SARS, MERS, and COVID-19 (28,29). In the 1960s, coronaviruses were discovered and studied continuously until the mid-1980s (30–32). Coronaviruses have genomes ranging from 26 to 32 kilobases, one of the longest among RNA viruses (33). These viruses occur naturally in humans, mammals, and birds, with millions of human-transmitted coronaviruses detected to date. Their latest strain, the acute respiratory syndrome coronavirus (SARS-CoV-2), emerged in Wuhan, China, in December 2019. After a short period, this coronavirus spread worldwide and became a pandemic (34).

4. Coronavirus infection symptoms

According to the type of coronavirus, the symptoms can be from common cold symptoms such as loss of sense of smell (anosmia) and taste (ageusia) to fever, cough, shortness of breath, bad smell in the nose (phantosmia) and acute respiratory symptoms. Moreover, the patient may cough for several days without apparent cause. The MERS coronavirus, unlike SARS, affects not only the respiratory system but also other vital organs of the body, such as the kidney and liver. In acute cases, there are reports of digestive problems such as diarrhea, respiratory failure, coagulation disorders, and renal failure which may require the patient to undergo hemodialysis (33).

Symptoms of SARS-CoV-2 (the virus that causes COVID-19 disease) infection usually appear a few days after infection. It may, however, take longer for some people to develop symptoms. Based on statistics and research, symptoms can include fever (in 8.43% of cases during admission and in 7.88% of cases during hospitalization), nonproductive cough (in 8.67% of cases), respiratory disorder, fatigue, tiredness, and muscle pain (in 11 to 14 percent of cases), and diarrhea (in 3.8 percent of cases).

There was an average incubation period of four days for symptoms. Ground-glass opacity was seen in 4.56% of chest CT scans. There were 9.17% of patients with non-severe symptoms and 9.2% with severe symptoms who did not show abnormalities on their radiology or CT scans. Lymphocytopenia, or a decrease in circulating lymphocyte number, was observed in 2.83% of people at admission. Infected individuals may not exhibit any symptoms or may experience only mild symptoms. However, this disease can lead to severe problems such as pneumonia, oxygen deprivation, and even death in other people. Individuals who suffer from other underlying health conditions are more likely to experience these symptoms (33).

5. Transmission mode

Coronaviruses transmit in a variety of modes depending upon their type. Occasionally, human-to-human transmission occurs through coughing and sneezing, as in influenza. However, there is little risk of disease transmission in the open space. Cases of human-to-human transmission have occurred when people have been close to the sick person for a considerable time, such as people in contact with patients in hospitals. As of now, it is unclear whether this disease was transmitted directly to humans by animals or by contaminated surfaces (35).

6. Vaccines

Several efforts have been made to produce vaccines to prevent diseases caused by coronaviruses. Several companies from the United States of America, England, Germany, France, China, Japan, Russia, and Iran have developed and are injecting various types of COVID-19 vaccines. Antiviral drugs, such as various antiviral proteases and polymerases, are also being investigated and tested

(36). Also, vaccines are available for different types of animal coronaviruses, including the avian coronavirus, contagious gastroenteritis virus, and canine coronavirus, which are not highly effective. However, these vaccines have been able to minimize the rapid spread of the disease in animals to a certain extent (27,37).

7. Advantages of utilizing artificial intelligence in the COVID-19 epidemy crisis

In general, today, societies are increasingly utilizing and developing artificial intelligence, as in the case of COVID-19. They use artificial intelligence, for example, to estimate mortality, control, identify symptoms and analyze test results. This has increased the speed and accuracy of treating or diagnosing this disease (38,39).

Among the primary purposes are:

1. Rapid diagnosis and treatment: increasing the speed and accuracy of diagnosis makes the decision-making process faster and helps develop the diagnosis and correct management of diseased cases using the timely development of algorithms.

2. Predicting and monitoring the spread of COVID-19 automatically: a neural network can provide solutions, detect the disease's manifestation, and update its status.

3. Follow-up of carriers: can determine the level of infection by identifying clustering and critical points.

4. Planning: Based on the available information, it is possible to determine the nature, risk, and prevalence of the disease. Furthermore, it can predict the number of cases of infection and death in each area and determine the most vulnerable areas.

5. Drug and vaccine designing: Reducing the time required to design and develop drugs and vaccines, as well as finding the best drugs for treating COVID-19 patients.

6. Reducing the number of personnel and the workload of health workers and physicians.

7. Prevention: Information is used to determine the characteristics and causes of outbreaks. Anticipates places where they may be at risk or need medical attention.

8. Providing assistance with a quick diagnosis

With the help of artificial intelligence, there will be a new diagnostic system with integrated management across clinical and paraclinical departments, enabling a definitive diagnosis through the review of algorithms and giving the necessary warning to patients, medical staff, and health centers as soon as possible (40,41). A virus-specific molecular test called RT-PCR is used to diagnose COVID-19. It may take up to two days for the results of this test to be available. Also, false negative results may occur. There is currently a shortage of RT-PCR test kits, which emphasizes the urgent need for alternative methods to diagnose infected patients rapidly.

High-resolution computed tomography (HRCT) is valuable in evaluating patients with suspected SARS-CoV-2 infection. However, a CT scan alone cannot determine the diagnosis of the infection as some patients may have normal radiological findings in the early stages of the disease. Artificial intelligence algorithms have been used to integrate chest CT scan findings with clinical symptoms, the history of disease exposure, and laboratory test results to diagnose patients quickly (42). In 2020, Mei et al. reported in Nature Medicine that among 905 patients tested by the RT-PCR method, of which 419 were reported positive after two repetitions, 279 were diagnosed with COVID-19 by radiologists. Using the artificial intelligence system for the definitive diagnosis of COVID-19 showed an accuracy of 92%, with an average 67% reduction in time. Another essential point was the elimination of false negative results in radiology. The results showed that HRCT, with a comprehensive review of the clinical history by the suggested artificial intelligence system, can assist in rapidly diagnosing COVID-19 patients (41).

9. Treatment monitoring

Artificial intelligence can create an intelligent platform for automatic monitoring and predicting the spread of the COVID-19 pandemic and is an integrated network for extracting the manifestations of this disease, enabling better monitoring and treatment of the affected individuals. This intelligent system can be updated, reporting this mutating virus's latest symptoms and characteristics and providing solutions for the COVID-19 pandemic.

Figure 2 shows an algorithm based on artificial intelligence compared to conventional methods. The most crucial point of this comparison is developing an accurate method for screening suspicious cases by artificial intelligence due to multiple surveillance at different stages (Figure 3). Also, the process is faster with reduced direct contact, less conflict with patients, and the possibility of monitoring after providing treatment through artificial intelligence-based systems. Artificial intelligence will help general practitioners identify the symptoms of COVID-19 with more confidence to refer them to a laboratory (43). Jamshidi et al. have suggested using artificial intelligence to fight the new coronavirus. They introduced the Deep Learning (DL) method that minimizes human intervention. DL can handle large, complex data sets and significantly challenge traditional data analysis methods. DL consists of multiple layers of algorithms that provide different interpretations of input data. However, DL fundamentally differs from ML because it presents data differently in the system due to its use of an artificial neural network (ANN). While algorithms or ML often depend on structured data (44).

Some subtypes of DL include:

Generative Adversarial Networks (GANs) (45),

Extreme Learning Machine (ELM) (46),

Long Short-Term Memory (LSTM) (47).

These bioinformatics systems require specific inputs for each operating system, including different forms of data, such as clinical data and medical imaging, which can be utilized in order to achieve the best outcome (5).

10. Epidemiology and tracking of infected areas

By analyzing the level of contamination in different regions, artificial intelligence can classify and identify critical regions. Also, an artificial intelligence-based application is used to track infected individuals, monitor the traffic of high-risk individuals, and predict the probability of occurrence in different populations (48). Gozes et al. presented a joint project between China and the US to develop automated analysis tools based on artificial intelligence to diagnose, measure and track patients. Their results show that it is possible to distinguish and track COVID-19 patients from non-patients with the help of artificial intelligence. They identified contaminated areas in China, mapped them in 2D and 3D, and then performed structural modification using artificial intelligence and clinical data. Next, they evaluated the movement of 157 confirmed patients with COVID-19 in different regions. In their report, the designed system had a 98% sensitivity, with 92% of patients being monitored. Altogether, they concluded that, due to the spread of infected areas and numerous patients, it is necessary to employ 3D image analysis using artificial intelligence. With this work, patients with COVID-19 can be diagnosed and tracked with high accuracy, speeding up diagnosis and increasing quality (49).

11. Predicting the status of a pandemic

Artificial intelligence can also predict the number of infections and death rates in each region. As a result, identifying the most vulnerable areas, people, and countries, allows treatment and prevention measures to be applied in those areas in order to control the COVID-19 pandemic (50,51). Due to the epidemic's approaching third and fourth waves in many countries and regions, predictive researches are necessary to determine the spread and prevalence of the COVID-19 pandemic.

Zheng et al. presented an AI-based model for predicting COVID-19. They used an artificial intelligence network that combined the natural language processing (NLP) model and long short-term memory (LSTM) network to improve the efficiency of preventive measures and public awareness of prevention. The initial results of this hybrid model showed that COVID-19 patients have a higher level of contamination during the third to eighth days following infection, which was in line with the actual transmission laws of the epidemics. The results of earlier research conducted in this manner on pandemic data in several provinces and cities in China showed that an artificial intelligence-based hybrid model is more effective than the classic models of epidemic analysis, resulting in a significant reduction in prediction errors (1). LSTM networks are distinguished by their learning ability and long-term correlation between inputs and outputs.

12. Pharmaceutical system management

Artificial intelligence aids pharmaceutical research in this field by analyzing the data available in various research centers for COVID-19, thereby facilitating drug development. In the COVID-19 pandemic, the rapid development of new effective drugs is of utmost importance. Artificial intelligence-based systems in pharmacies and referral and research hospitals may be helpful (52). Figure 1 illustrates the use of artificial intelligence and how it relates to developing new drugs. With this technology, it is possible to speed up drug testing and collect results quickly, whereas standard testing usually takes a long time. Therefore, artificial intelligence accelerates this process. The total potential of artificial intelligence has made it a powerful tool for designing diagnostic tests and developing vaccines, as well as being useful for clinical trials during vaccine development (50,53).

13. Reducing the workload of medical personnel

Due to the rapid and extensive increase in patients during the COVID-19 pandemic, healthcare centers have excessive workloads, so artificial intelligence has been used to reduce the workload. This technology enables quick, definitive diagnosis and early treatment using digital approaches and services based on artificial intelligence for correct decision-making. Furthermore, it enables the medical staff to receive the best training and consensus regarding this new disease. Therefore, artificial intelligence can impact patient care and reduce the workload of medical personnel (54,55). In the COVID-19 pandemic, reducing unnecessary tests is one way to reduce hospital staff workload. Recent studies have shown that repeating laboratory tests does not necessarily yield better results.

Cismondi et al. proposed processing and employing artificial intelligence and modeling to predict and distinguish unnecessary laboratory tests from necessary ones. They aimed to process the data and further assign and classify the tests needed to examine patients. The study involved 746 patients in intensive care units. Laboratory tests were classified as necessary or unnecessary with more than 80% accuracy, and sensitivity and specificity were satisfactory for all results. Artificial intelligence reduced laboratory tests by an average of 50%, better than previous similar studies, with an average performance of 37% (56–58). Their overall result showed less repeated testing, improved clinical outcomes, and decreased financial burden, reducing health care providers' physical and mental workload.

14. Prevention

Artificial intelligence allows real-time, up-to-date data analysis to be available, thereby preventing COVID-19. It can predict possible sites of infection, virus outbreaks, and the need for beds and healthcare professionals during this crisis. It can potentially be used to prevent and treat many other diseases. In the future, artificial intelligence will play an essential role in providing predictive and preventative public health care (51,56). There have been unprecedented challenges to the classic control and prevention system. Traditionally, classical methods were used for prevention and control in Wuhan. Shanghai is an international metropolis with a population of 20 million people, equipped with an artificial intelligence analysis platform; Therefore, Wei Zhi population monitoring and analysis technology can be implemented in this city to develop prevention and scientific control strategies. This intelligent technology is evident from the difference in infection and mortality rates between these two cities. A new system for controlling and preventing infectious diseases across the country or even the globe may be possible with artificial intelligence (59).

Regarding definitive diagnosis methods for COVID-19 based on artificial intelligence, having a reliable, sensitive, and specific diagnostic test is particularly important in preventing and controlling infection-related complications. The diagnosis seems to depend on molecular tests or chest HRCTs. These two methods are used to monitor the progression of the disease and changes in severity and response to treatment.

Artificial intelligence can facilitate the diagnosis of COVID-19 cases. Infervision, for instance, provides a rapid diagnosis of COVID-19 cases through medical imaging by recognizing specific lung characteristics. *Blockchain technology* is a unique decentralized system that records and verifies data and performs a series of computations. It is a highly secure technology that can provide services in health centers, including medical diagnostic laboratories, thereby improving public health surveillance.

During the COVID-19 pandemic, treatment and health services have slowed down due to a limited supply of diagnostic kits, low capacity of radiology centers, and a high level of demand. For this reason, healthcare systems in different countries collected information using advanced techniques and computational methods to identify at-risk individuals. Infected individuals can be recognized by a startup (MEGVII) using an advanced facial and body recognition system. It is possible to detect fever in busy and passing environments using infrared and visible light cameras that can serve as thermal scanners to detect fever and high temperatures. Some mobile phone applications are designed to send health reports, record travel histories to high-risk areas, and track contacts with suspected carriers of COVID-19. These programs also provide information regarding the quarantine period.

It is an effective combination of artificial intelligence, information technology, and the healthcare system, enabling alerts to be sent to medical clinics and health units so that they can visit and confirm suspected or confirmed cases (55,60–62).

15. AI-based laboratory programs

Artificial intelligence has many potential applications in public health, disease prediction, and pharmaceutical production. In terms of public health, these methods have been employed in various settings. The settings include

- analyzing real-time data to diagnose diseases,

- developing disease risk models based on mathematical calculations, and
- increasing the efficiency of health systems as a model and comparing them to human behavior modeling (63).

Several promising studies have focused on predicting virus mutations before the emergence of a new strain. A program developed by researchers can detect nucleotide substitutions in a pathogenic virus's primary RNA sequences and predict the pathogenic gene's evolution using a particular technique. An essential use of set theory is processing contradictory and incorrect information, especially in artificial intelligence applications. The prototypes are produced using the RNA sequence obtained from one virus generation as input and an output of the RNA sequence from the next virus generation. An algorithm was developed to predict RNA sequences from successive generations, and then the predicted sequences were compared with the observed sequences. This group of algorithms in the virus data set can also be applied to predict the pathogenicity conditions of the new coronavirus. South Korea and China have reported about 70% accuracy in predicting mutated nucleotides (64–66).

Following identifying a virus strain with predicted or occurring mutations, the next step is determining viral proteins that can predict pathogenic effects.

As a breakthrough in structural biology, bioinformatics scientists at Deep Mind, a British artificial intelligence research laboratory, have developed a new method for predicting protein structures using artificial intelligence (67). This program uses a neural network to predict the distance between protein residues, which may have a significant impact depending on the prediction's accuracy. After applying an optimized algorithm, it allows for the computation of the protein structure. Such structural prediction can lead to broader access to structural information compared with older methods and can be particularly useful in the absence of experimentally determined homologous protein structures.

As a result of determining the structure of a protein, its function can be identified, providing evidence for the structural and functional relationship between proteins. Drug development is the next important task following determining viral structures and their functions. Discovering new drugs is expensive and time-consuming. In the COVID-19 crisis, time is of greater significance, yet AI can improve efficiency and productivity through intelligent networks. Artificial intelligence will revolutionize the pharmaceutical process cycle from regulatory procedures to pharmaceutical manufacturing (68,69).

Conclusion

Artificial intelligence can assist in rapid diagnosis, monitoring of COVID-19 patients, developing treatment, facilitating research, prevention, and designing drugs and vaccines. Artificial intelligence-based software uses intelligent networks designed to mimic the thinking process of humans. Artificial intelligence can recognize patterns beyond defined rules, allowing it to analyze large quantities of information that humans cannot manage. Therefore, diagnostic informatics technology will enhance and significantly improve current technological capabilities. For example, we may refer to the simplification of laboratory operations, clinical analysis, the reduction of unnecessary tests, the reduction of medical personnel, the prediction of contaminated areas for preventive measures, and the facilitation of decision-making. All these advantages and capabilities will solve a significant part of the problems caused by the COVID-19 pandemic for hospitals and healthcare service providers. Artificial intelligence-based systems make it possible to identify suspected cases of COVID-19 with minimal contact between medical personnel and patients and to monitor treatment progress. It is essential to consider the high potential of AI-based systems for monitoring COVID-19 patients throughout all stages of treatment and care following the diagnosis of the infection.

While artificial intelligence systems have many advantages, several serious obstacles and challenges are associated with their application in medicine. A few of these limitations include technology and cost limitations. Moreover, their performance requires constant updating. Some believe relying on intelligent systems may reduce innovation in the long run. Also, these systems require entering the patient's data into the system to receive diagnostic or treatment recommendations. As a result, the doctor must enter the patient's information once in this system and again in the patient's medical records (manually or electronically). This repetition of entering information can be an obstacle to using these systems; unless the patient's data is available electronically in the patient's medical record enabling the use of the systems in conjunction with it.

Author contributions

All authors are equally involved in the preparation of this manuscript and endorse the manuscript.

Conflict of interests

None declared

Ethical declarations

I now declare all ethical standards have been respected in the preparation of the submitted article.

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Figure

Figure 1. Artificial intelligence and its applications in the development of new pharmaceuticals.

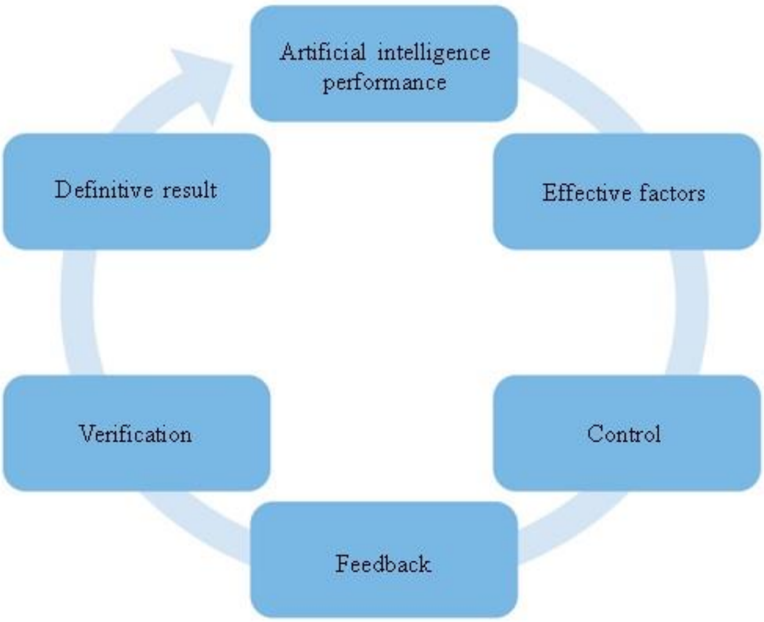

Figure 2. Artificial intelligence applications compared to conventional methods.

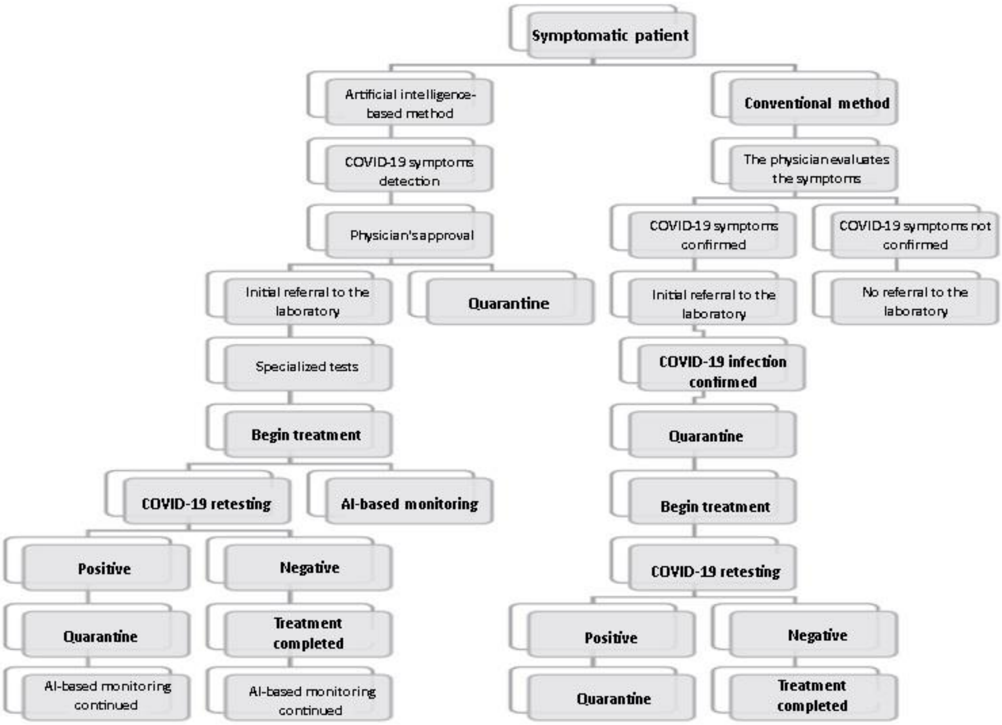

Figure 3. multiple surveillance at different stages by artificial intelligence.