

Artificial Intelligence and technology in COVID Era: A narrative review

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Abstract

Application of artificial intelligence (AI) in the medical field during the coronavirus disease 2019 (COVID-19) era is being explored further due to its beneficial aspects such as self-reported data analysis, X-ray interpretation, computed tomography (CT) image recognition, and patient management. This narrative review article included published articles from MEDLINE/PubMed, Google Scholar and National Informatics Center egov mobile apps. The database was searched for “Artificial intelligence” and “COVID-19” and “respiratory care unit” written in the English language during a period of one year 2019-2020. The relevance of AI for patients is in hands of people with digital health tools, Aarogya setu app and Smartphone technology. AI shows about 95% accuracy in detecting COVID-19-specific chest findings. Robots with AI are being used for patient assessment and drug delivery to patients to avoid the spread of infection. The pandemic outbreak has replaced the classroom method of teaching with the online execution of teaching practices and simulators. AI algorithms have been used to develop major organ tissue characterization and intelligent pain management techniques for patients. The Blue-dot AI-based algorithm helps in providing early warning signs. The AI model automatically identifies a patient in respiratory distress based on face detection, face recognition, facial action unit detection, expression recognition, posture, extremity movement analysis, visitation frequency detection sound pressure, and light level detection. There is now no looking back as AI and machine learning are to stay in the field of training, teaching, patient care, and research in the future.

Keywords: Artificial Intelligence, clinical research, COVID-19, diagnosis, disease management, teaching

Introduction

Artificial intelligence (AI) is an emerging field, which means that a machine will show abstract thinking and cognitive behavior resembling human intelligence. AI includes machine learning (ML) and artificial neural networks. Application of AI is flourishing in the medical field in the coronavirus disease 2019 (COVID-19) era due to its beneficial aspects such as self-reported data analysis, X-ray interpretation, computed tomography (CT) image recognition, language processing, and managing drug infusions.^[1] The accuracy observed from machine learning technology (97.25%) is on par with

humans (97.53%). ML helps in solving complex relationships with better judgment.^[2]

The COVID-19 pandemic is caused by the novel coronavirus (SARS-CoV-2). SARS-CoV-2 is structurally similar to SARS-CoV-1, which damages the ciliated bronchial epithelium and type-II pneumocytes via angiotensin-converting enzyme (ACE)-II receptors. This leads to the rapid spread and causes serious infections posing a continuous human threat. This is particularly true when there are no drugs or vaccines against COVID-19 infection to date.^[3] The mode of infection is through droplets and aerosol. The viral particles get attached to droplets and aerosol within a close

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range. Hence, it is important to promote social distancing and maintain a “no-touch” emergency state in the health care setup. The incidence and case-fatality rates are higher among patients with diabetes mellitus, hypertension, elderly age (above 60 years), and high body mass index (BMI).^[4] The major concern among the health care workers is to safely manage the patients and to break the chain of infection to “flatten the curve.” Social distancing is one of the modes for the prevention of the spread of infection.^[4] Lack of regular follow up and the need for continuity of medical assessment has laid a greater emphasis on the need for digital health application in the present scenario.^[5]

This narrative review article will assess the available newer technologies in AI in tracking COVID-19 infection, screening programs, and predicting the mortality rate based on previous data reports of the patients globally and in India [Figure 1]. Apart from early detection and treatment, neural networks can analyze the visual features of the disease. The comparison of the AI-based and non-AI-based approach of identification of the disease has been done.^[6] During the writing of this narrative review, literature search was carried out on October 24, 2020 in electronic database: MEDLINE/PubMed and Google Scholar. The database was searched for “Artificial intelligence” and “COVID-19” and “respiratory care unit” written in English language during a period of one year 2019-2020 for observational studies, randomized controlled trials, and review articles. The search retrieved 16 articles from PubMed, 16 articles from Google Scholar, and Arogya setu app form National Informatics Center egov mobile apps. Database was also searched for “Artificial intelligence” and “COVID-19” and “student training” written in the English language during a period of one year 2019-2020, and nine studies were retrieved. The studies retrieved were

checked, deeply studied, duplicates were removed, and key information was included from cross-references. The eligible studies were included if they broadly described the role of artificial intelligence in COVID-19 management for health care, respiratory care management in COVID-19 patients, and student teaching. Finally, 31 articles were selected for writing the narrative review. The review was broadly written in the following subheads: digital health tool and AI for COVID-19 patients, AI in early diagnostics of COVID-19, AI in teaching and training in anesthesia, and AI in COVID-19 patient management and vaccine.

A. The relevance of digital health tool and AI for COVID-19 patients

COVID-19 digital health innovation policy has been put forth to deploy health car while maintaining social distancing.

- a. **Digital health tools:** Several digital health tools such as the Internet of Things (IoT), biosensors, and AI have been launched currently.^[4] The provision of telehealth services can be either in the form of care provider-patient interaction alone or a public online platform. Such services help health care providers to focus on warning signs and indications of whether the patient needs inpatient care.^[7] The introduction of telemedicine and remote patient monitoring (RPM) is useful in patient surveillance and monitoring of vitals. This eventually helps in curtailing the risk of direct exposure to the patients and will help in preserving personal protective care equipment (PPE) in stock.^[5] The conversational form of AI includes a chatbot, which has multiple benefits. This helps in triaging the patients based on the symptom tracker. Another benefit is that it also promotes self-management of chronic

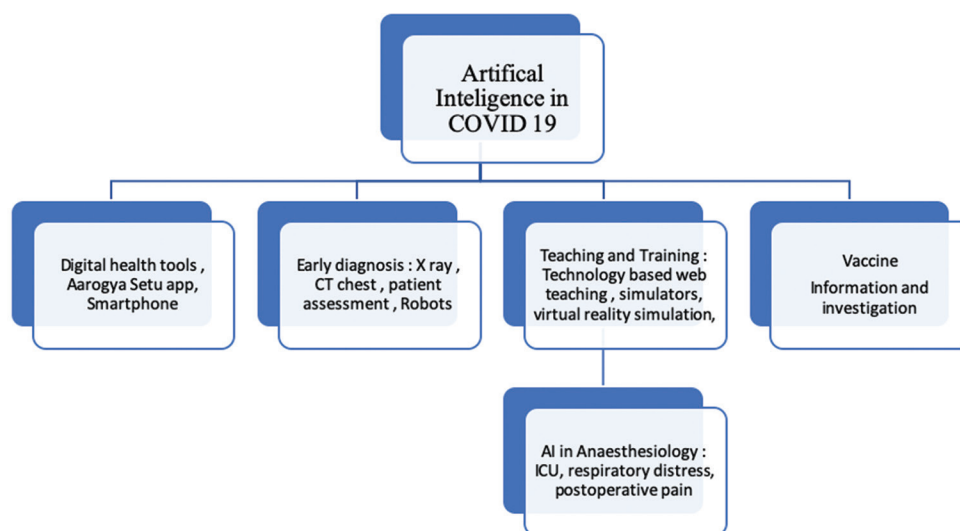


Figure 1: Flow chart showing artificial intelligence and its application during COVID pandemic in the medical management of patients

pain (SELMA) in patients.^[6] The major advantage of AI and telemedicine is that patients can be given care remotely and the same care standards may be possible throughout our country where there is a big disparity.

- b. **Aarogya setu app:** India has launched this app on 2nd April 2020. The Aarogya setu app for contact tracing. This app records details of all the people that we have come in contact with and we will be immediately informed if anyone out of them turns out to be COVID-19 positive. Special surveillance and data collection can be carried out within a range of 500 meters, 1 kilometer, 5 kilometers, and 10 kilometers.^[8]
- c. **Smartphone technology:** The use of mobile and smartphones for health care services is referred to as mobile health or mHealth. The advantage of mHealth via smartphone is the provision of several features such as video, camera, information at the tips of fingers. Smartphone technology (SMT) enables health care essential services without a person-to-person interaction. Communication can be carried out through different modes in the form of video, audio, or text messages. With the introduction of 5G SMT, the ultrahigh definition helps in a virtual face to face clinic. AI with 5G SMT phones helps in tracking symptoms, early detection of warning signs and symptoms, early diagnosis, prognosis, and cure as well as controlling the social spread of infections. Another application of SMT is the installation of Virtual Fracture Clinics (VFCs). This helps in the treatment and monitoring of patients with musculoskeletal injuries. Apart from physical health care, group counseling programs can be carried out via web-based applications such as ZOOM, Facetime, or Skype to provide mental support and care.^[9]
- d. **The use of the smart quarantine station AI trilogy** has been described by a referral medical center and teaching hospital in Taiwan. This diverted patients from the crowded emergency department to quarantine tents. The quarantine tents were equipped with medical staff members estimated to examine 35–50 quarantine patients per day. The staff had access to electronic medical records, AI radionics of chest X-ray analysis with early AI models for diagnosis of pneumonia patches, and clinical decision-making guidelines for updating records of patients daily. This allowed the facilitation of isolating patients with high-risk features with COVID-19, avoid cross-infection, reduce the burden and contact of team members including physicians, nurses, and technicians with patients.^[10]

B. AI in early diagnostics of COVID-19

It has been noted that 2%–8% of people infected with COVID-19 land up into fatal pneumonia. A rapid

transmission rate has been observed due to a shortage of protective equipment, misinformation, and varying accessibility to point-of-care testing such as reverse transcription polymerase chain reaction (RT-PCR) techniques. RT-PCR tests are rapid and easily available, but there is increasing evidence of false negative reports and sensitivity as low as 60%–70%.

- a. **AI in radiology:** AI has penetrated the field of radiology and several studies have been published regarding diagnostic imaging test and COVID-19. In a retrospective single-center study conducted in Italian patients; AI was compared with the radiological assessment of lung edema calculated by two experienced radiologists. The death and critical COVID-19 admission to the intensive care unit were the outcome measures. The authors found that an AI-based score of ≥ 30 on initial chest X ray was an independent and comparable predictor of adverse outcomes for mortality and critical COVID-19 patients.^[11] The Italian Society of Medical Research considers and supports the use of AI as a predictive and prognostic decision support system and not as a first-line test to diagnose COVID-19.^[12] The definitive pattern of CT chest showing ground-glass opacities progressing to consolidations are signs of deterioration in critically ill patients. AI-based diagnosis shows about 90.8% accuracy, 84% sensitivity, and 93% specificity in detecting COVID-19 pneumonia. AI helps in supporting clinicians in assessing the severity and progression of the disease. Harmon *et al.* studied a diverse cohort of 1,280 patients and compared the specificity of AI-based CT reports over RT-PCR and found that deep learning-based AI algorithms can readily identify COVID-19 pneumonia from the non-COVID lung.^[13] Despite the widespread adoption of AI in clinical practice, the major concern remains the lack of an open database to train AI models to professionals with limited expertise in AI. Online auto-machine learning platforms may help in training medical professionals for image recognition by uploading the examined database and performing some basic settings. This will revolutionize the fight against this new pandemic COVID-19 by allowing early detection and patient care.^[14] Ardakani *et al.* evaluated 1,020 CT slices from 108 patients with laboratory-proven COVID-19 using AI bases technique. The authors used 10 well-known neural networks AlexNet, VGG-16, VGG-19, SqueezeNet, GoogleNet, MobileNet-V2, ResNet-18, ResNet-50, ResNet-101, and Xception. The performance of the radiologist was moderate, and ResNet-101 and Xception showed superior sensitivity and specificity radiologically to characterize and can be used as an adjunct method to diagnose COVID-19 infections in radiology departments.^[15] Recently, in

another model development trail FCONet, a simple 2D deep learning frame work based on ResNet-50 was mentioned as the best model (sensitivity 99.58%, specificity 100.00%, and accuracy 99.87%) that outperformed VGG16, Xception, and Inception-v3 for diagnosing COVID-19 pneumonia in CT images and differentiating from non-COVID-19 pneumonia and nonpneumonia diseases. Further information on the detail of these model systems is beyond the scope of this narrative review.^[16]

- b. **Several imaging system studies** on COVID-19 patients have been performed to explore the extent of major organ tissue characterization including heart, brain, lungs, and liver using machine learning (ML) and deep learning modalities of AI in a review article. The authors have described ML architecture for stroke risk stratification, vessel characterization for cardiovascular disease, AI used for chest CT and liver disease classification, AI-based plaque tissue characterization and risk stratification for cardiac death, DL-based system for tissue characterization and classification of COVID-19 severity with patients with comorbidities. These methods have been proposed to speed up assessments and diagnosis of COVID-19 causes, health hazards in patients with comorbidities, and risk stratification.^[17]

C. AI in teaching and training in Anesthesia

The pandemic outbreak has replaced the classroom method of teaching with the online execution of teaching practices. Even though the real patient contact is restricted, students need to develop their clinical knowledge without any interruption. In a recently published scoping view, the authors mentioned the suboptimal state of e-health training of medical students and stressed clinical environments and innovative approach in health care for training.^[18] Hence, smart technologies are reliable to cultivate skills and knowledge.

- a. **Technology-based learning** includes audio recordings, video tutorials with online chatting, and mannequin simulators. This is possible with the help of online teaching apps such as Google meet, Zoom, Cisco Webex, Massive Open Online Course, National Digital Library of India (NDLI), etc. The NDLI is developed by the Indian Institute of Technology, Kharagpur. The library was made accessible in June 2018. The ministry of education has provided funding for the development of NDLI, which is a platform for learning resources available in almost all languages in India. The repository content includes e-books, lectures, articles, journals, thesis, videos, and simulation materials. This is made available in all fields and is free of cost.^[19]

Zhou *et al.* conducted a study during the pandemic outbreak on 60 trainee nurses. The study was done to analyze the effectiveness of the massive online open classes (MOOC) micro-video method of distant teaching. This was compared with the conventional mode of teaching. It was observed that the overall satisfaction of both teaching faculties and students was higher among the MOOC group.^[20] Virtual patients are used for developing clinical examination skills, procedural learning, and cultivating communication skills while dealing with real patients.^[21]

- b. **Virtual-reality simulators** are used for developing skills related to examination, surgery, and resuscitation. India being a developing country has many constraints; hence, it is important to inculcate a positive attitude amongst both students and medical educators. Medical students can educate their peers, patients, and community through self-made videos. They can propagate information regarding proper donning and doffing steps, proper mask fitting, and hand wash steps. Technology-based learning needs to be developed and executed at its earliest. This has become an integral part of our education system.^[21]
- c. **Simulators:** The role of simulators is gaining importance during the health crisis of the pandemic outbreak. This is acting as a supplementary learning tool for imparting clinical skills. As demands are exceeding the availability of resources, simulation focuses on carrying out a procedure effectively. Hence, resources can be used adequately along with the provision of the best patient care. Singh *et al.* have reviewed an article based on simulators in anesthesiology. The simulators can be device-based, patient-based, or environment-based. Simulator-based training can be for several skills such as chest compression, central venous cannulation, endotracheal intubation, tracheostomy, cricothyrotomy, etc. Studies have shown that residents who have undergone the simulation-based training program of 6 weeks duration showed much better skills when compared to those with conventional residency. Anesthesiologists well versed with video technology finds it easier to handle video laryngoscopy procedures. Proper hand-eye coordination is obtained with such simulation-based training programs. Another perspective of AI-based simulation training can be applied for evaluating newer equipment before launching into the market for its safety.^[22]
- d. **The proposal of e-patients** in medical education, changing demands, and opportunities will be required in medical education. The teaching guides will equip medical teachers and students with necessary background information, also assist teachers so that students can become health practitioners to deal with problems and potential of the e-patient.^[23]

- D. AI in COVID-19 patient management** includes perioperative care, intensive care, pain management, drug delivery, and monitoring. The learning algorithm used in AI is mainly of three types: supervised learning, unsupervised learning, and reinforcement learning.^[24]
- a. Poncette *et al.* conducted a study on AI-based vitals monitoring in Intensive Care Unit (ICU) patients. A survey was conducted on ICU staff and physicians using a questionnaire. AI in ICUs used intelligent remote alarm systems. This helps in early detection and management. AI also provides guidelines for diagnosis and treatment. For appropriate utilization of this intelligent system, the staff and physicians require adequate training. Remote patient monitoring requires AI-based mobile phones and smartwatches. The introduction of a clinical decision support system (CDSS)-based AI helps in more precision medicine. This helped in reducing the frequency of false alarms, improving the digital literacy in ICU staff, and using wireless sensors.^[25]
Hollander *et al.* have discussed the use of electronic ICU (eICU) during the pandemic. This technology helps in the provision of critical care services to sicker patients. This is beneficial to multiple health care centers.^[26]
 - b. Rahmatizadeh *et al.* studied the development of an AI model for ICU patients. They have developed a three-stage model of AI in critically-ill patients. This model was developed to ensure improvement in the management of ICU patients. This included the input, process, and output analysis. Apart from risk stratification and management, AI also helps in the prediction of laboratory assessment, thereby reducing the need for daily invasive laboratory testing and is cost-effective.^[27]
 - c. Israel has developed a patient assessment AI device for patient follow up every day. AI-based technology developed in Israel was handed over to the All India Institute of Medical Science. These videos and voice-based robotic systems helped in the continuous monitoring of the patient's vitals. This robotic technology also ensures disinfection using a disinfectant called CPD, which provides 12-h disinfection. It also included remote-based noninvasive patient monitoring, which aids in screening patient's respiration.^[28]
 - d. Robots with AI are being used for patient assessment and drug delivery to patients. The main intention is to avoid the spread of infection. Several medical institutions in Jaipur and Kerala are running trials on developing humanoid robots. This technology can be used to deliver food, drugs, and timely temperature, and random blood sugar (RBS) monitoring. This helps in minimizing the interaction between health care workers and patients. The duration of disinfection can be reduced with the introduction of UV-based disinfection by robots. Apart from this, to make patients socially engaged, AI-based social robots are used for interacting with them.^[29]
 - e. Patient monitoring system with video imaging-based high-speed medical monitoring system can be used for COVID-19 patients to gather information regarding vital signs, condition severity, existing comorbidities, and patient discharge. These monitoring systems have been investigated with promising results.^[30]
 - f. Incorporation of a clinical decision support system (CDSS) in the intensive care unit (ICU) can enhance patient monitoring by nurses and doctors. The proposed methods for training ICU staff in digital literacy may help in the reduction of false alarms, the introduction of wireless sensors, and the use of CDSS based on AI. The role of AI in this aspect needs to be explored for future ICUs.^[25]
 - g. A deep learning Survival Cox model to triage COVID-19 patients was developed by Liang *et al.* for early triage of critically ill COVID-19 patients. The online calculation tool predicts severe illness ensuring that patients at greatest risk receive appropriate care as early as possible and allow for effective allocation of health resources. The variables were X-ray abnormalities, age, dyspnea, chronic obstructive pulmonary disease, number of comorbidities, cancer history, neutrophil/lymphocytes ratio, lactate dehydrogenase, direct bilirubin, and creatine kinase. The prediction performance of area under the receiver-operator characteristic curve (a measurement for classification problem) and C-index (a standard performance metric for survival analysis) were 0.960 and 0.935, respectively. However, the model needs to be implemented in other countries for usefulness.^[31]
 - h. Postoperative pain management is one of the major concerns for physicians, especially anesthesiologists. AI algorithms have been used to develop intelligent pain management techniques for patients. A Cochrane systematic review suggested the effectiveness of wireless-based intelligent Patient Controlled Analgesia (wi-PCA). The wi-PCA is connected to the central computer server. The study shows that the incidence of pain at rest and movement (NRS ≤ 4) was significantly lower when compared to that of those with traditional PCA pumps. This wi-PCA helps in reducing moderate-severe pain and hence promotes cost-effective treatment with patient satisfaction.^[32]
 - i. The Blue-dot algorithm (AI-based) helps in providing early warning signs. Similarly, an AI-based diagnostic tool for blood sampling developed in Wuhan shows 90% accuracy in the survival rate of covid-19 patients. The above few examples are quoted to highlight the role of AI in the present scenario.^[33] Apart from risk stratification,

- diagnosis, and management, AI is equally effective in surveillance, contact tracing, and pandemic planning.^[34]
- j. The AI model automatically identifies a patient in respiratory distress based on face detection, face recognition, facial action unit detection, expression recognition, posture, extremity movement analysis, sound pressure level detection, light level detection, and visitation frequency detection.^[35] The use of AI-based decision-making system can double the effective critical decision making, especially in COVID-19 patients.
- k. AI-based platforms have been developed for the treatment of global pandemic COVID-19. A unique AI platform is “IDentif. AI” (identifying infectious disease combination therapy with AI) to integrate the knowledge of different drugs with different dosage on one platform to pinpoint regimens and interventions.^[36]
- E. **Vaccine:** The latest challenge in a pandemic is to produce the COVID-19 vaccine and its safety trial. The latest being vaccine investigation and online information network, (VIOLIN) which relies on AI, database, and in silico tools. The Vaxign reverse vaccinology tool integrates ML with proposed candidates. This AI model follows vaccine investigation and online information.^[37-39] Currently, India is conducting trials on the COVID vaccine and there have been no serious adverse events in the first few days of vaccine dosing during Phase 1 trials in healthy volunteers. The phase 2 trial of recruitment of volunteers is currently being conducted. It would be interesting to observe how AI may play a role in COVID-19 vaccination in the future.

Limitations

The COVID-19 pandemic has globally increased the need for health care workers and hence this led to the extrapolation of various applications of AI in the medical field. But as a two-sided coin, AI has its own limitations which include its lack of explaining ability, accuracy, and privacy-related aspects. The data processed by AI using multiple network models are not proving their reliability. Another major concern regarding the AI models are privacy-related risks. People share their personal data including location and banking history, which is a matter of fact that is questionable by the consumers.

Another important concern regarding AI models is that the resultant data generated is based on the inputs provided by the specialists. During an evolving pandemic crisis, the input data saved to the AI models keep on varying; hence, this is posing a challenge to process these inconsistent data and generate a reliable output.^[40]

Last but not the least, the launching of medical simulators will be effective in providing essential training for the trainees and it has been proved beneficial. But it is quite expensive to implement these modalities of AI system with the available infrastructure facilities. Even though these systems are not affordable, it is important to note that the cost of developing such medical simulators will be on par with its price. Hence, we need to compare the cost-benefit ratio while deciding the implementation of such technology.^[41]

COVID-19 has come like a storm and initially, AI was not updated to tackle the situation. Also considering that the guidelines are changing every minute regarding every domain of COVID-19 the possibility of a fast update on the same is challenging. We need to adapt continuously to changing management perspectives to be able to ensure care based on recent evidence. This is a challenge with AI, especially in managing the pandemic situation and should be mentioned as a major limitation.

Conclusion

With AI-based technological advancement, overburdened frontline health workers, and digital technology there is now no looking back as AI and ML are here to stay even in low resource countries. In the future, we can expect that AI will play a major role in training, teaching, patient care, and research.

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Conflicts of interest

There are no conflicts of interest.

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