An intelligent framework using disruptive technologies for COVID-19 analysis

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ABSTRACT

This paper describes a framework using disruptive technologies for COVID-19 analysis. Disruptive technologies include high-tech and emerging technologies such as AI, industry 4.0, IoT, Internet of Medical Things (IoMT), big data, virtual reality (VR), Drone technology, and Autonomous Robots, 5 G, and blockchain to offer digital transformation, research and development and service delivery. Disruptive technologies are essential for Industry 4.0 development, which can be applied to many disciplines. In this paper, we present a framework that uses disruptive technologies for COVID-19 analysis. The proposed framework restricts the spread of COVID-19 outbreaks, ensures the safety of the healthcare teams and maintains patients' physical and psychological healthcare conditions. The framework is designed to deal with the severe shortage of PPE for the medical team, reduce the massive pressure on hospitals, and track recovered patients to treat COVID-19 patients with plasma. The study provides oversight for governments on how to adopt technologies to reduce the impact of unprecedented outbreaks for COVID-19. Our work illustrates an empirical case study on the analysis of real COVID-19 patients and shows the importance of the proposed intelligent framework to limit the current outbreaks for COVID-19. The aim is to help the healthcare team make rapid decisions to treat COVID-19 patients in hospitals, home quarantine, or identifying and treating patients with typical cold or flu.

1. Introduction

The coronavirus disease (COVID-19) is denoted to a severe acute respiratory syndrome coronavirus 2 SARS-CoV-2. It was reported in Wuhan, China, in December 2019 with unexplained phenomena for cases (Wang et al., 2020a; Bai et al., 2020). The COVID-19 has been widespread for 213 countries worldwide, with a total of 41,908,988 confirmed cases, 1141,130 deaths and 31,100,678 recovered on 22 October 2020 (coronavirus, 2020). Unlike Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS), COVID-19 can be transmitted rapidly through contact human and infected surfaces (Mallapaty, 2020). Additionally, COVID-19 is very dangerous for patients with weak immune systems, the elderly, chronic disease (Tuli et al., 2020). The governments globally realized to take immediate procedures in many vital aspects to govern the crisis of COVID-19 outbreaks (Martin et al., 2020; Gharehgozli et al., 2020). The WHO assigns guidelines for COVID-19 cases include confirmed cases,

probable cases, suspect cases, and contract cases. The confirmed cases are people with lab affirmation to the COVID-19 epidemic regardless of clinical signs and syndrome. The possible examples are suspect cases for whom testing for the COVID-19 virus is indecisive or whose trial could not be operated for any causes. The suspect cases are patients with an acute respiratory illness who are in contact with confirmed or probable COVID-19 cases in the last 14 days before symptom onset.

Every country in the world is under the threat of infection with COVID-19, especially the healthcare team and their families. There is no reassuring procedure evidence for any improvement in the next day (Jason et al., 2020). Due to the urgent need to analyze COVID-19, disruptive technologies are required to provide efficient, effective and low-cost analysis. These key technologies include artificial intelligence (AI), industry 4.0, Internet of Things (IoT), Internet of Medical Things (IoMT), big data, virtual reality (VR), Drone technology and Autonomous Robots, 5 G, and blockchain to achieve specific goals. In order to answer the questions on what are disruptive technologies and how they

can be used, Table 1 presents the effective disruptive technologies that can be applied to limit the COVID-19 outbreaks based on literature (Lasi et al., 2014; Koro, 2015; Alladia et al., 2019 a; 2019 b; S Chen et al., 2020; Chamola et al., 2020; Javaid et al., 2019; 2020; Nabeeh et al., 2019a; R.P.. Singh et al., 2020) and our analysis. Additionally, the following disruptive technologies can be used jointly to meet the criteria for having an intelligent framework used in COVID-19 analysis.

Hence, the use of disruptive technologies reduces the burden of the healthcare team in the COVID-19 pandemic. The use of smart technologies can observe the patients affected by COVID-19. The public healthcare organizations recommend the vital role for disruptive technologies to public health for COVID-19.

The rest of this study is structured as follows. Section 2 presents the related work with the current COVID-19 review and motivation of our work. Section 3 describes our intelligent framework using disruptive technologies in detail for COVID-19 analysis. Section 4 illustrates an empirical case study to show the importance of the proposed intelligent framework. Section 5 explains the results and how disruptive technologies and methods offer better COVID-19 analysis. Section 6 presents two topics for discussion. Section 7 sums up the conclusion and future work.

2. Related work

This section presents the related work for the current COVID-19 status and the framework using disruptive technologies for COVID-19 analysis.

2.1. The current COVID-19 status

The best practice approaches are suitable for many disciplines, particularly for health, since they can reduce risk and improve efficiency (Melnyk and Fineout-Overholt, 2011). The medical best approach provides a brief review for COVID-19 about the way of transmission, clinical presentation, Laboratory Diagnosis, Radiological findings, Categories and Management, and preventative measures presented in Fig.1 with details as follows:

I. Transmission

There are several studies on the pathophysiological properties and the propagation mechanism for COVID-19 (Chamola et al., 2020). Initially, COVID-19 infected people interacted directly with infected animals. Nowadays, rapidly the outbreaks of COVID-19 are transmitted directly from human to human. The transmission mechanisms between human to human are classified as follows.

a. Respiratory transmission

The SARS-CoV-2 is a respiratory virus that is mainly transmitted across the respiratory droplets. The CDC advises people to maintain at least a 6-foot distance between people. Since at least 25% of people may be asymptomatic at a time (CDC, 2020).

b. Aerosol transmission

The SARS-CoV-2 remains viable in aerosols for three hours, according to the experiment (MD, 2020). Los Angeles Times reported that 45 people became infected with COVID-19 and at least two people died with the aerosol transmission (MD, 2020).

c. Contact transmission

The contact transition occurs when the viral particles are emitted from the respiratory tract from an infected person on the surface. Consequently, another person touches the surface, and the personal touch nose, mouth, or eye. According to Wang et al. (2020a) and Read (2020), COVID-19 is more stable on plastic than copper and cardboard.

Table 1
The disruptive technologies used to limit the COVID-19 outbreaks.

Technologies	Explanations	Benefits
1. Artificial Intelligence (AI)	AI is a powerful tool and technique that makes computers to learn and think. AI can make predictions of patterns.	The AI can be used to predict the outbreak for COVID-19. The AI has analysis models to test the validity of the statistical data about COVID-19, consequently remove unwanted data. The AI develops robots to burden from the healthcare team some duties to perform the medical examination of patients.
2. Industry 4.0	Industry 4.0 augments industry advancements based on the focus on environmental conditions and the development of related technologies (Lasi et al., 2014). Industry 4.0 relied on the technology of IoT that provides organizations with resilient services. (Abdel-Basset et al., 2019)	Industry 4.0 developed many applications for the sake of solving healthcare problems. Industry 4.0 can analyze the patients' real data with various technological methods to increase the accuracy of the rapid and accurate diagnosis and treatment (Javaid et al., 2019). Industry 4.0 can be useful in following up on the first vital signs for COVID-19 hospitalized patients or home quarantine patients.
3. Internet of Things (IoT)	The connection between objects over a specific network without human intervene. People could access the needed content remotely from anywhere to attain the proper medical service (Nabeeh et al., 2019a). The IoT, an essential part of the revolution of Industry 4.0, is the connection between services and semantics via wireless protocols (Koro, 2015) .	IoT is a useful technology to prevent COVID-19 outbreaks. The sensors can make a periodic follow up for hospitalized patients or home quarantine patients (Ting et al., 2020). IoT can ensure that the healthcare team is taking the PEE right conditions. The IoT can be used to trace the contact people with COVID-19 patients.
4. Internet of Medical Things (IoMT)	IoMT is a contemporary mean for connecting the medical sensor devices and the associated applications with healthcare technology systems via networks connectivity (R.P.. Singh et al., 2020)	The IoMT takes the medical team's burden to perform data sharing, monitor patient reports, track patients and contact, gather vital signs, etc. (R.P.. Singh et al., 2020). The use of IoMT can enhance the physical and psychological healthcare of hospitalized patients or home quarantine patients due to the feeling of confidence that everything can be under control with the medical team quickly. Moreover, the comfortability for the medical team and the presentation for the severe shortage of PPE.
5. Big Data	Big data is a discipline that analyzes and extracts information and features from large and complex data that cannot be traditionally processed with application software.	The big data can make a practical analysis of the data generated from sensors and healthcare databases to produce many statistics about the COVID-19 outbreaks and other reports to limit the effect of pandemic across the world (S Chen et al., 2020).

Table 1 (*continued*)

6. Virtual Reality (VR)	VR is a technology used in a computer program to create a suitable simulated environment. People can participate in work in real-time through a distributed whiteboard.	VR offers an appropriate environment for a video call between the healthcare team with patients in hospitals or in-home quarantine. The VR can improve patients' psychological side, especially the home quarantine patients, to make them feel that the healthcare team follows up on all the vital signs and any consequence complications of COVID-19 (Manto et al., 2020).
7. Drone technology and Autonomous Robots	Drone technology is a flying robot controlled by a software application. Like drone technology, the autonomous robot has the capability to carry out specific responsibilities without the intervention of external agencies (Chamola et al., 2020).	Drone technology can be used to reach specific areas in the infected country and minimize human interaction (Chamola et al., 2020). The robot can take many responsibilities from the healthcare team to track and manage some medical care services to patients in hospitals or in-home quarantine
8. 5G	The fifth-generation technology can support global mobile networks (Qualcomm et al., 2020). The 5 G provides more excellent characteristics than 3 G and 4 G.	The 5 G can cooperate with the pandemic of COVID-19 by providing the healthcare team rapid speed communication between assistance to improve the track of COVID-19 and continuously monitoring and analyzing the patients' cases.
9. Blockchain	Blockchain is a transaction record between two parties (Alladia et al., 2019 a). The recorded transaction was used to verify the actions that happened. The blockchain has various applications in different life aspects.	The blockchain can be used to limit the pandemic of COVID—19 by making the integration of different data sources (Alladi et al., 2019 b) The integrated source can be statistically analyzed to extract essential features for the healthcare team and governments.

II. Clinical presentation

The incubation period for COVID-19 extended to fourteen days, with a median of four to five days from exposition to symptoms onset (Guan et al., 2020; Lauer et al., 2020). Guan et al. (2020) announced that 97.5% of people infected with COVID-19 who develop symptoms would do so during 11.5 days of SARS-CoV-2 infection. The manifestation of infected people with COVID-19 will experience the following symptoms in Table 2 (Leiwen et al., 2020; Chen et al., 2019; Huang et al., 2020; Xu et al., 2020; Wu et al., 2020; L. Pan et al., 2020).

III. Laboratory Diagnosis

The most frequent abnormalities in COVID-19 are lymphopenia, increased values of C-Reactive Protein (CRP), lactic dehydrogenase (LDH), erythrocyte sedimentation rate (ESR) and D-dimer, as well as low concentrations of serum albumin and hemoglobin, less common low platelet, increase Serum Creatinine Kinase (CK), Alanine aminotransferase (ALT), Aspartate Aminotransferase (AST) (Giuseppe and Plebani, 2020).

IV. Diagnostic Testing

The respiratory samples are endorsed from the lower respiratory tract, including sputum, bronchoalveolar lavage, and tracheal aspirate (when possible). When it is not possible, samples from the upper respiratory tract are also adequate. Generally, the collection of a combined nasopharyngeal swab and the oropharyngeal swab is recommended (Pan American Health Organization (PAHO), 2020).

The molecular method relied on the disclosure of COVID-19 virus nucleic acid RNA by real-time polymerase chain reaction (RT-PCR) assays. RNA extracted from samples using any standard extraction protocols or kits.

V. Radiological findings

The imaging radiology indicates that in a patient with COVID-19 and worsening respiratory status (Rubin Geoffrey, 2020). The imaging may be a chest X-ray or CT chest. The chest x-ray shows airspace opacities (Wong et al., 2019) and 1) ground-glass opacities; 2) abnormal paving appearance; 3) air space consolidation; 4) bronchovascular thickening in the lesion and 5) traction bronchiectasis (Wang et al., 2020a; Javaid et al., 2020; L. Pan et al., 2020; Shi et al., 2020; Lee et al., 2020):

VI. Categories and Management

The COVID-19 are classified into five main categories and modeled in Fig.2. The description of types are mentioned as follows (Zhoa et al., 2020; Clinical Management of Covid-19, 2020):

1. Mild COVID-19: Symptomatic treatment

WHO (2020) advice infected people with COVID-19 with complete isolation and take symptomatic treatment. e.g., antipyretics to treat fever and pain, appropriate nutrition, and suitable rehydration

2. Moderate COVID-19: Pneumonia treatment

WHO (2020) advises moderate COVID-19 patients with complete isolation and recommends a close monitor for moderate patients to detect signs and symptoms of progress or deterioration. The urgent provision techniques should be carefully performed to monitor a close follow up to determine the escalation of medical care.

3. Severe COVID-19: Severe pneumonia treatment

The severe COVID-19 patients could be treated by equipped with pulse oximeters, functioning oxygen systems and disposable, single-use, oxygen-delivering interfaces (nasal cannula, Venturi mask, and mask with reservoir bag). WHO (2020) advises the rapid administration of supplemental oxygen therapy to any patient with emergency signs and any patients without emergency signs and oxygen saturation (SpO2) < 90%.

4. Critical COVID-19: Acute Respiratory Distress Syndrome (ARDS)

The patients with critical COVID-19 treated by a trial of high-flow nasal oxygen HFNO, non-invasive ventilation – continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP) may be used.

VII. Preventive measures

The public health recommendations for the prevention of the spread of COVID-19 guidelines are recommended as follows

Table. 2
The presentation for symptoms of COVID-19.

COVID-19 Symptoms	Percentages
Fever	83%-99%
Dry Cough	59%-82%
Fatigue	44%-70%
Anorexia	40%-84%
Shortness of breath	31%-40%
Sputum production	28%-33%
Myalgias	11%-35%
Headache, confusion, rhinorrhea, sore throat, hemoptysis, vomiting, and diarrhea	<10%
Loss of smell (anosmia)	Variable/ undetermined
Loss of taste (ageusia)	Variable/ undetermined

(Clinical Management of Covid-19, 2020):

Keep on personnel preventive measures (e.g., hand hygiene, respiratory etiquette and face covers, environmental disinfection).

Keep on social distances between people in work, governmental agencies, etc..

Keep on the safety of people by staying at home and close non-essential business closure (Yoo et al., 2020; Nakamura et al., 2020).

Apply restrictions on public communications.

Apply travel restrictions with the screening of travelers.

Identify and isolate infected cases with COVID-19.

Keep contact tracing for people to limit the pandemic of COVID-19 outbreaks.

The influence of COVID-19 on the healthcare team's first-line defense, the patient's physical and psychological healthcare conditions, the severe shortage of (PPE) for the medical team, and massive pressure on hospitals can impose a hazardous consequence. Since March 2020, WHO officially declared COVID-19 as a pandemic. The outbreaks cause the symptoms of discomfort, disappointment, and disquieted not only for ordinary people but also for medical service providers (Montemurro, 2020). Li et al. (2020) stated that medical staff members bear Vicarious traumatization (VT) of non-front-line medical staff is more earnest than that of front-line medical staff. The outbreaks for COVID-19 placed a handicap on healthcare with an improbable workload and provision of all means of PPE. Indeed, the COVID-19 pandemic has spread in a frightening way around the world, which leads to a severe shortage of medical team care and PPE. For patients and the healthcare team, psychiatric symptoms without a mental illness may occur and distress the caregivers of affected individuals (Kelvin et al., 2020). Unfortunately, most healthcare givers in isolation units in COVID-19 do not receive any preceded preparation or training or give proper mental healthcare (Lima et al., 2020). In Barbisch et al. (2015), the pandemic of COVOD-19 leads the healthcare givers to a sense of collective hysteria that leads to despairing and hopeless measures. In India, suicidal cases were recorded. Additionally, two nurses in Italy committed suicide due to the volume of workloads and fear of outbreaks of COVID-19 to patients (Goyal et al., 2020). A devoted national suicide prevention lifeline was stimulated for emotional adversity for the pandemic COVID-19 to prohibit suicide cases in the US.

The healthcare team noticed that patients who suffered from the COVID-19 pandemic are subjected to anxiety and panic attacks, which leads to the need for medical and psychological support (Katafuchi et al., 2020). According to NICE guideline [NG163], (2020):

1. Explore the causes of anxiety.

    The health care team directly contacts patients to decrease and to talk about his/her anxiety and provide effective communication and orientation for patients—the provider of adequate ways for rest (e.g., adequate light brightens, bed, etc.). Moreover, health workers provide explanations to the caregivers on how they can help patients physically and emotionally.

2. Medically, patients can take some drugs. e.g., Benzodiazepine can be tried to relieve anxiety.

    As a result of the need for direct communication between the healthcare team and infected patients, the infection control recommended for the healthcare team to use fitted respirator masks (e.g., N95 respirators, FFP2), moreover to the other PPE to assure the safety and to prevent the COVID-19 outbreaks (Jason et al., 2020). The outbreak of COVID-19 in 213 countries leads to a severe shortage of PPE and healthcare teams, which encourage technological solutions to decrease the pandemic crisis consequent on humanity. The study addressed the main milestones for COVID-19.

2.2. The motivation and rationale of using a framework approach

This section describes the motivation and rationale to adopt our framework using disruptive technologies for COVID-19 analysis. In short, an intelligent framework is proposed since it can blend different types of disruptive technologies to conduct an effective COVID-19 research analysis. The intelligent framework concerns keeping the healthcare team healthy, keeping the physical and psychological healthcare of patients, and preventing the severe shortage of PPE, reducing the burden in hospitals tracking recovered patients to treat COVID-19 patients with plasma. The intelligent framework adopts the use of leading technologies of AI, industry 4.0, IoT, IoMT, big data, virtual reality (VR), Drone technology and Autonomous Robots, 5 G, and blockchain to achieve the proper goals.

The proposed intelligent framework is designed to accommodate the COVID-19 crisis that affected human survival worldwide. The aim is to help governments with pandemic management. The intelligent framework is focused on limiting the spread of COVID-19 outbreaks, providing a safe environment for the medical team and health caregivers, and maintaining the patient's physical and psychological healthcare. The framework also manages the severe shortage of PPE, reduces the massive pressure on hospitals, and tracks recovered patients to treat COVID-19 patients, as mentioned in Fig.3.

3. The framework using disruptive technologies for COVID-19 analysis

This section describes our intelligent framework using disruptive technologies for COVID-19 analysis. Our study focuses on traditional procedures without using the intelligent framework to illustrate the importance of research concerning the framework goals. The conventional procedures are presented started from patient requests for help or complaint until the healthcare team makes a diagnosis for the patient to be hospitalized, home quarantine, or healthy, as mentioned in Fig.4.

In order to achieve study goals, a general framework is proposed to include technologies of AI, industry 4.0, IoT, IoMT, big data, VR, drone and robotics technology, 5 G, and blockchain modeled in Fig.5. In Fig. 5, the proposed intelligent framework focused on three main actors: 1) Patients, 2) Healthcare team and 3) Competent government agencies. The three main actors can remotely connect with the intelligent framework to take the proper services. The patients can remotely diagnose, treated, and monitored. The healthcare team can perform medical services to patients remotely. The competent governmental agencies can remotely monitor and retrieve required data on time for urgent and regular situations. The proposed intelligent framework adopted: 1) AI with analytical models for the healthcare system, 2) Industry 4.0 with medical applications, 3) IoT with effective sensors to help patient and healthcare team, 4) IoMT with medical sensors with hospitalized and home quarantine patients, 5) Big data used statistical methods to perform an operation on healthcare system data, 6) VR provided healthcare team and patients with appropriate virtual environment, 7) Autonomous robotics and drone technology take on critical tasks from humanity, 8) 5 G used in rapid communication between healthcare system actors and patients, and 9) Blockchain applied integration and standardization for the healthcare system.

The intelligent framework proposed systematic procedures to achieve the study goals, as mentioned in Fig. 6. The systematic procedures are presented to patients that have complained about COVID-19 symptoms. The patient can contact the hospital according to available technologies, e.g., cellular phones, industry 4.0 applications, IoT sensors, or AI analysis models. The healthcare team receives a complaint to address patients to a suitable disease category. The healthcare team can decide to treat the patient in-home quarantine, hospital, or treat patients with typical cold or flu. For hospitalized patients, the healthcare team assigns suitable IoMT according to the patient category. The healthcare team can remotely communicate and treat patients with virtual reality and

robot technologies. For home quarantine patients, the healthcare system assigns the available and suitable IoT sensors, e.g., smart wears, to monitor and track patients' vital signs and locations. The healthcare team can monitor and treat home quarantine patients according to the current readings for vital signs of IoT sensors. In addition, drone technology and robotics are assessed to track, nurse, and clean patient rooms. The healthcare system data can be integrated and analyzed with the aim of big data and blockchain technologies. For patients, recovered or healthy, have treated with some medical advice or guidelines.

The AI can be useful for the monitoring and prediction for COVID-19 patients and the outbreaks curve. The neural networks and data mining can be developed to extract main features for the COVID-19 and provide daily solutions for the pandemic (Vaishya et al., 2020). Industry 4.0 is an automatic solution for manufacturing purposes. Industry 4.0 can easily use digital information to gather, transmit, store, analyze, and monitor the healthcare system. The technology of industry 4.0 is a novel method to isolate COVID-19 patients to reduce the high death rate, improve drug production, and enhance treatment of COVID-19 (Javaid et al., 2020). The IoT provided useful technological sensors to help fight the current crisis, especially to patients for home quarantine treatment. Fig. 7 illustrates the importance of using IoT technologies to support the proposed framework. The IoT technology, especially for home quarantine, aided the COVID-19 patients to remotely transfer the complaint and vital symptoms to the healthcare system across the IoT equipment and network with a cellular phone or any communication to inform the healthcare team and to receive remote diagnosis and treatment.

The IoMT denoted the use of IoT in the field of medical healthcare. The IoMT in the COVID-19 pandemic used medical instruments and applications to provide healthcare services to patients in hospitals or under home quarantine, in addition to producing valuable big data for healthcare systems and related governmental sectors. Nowadays, most people are using smartphones for different purposes; the IoMT is proposed a possible number of available medical application services (Hassija e al., 2019). The IoMT provides potential applications in healthcare that can significantly serve in the pandemic of COVID-19. The applications include smart healthcare, patient tracking, remote health monitoring, Emergency cautions, and Wearable devices (R.P.. Singh et al., 2020). The integrated technologies in IoMT are presented in the proposed intelligent framework as follows (Chamola et al., 2020):

1. Smart thermometers

Kinas, a US technology manufacture, developed a smart thermometer to scan people's temperature. During the COVID-19 pandemic, the intelligent thermostat has been connected to mobile applications to make the patients' data available for the related governmental sectors, e.g., the healthcare system. The Kinsa's maps regarded toe be consistent in identifying the high spotted areas for COVIID_19 outbreaks (Mcneil, 2020)

2. IoT buttons

Many hospitals in Canada use IoT buttons to ensure cleaning standards and reduce hospital-acquired infection (HAIs) numbers (Watson et al., 2020). The main advantage of the IoT buttons is the adequality to be attached to any superficies (D'mello et al., 2020).

3. Telemedicine

It provides the healthcare team the ability to remotely diagnose and treat patients in various locations using IoMT technology. Various telemedicine applications are evolved, e.g., teleconsultation software, etc. (Chamola et al., 2020). While aiming to get accurate representation, an integrated framework of intelligent methods should be presented using robotic and drone technology, 5 G, smartwatches, and blockchain.

In Fig.8, the data generated from the IoMT sensors classified according to the place of treatment, either hospitalized or home quarantine. The IoMT sensors of smart wearable, robot technology, and drone technology in-home quarantine treatment associated with governmental healthcare applications to direct the non-emergent data to the healthcare system. The IoMT sensors can send data to emergency agencies, such as calling an ambulance to COVID-19 patients based on tracking the patient's location according to police regulations to ensure that patient does not move and break out the home quarantine. For hospitalized patients, the smart hospital can send patients data to the healthcare team to be monitored, diagnosed, and treated. The data generated from the IoMT sensors and healthcare systems can be managed and analyzed with significant big data, AI techniques, and big data to make useful reports for governments and society (AMD Telemedicine., 2020; Nathali et al. 2020). In addition to the track, COVID-19 outbreak experts and decision-makers can use the generated data to aid researchers in applying MCDM methods with neutrosophic theory to produce efficient and accurate decisions for the COVID-19 pandemic (Nabeeh et al., 2019b; Nabeeh, 2020, 2020a; Nabeeh et al., 2020b). Fig. 8 illustrates the importance of IoMT with the proposed intelligent framework to achieve study goals.

Virtual reality is extended to the proposed intelligent framework to ensure patients' physiological support in hospitals or in-home quarantine patients. The patients' ambition to allow the healthcare team to manage or intervene any time improves the healing rates, especially for mild and moderate COVID-19 patients. Drone technology is useful in cases of quarantine patients because it can make the full map for the hotspot cases and help decision-makers make decisions with such emerged cases—moreover, drone technology aid police in reaching to handle emergent situations (Cyient, 2020). Robotics technology is a mild stone for the proposed intelligent framework since the robot can take a burden from the healthcare team. For patients in hospitals, robots can visit patients and track their development and cases. On another side, the physiological support for patients will provide many improvement signs in physical healthcare. The robot technology can be beneficial in cleaning teams and services from the people responsible for cleaning the patient's wards and rooms. Regarding the mild and moderate COVID-19 patients, the study recommends that robots visit patients instead of the healthcare team, provide patients with the first aids, and provide vital responsibilities to remove the burden of cleaning and to cook healthy food from COVID-19 patients. The robot can maintain the healthcare for patients' physical and psychological healthcare conditions, decrease the direct contact between healthcare and COVID-19 patients, and limit the decrease of outbreaks aiding governments in reducing hospitals' massive pressure. The 5 G as a speed communication can maintain direct contact between the healthcare team and patients in the case of new cases and work as an efficient link between intelligent framework methods. The blockchain is used to ensure the standardizations for the various healthcare systems and is used as a single and consistent block.

4. An empirical case study

The primary objective of the empirical case study is to highlight how the intelligent framework can be applied with respect to the real situations in the daily healthcare organization. As mentioned inFig. 2, which describes the categories for COVID-19 patients, the case study performs a numerical description according to specific clinical parameters (Clinical Management of Covid-19, 2020). The COVID-19 has many symptoms, as mentioned in table1. The severity of the disease can be categorized according to the following clinical parameters mentioned in table 3. The numerical parameters are described in decimals or percentages. The binary parameters are denoted as 0 (not found), 1 (found). The descriptive parameters are described in the text. The descriptive parameter of the Chest x-ray imaging category is mentioned as follows:

1. *Mild Covid-19 patients:* No evidence for pneumonia, as mentioned in Fig. 9 and denoted to be symbolled with 0.
2. *Moderate Covid-19 patients:* They have pneumonia symptoms, as mentioned in Fig. 10 and denoted to be symbolled with 1.
3. *Severe Covid-19 patients:* They have severe pneumonia symptoms, as mentioned in Fig. 11 and denoted to be symbolled with 2.
4. *Critical Covid-19 patients:* Bilateral opacities and lung collapse may occur, as mentioned in Fig. 12 and denoted to be symbolled with 1.

The numerical case study can be applied to Mansoura University Hospitals Quarantine. The healthcare team provides research with samples of 20 patients with corresponding clinical parameters and the healthcare team suggestions treatment for COVID-19 patients. Table 4 mentions the main guidelines to address patients to their suitable category. Indeed, there are many clinical varieties in the cases of COVID-19. Table 5 presents real data for COVID-19 cases, and the diagnosis may be variant from one case to another. The severity of cases can be determined with the most commonly used parameter results aggregated in table 5. Table 5 shows the final diagnosis for COVID-19 patients as mild, moderate, severe, or critical. Each category can be treated according to guidelines mentioned in Fig.2.

The case study shows the direct interaction between the healthcare team and patients, which leads to the great importance for the proposed framework. Some hospitals have an electronic monitor to read the vital signs for patients and other hospitals, depending on human intervention in all medical processes. Hospitals have a monitor to record vital signs (Ammenwerth et al., 2007). However, reading results cannot be transferred automatically to the healthcare system. The healthcare team (e.g., nurses) must save the monitor readings and transform the results into the proper format to the healthcare team (e.g., Doctors). The systematic procedures for the traditional use of monitor are presented in Fig. 13. The procedures are automatically performed to record vital signs with a monitor. However, the other procedures need humans to intervene such that way, and the nurse needs to record the patient's vitals manually and inform doctors with clinical parameters. The healthcare diagnosis the category of disease and puts the treatment plan. The nursing team carries out the treatment plan to patients.

The intelligent framework limits the spread of COVID-19 outbreaks provides a safe environment for the medical team and health caregivers and maintains the patient's physical and psychological healthcare. The framework also manages the severe shortage of PPE, reduces the massive pressure on hospitals, and tracks recovered patients to treat
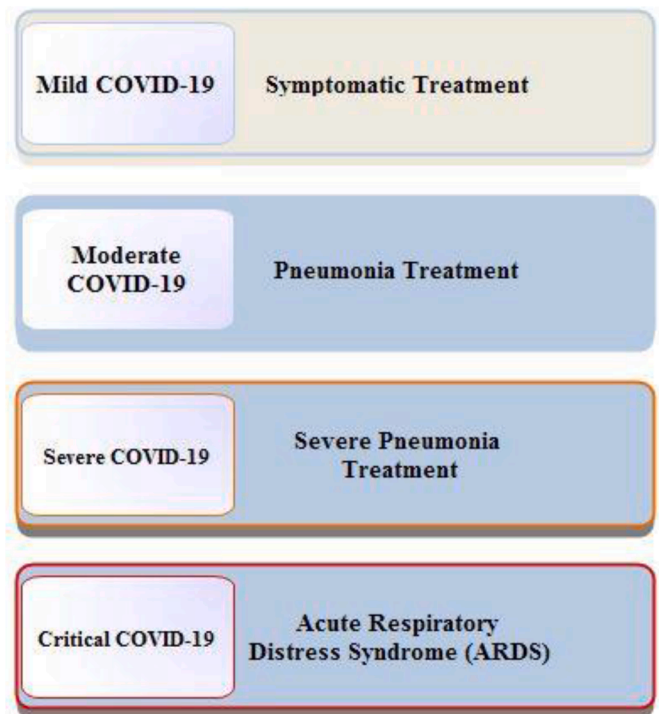

Fig. 2. The workflow for the main categories affected COVID-19 patients.

COVID-19 patients.

In the light of Fig.12, the stop symbols can be handled remotely with the proposed intelligent framework. The initial diagnosis can be applied with disruptive technologies of an intelligent framework using AI, IoT, and IoMT technologies via 5 G and cloud platforms. The medical healthcare team can decide to treat patients in-home quarantine, hospitalized, or identify or treat patients with typical cold or flu. The drone technology can scan critical regions with emitted people to limit the COVID-19 outbreaks regions. The robot technology takes a massive burden from the healthcare team and government and can treat and track COVID-19 patients. In addition, they are taking cleaning and cooking duties from patients and healthcare givers. The healthcare system data can be processed to produce valuable and predictive results via AI models, big data, blockchain. Finally, the proposed intelligent framework can be a safe environment for COVID-19 patients to be remotely monitored, diagnosed, and treated.

5. Results and how disruptive technologies and methods offer better COVID-19 analysis

5.1. Neutrosophic and multiple-criteria decision-making (MCDM) methods

The proposed intelligent framework is aimed to limit the COVID-19 outbreaks. An innovative breakthrough in current disruptive technologies and its offering can become essential for making better COVID-19 analysis. The contemporary literature presented in Table 1 does not include Neutrosophic and Multiple-criteria decision-making (MCDM) methods (Abdel-basset and Mohamed. R., 2020a; Abdel-Basset et al., 2020a). Therefore, the framework offers something new to demonstrate how our work.

While aiming to show the applicability of the proposed study, real data are collected from Jaber Alahmad Al-Sabah Hospital Kuwait for COVID-19 patients. Real data are collected from the healthcare system, healthcare teams, and healthcare givers to provide the decision-makers of the healthcare team to categorize patients with their symptoms to be hospitalized, home quarantine, normal cold, flu, or healthy person. The
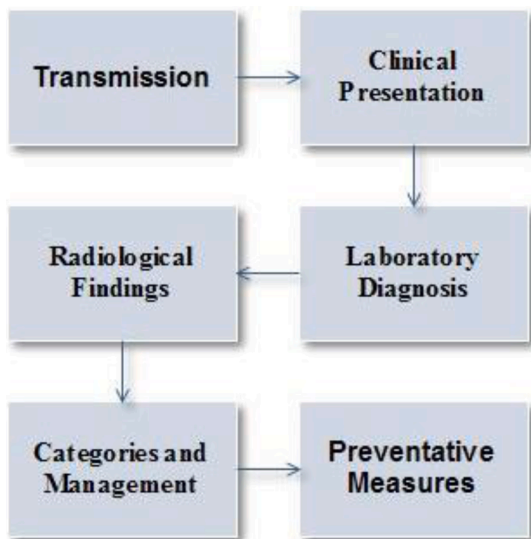

Fig. 1. Guidelines for the basic information about COVID-19 (Clinical Management of Covid-19, 2020).
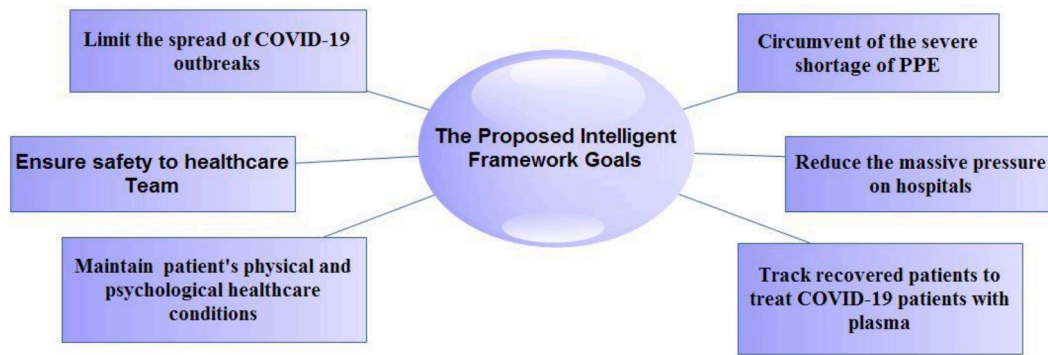
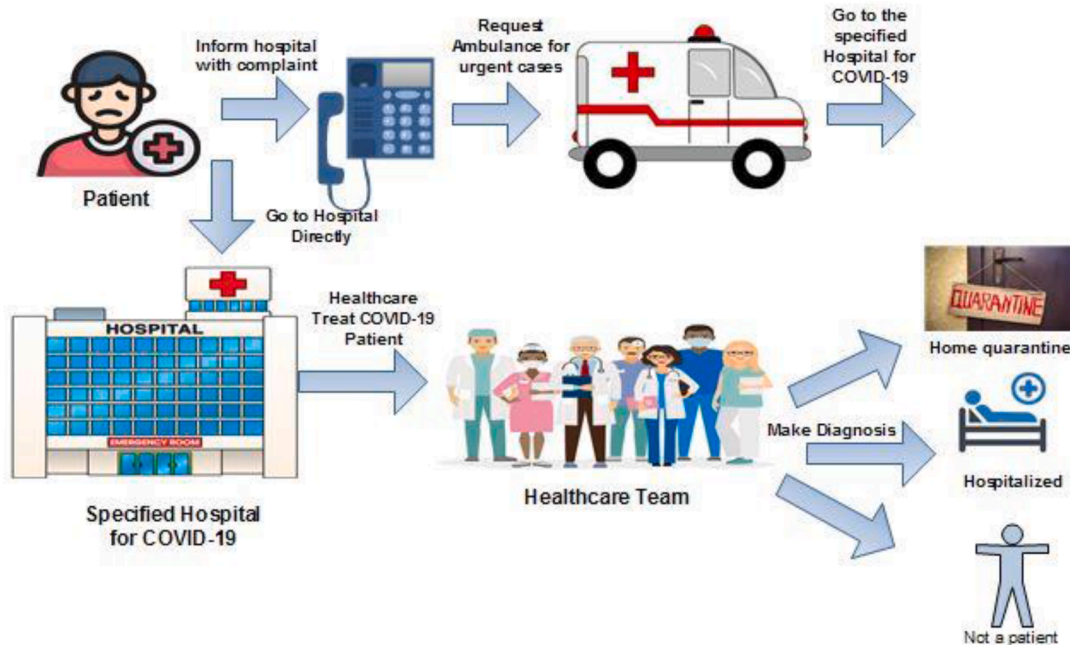**Fig. 3.** The main goals for the proposed intelligent framework.

Fig. 4. Traditional Procedures for COVID-19 patient's treatment.

study adopts the neutrosophic theory with the MCDM method of TOPSIS. Since the pandemic of COVID-19 is a complex problem with various alternatives and criteria with conditions of uncertainty.

In results and discussion, the study applies the neutrosophic theory with TOPSIS (Abdelbasset et al., 2019; Nabeeh et al., 2019a, Nabeeh et al., 2019b). The study regards four decision-makers from the healthcare team to record their perspectives about the COVID-19 symptoms, patients' symptoms, and recovery steps. The research includes 20 patients as alternatives and 16 common symptoms recommended with the studies (Leiwen et al., 2020; Chen et al., 2019; Huang et al., 2020; Xu et al., 2020; Wu et al., 2020; L. Pan et al., 2020) as criteria. The results provide the healthcare team with neutrosophic weighted criteria according to AHP procedures and ranked symptoms of patients according to TOPSIS. The requirements are considered, as mentioned in Table 6. The alternatives are considered 20 patients from A_1 to A_{20} with details in the Appendix A.

The results and discussions show the priorities of patients according to the weighted results of recommended symptoms. The results take a massive burden from the healthcare team. The healthcare team can do a quick review in the light of results to decide to treat patients in hospitals, quarantine at home, or identifying and treating patients with typical cold or flu.

5.2. How AI can impact COVID-19 research

Healthcare services are demonstrated with continuous challenges due to the prospect of the appearance of variant types of bacteria, viruses, and diseases (Chang, 2018). The case of COVID-19 is studying from all governmental aspects, trying to reach solutions to save humanity. This section illustrates how disruptive technologies and applications from the literature can be practically applied to the proposed intelligent framework.

The core applications and technologies of AI for COVID-19 are concluded by Vaishya et al. (2020) as follows:

1. Early disease detection and diagnosis

The AI can be used to make analysis with irregular symptoms and produce an alarm to the healthcare system. The AI can be valuable in the COVID-19 diagnosis of patients with medical image technologies such as Computed tomography (CT), Magnetic resonance imaging (MRI) scan to patients.

2. Observation and management

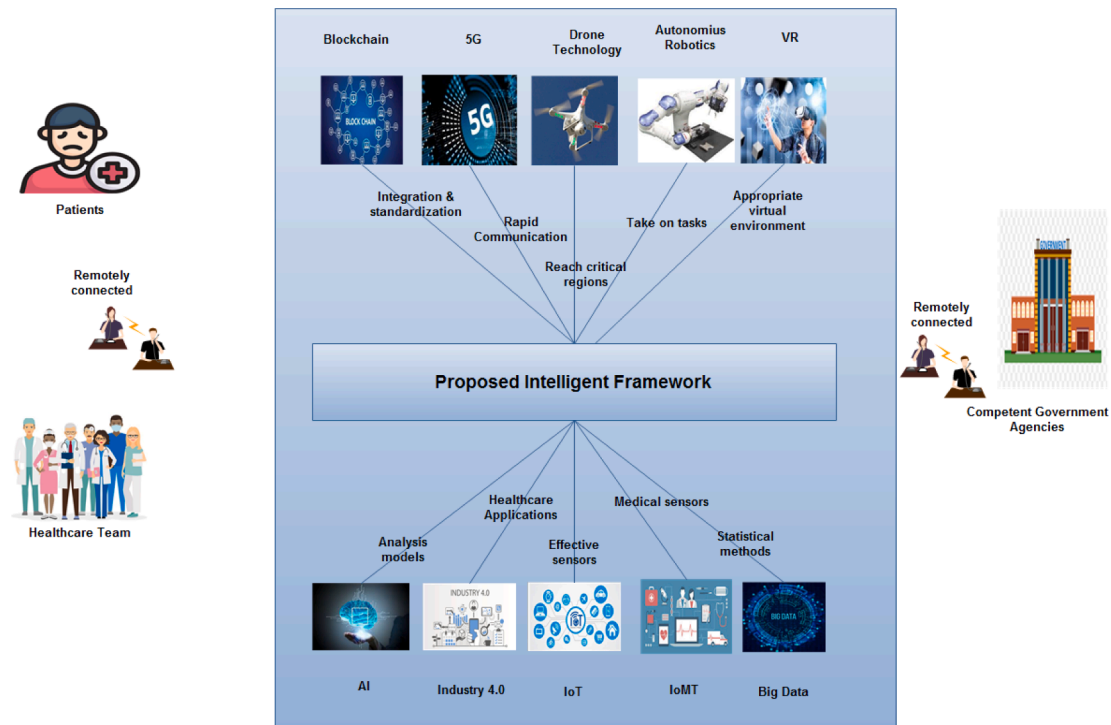The AI can apply neural networks to monitor and to treat COVID-19

Fig. 5. The general intelligent framework proposed to limit the pandemic of COVID-19.
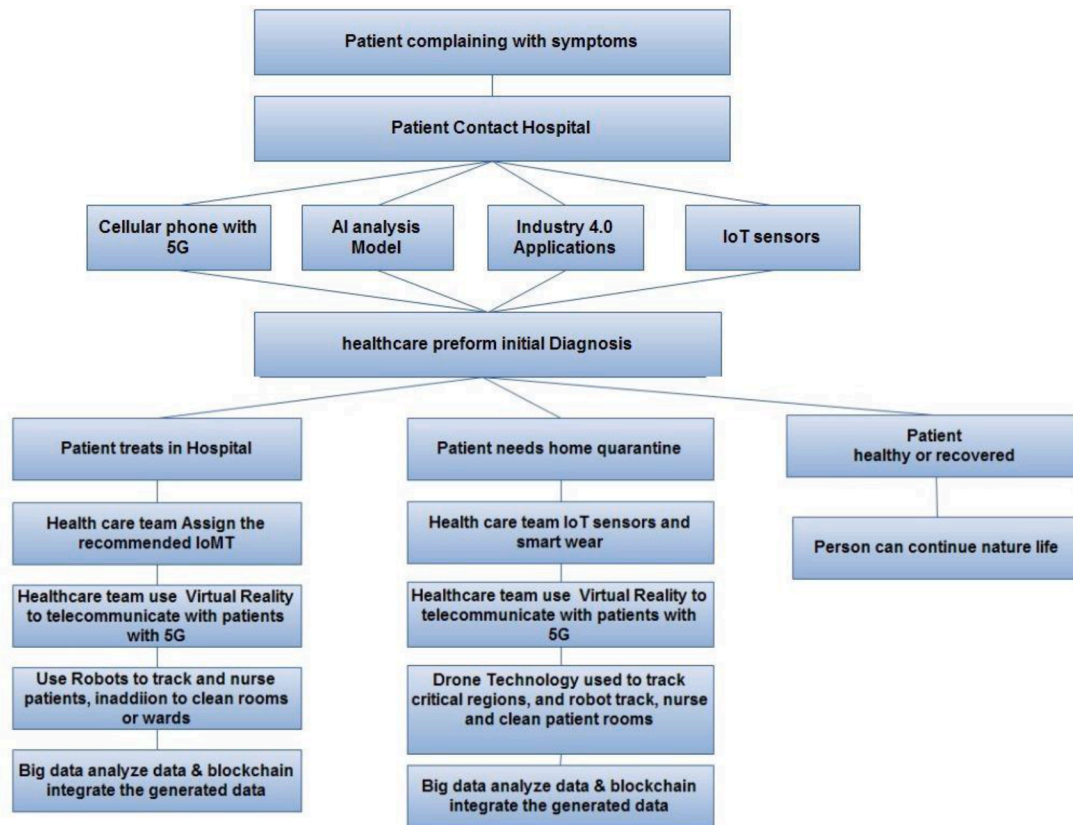

Fig. 6. Procedures for the proposed intelligent framework to limit the COVID-19 outbreaks.

patient to produce remote solutions to limit the pandemic of COVID-19 outbreak (Haleem et al., 2019; Biswas and Sen, 2020; Chen S et al., 2020)

3. Follow contact with the patients.

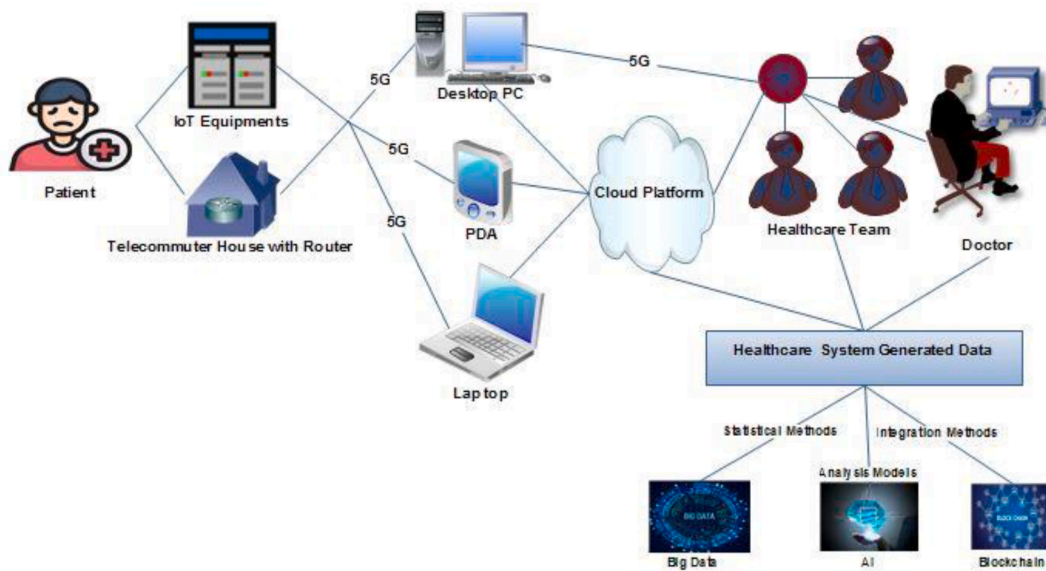The hotspot can be helpful to monitor and to predict disease

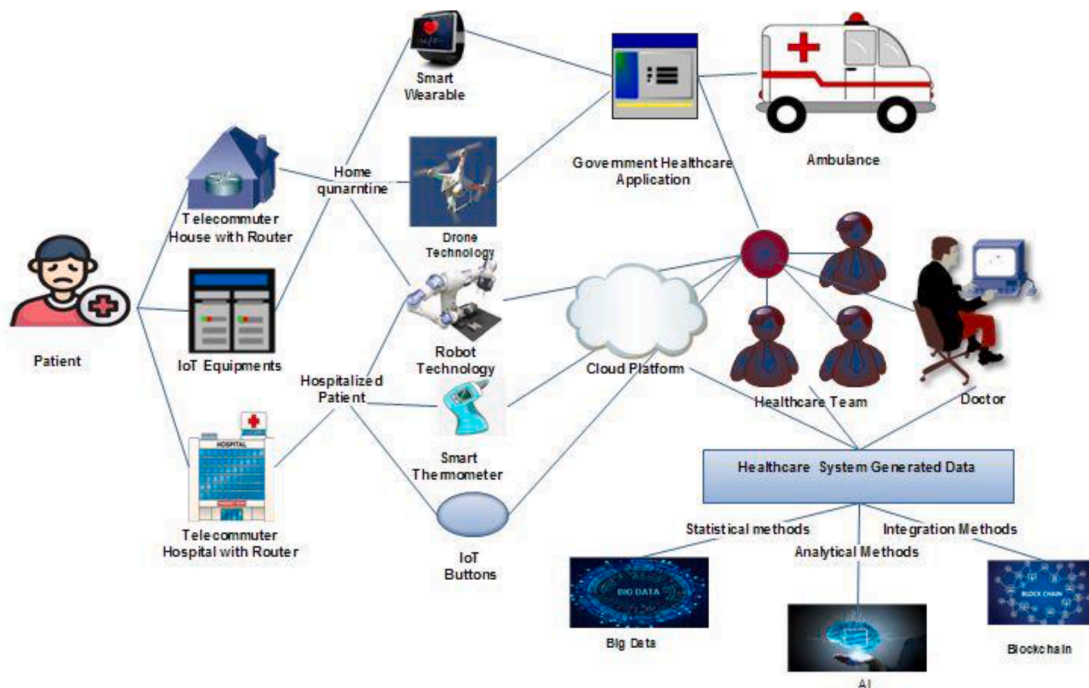**Fig. 7.** The proposed intelligent framework treatment using IoT technologies.

Fig. 8. The proposed intelligent framework treatment using IoMT technologies.

Table. 3

The data type for differentiation of COVID-19 patients' categories.

Numerical parameters	Binary parameters	Descriptive parameters
Fever	Cough	
Respiratory rate	Dyspnea	Chest x-ray
Oxygen saturation	Mechanical Ventilations	

categories to make rapid diagnosis and treatment.

4. Projection of infected person & mortality prediction

The technology can monitor and follow-up the evolution of the diseases from available governmental, social, media data and platforms to limit the outbreaks. AI applications can predict COVID-19 patients and the death rate.

5. Medications and vaccines development

The technologies and applications can analyze data using statistical methods and algorithms. The AI can be helpful to rapid vaccine development to make diagnostic tests vaccination progress (Ren et al., 2020)**.**

6. Disease prevention

The AI technologies and applications can provide updated and analyzed data to governmental issues to provide more preventive healthcare services.

Fig. 9. The chest X-ray for mild COVID-19 patients.

Fig. 10. The chest X-ray for moderate COVID-19 patients.

Fig. 11. The chest X-ray for severe COVID-19 patients.

5.3. How other disruptive technologies can impact COVID-19 research

The vital applications and technologies of industry 4.0 for COVID-19 can provide day-to-day digital results to manage the pandemic of COVID-19 outbreaks (Javaid et al., 2020). Industry 4.0 can offer various innovations to the digital technology of media platforms to achieve unusual information. Industry 4.0 can achieve better risk management for emergent healthcare conditions of COVID-19 outbreaks (Yang et al.,
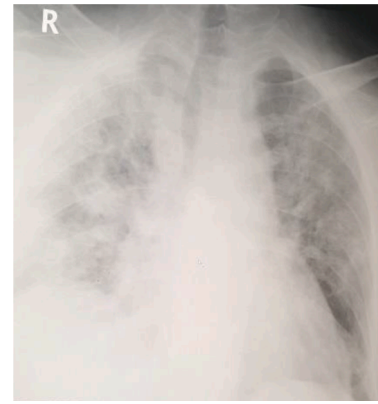

Fig. 12. The chest X-ray for critical COVID-19 patients.

2020). The IoT application and technology provides smart healthcare with important opportunities to manage the crisis of COVID-19 on humanity. The IT sensors can perform automatic processes and communication between patient and healthcare systems (Swayamsiddha and Mohanty, 2020). The IoMT, an extensive for IoT, provides remote medical services for hospitalized or home quarantine patients (Chenghu et al., 2020). The generated data can help build a medical platform to be analyzed further to achieve valuable statistical results. In (R.P.. Singh et al., 2020), big data integrate a heterogeneous form of data to rapidly acquire the data to provide to governmental aspects to limit the widespread pandemic of COVID-19 outbreaks.

Mashamba and Crayton (2020) provide digital solutions to limit the pandemic of COVID-19. The tracking of high-risk COVID-19 patients with digital DH1S2 based solutions defined as a standalone package for disease surveillance systems, international and national dashboards, and drones for surveillance. In addition to telemedicine applications to categorize patients of COVID-19 as follows: virtual chatbots and web bots to take follow up with virtual visits, telemedical robot cards, electronic intensive care units, and virtual visits to patients' rooms. For home quarantine, Mashamba and Crayton (2020) adopt some valuable applications such as the Apple health check app, Siri gives me guidance and Alexa daily check. Bakken et al. (2020) provided a community based on blockchain and AI technologies linked with self-testing and tracking system for urgent infectious diseases. In Chamola et al. (2020), the proposed technology is used in China to improve communication between the healthcare team to improve the track and monitor for patients and viruses.

5.4. How predictive modeling can provide possible solutions and recommendations on the proposed intelligent framework?

Predictive modeling can predict outcomes using data and statistics. The intelligent framework can be extended with predictive data modeling features to estimate the predictions for the spread of COVID-19 to inform the competent authorities to take preventive methods. Koutsellis et al. (2020) used predictive modeling to predict the spread of COVID-19 outbreaks in the United States and European countries. Ghosh (2020) applied analysis and prediction to the spread of COVID-19 and the effect on countries and people. Due to the rising of the death rate of COVID-19 and the unclear risk factors. Ran et al. (2020) applied the regression model of Cox regression models to investigate the risk factors for case fatality and predicted the death probability under specific combinations of key predictors. In addition, Wang et al. (2020b) developed a model to predict the prognosis of COVID-19 to produce a good performance in predicting the outcome of COVID-19. Therefore, predictive modeling can generate possible solutions and recommendations that help countries limit the pandemic for COVID-19 outbreaks.

Table. 4
Definitions for different COVID-19 patient's categories according to clinical parameters.

Categories	Fever	Cough	Dyspnea	Fast Breathing	Chest X-ray	Oxygen Saturation	Mechanical ventilation
Mild			×	× (Respiratory rate<22 breath per min)	No evidence of pneumonia	>94%	×
Moderate				(Respiratory rate<30 breath per min)	Evidence of pneumonia (not severe)	90%-94%	×
Severe				(Respiratory rate> 30 breath per min	Evidence of severe pneumonia.	< 90%	×
Critical				(Respiratory rate> 30 breath per min	Bilateral opacities, lung collapse, may occur	<85%	

Table 5
Clinical parameters for samples of COVID-19 patients.

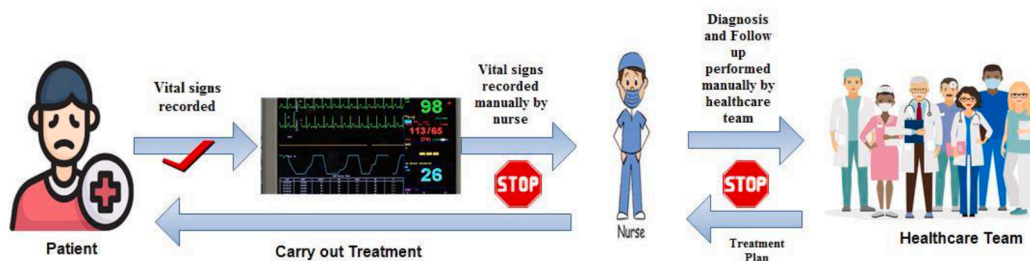| Patients	Fever (Temperature)	Cough	Dyspnea	Respiratory rate	Chest X-ray	Oxygen Saturation	Mechanical ventilation	Category
1	38.1	1	0	27	0	92%	0	Moderate
2	37.7	1	0	20	0	97%	0	Mild
3	38	1	1	29	1	93%	0	Moderate
4	39.2	1	1	39	3	81%	1	Critical
5	37.5	1	0	19	0	99%	0	Mild
6	38.9	1	1	34	2	89%	0	Severe
7	39.4	1	1	41	3	78%	1	Critical
8	38.2	1	1	29	1	94%	0	Moderate
9	39	1	1	36	2	88%	0	Severe
10	37.7	1	0	22	0	97%	0	Mild
11	39.2	1	1	32	2	90%	0	Severe
12	38.4	1	1	28	1	93%	0	Moderate
13	39.7	1	1	37	3	83%	1	Critical
14	37.6	1	0	18	0	99%	0	Mild
15	39	1	1	31	2	87%	0	Severe
16	38.3	1	1	24	1	94%	0	Moderate
17	39.5	1	1	37	3	80%	1	Critical
18	39.8	1	1	41	3	79%	1	Critical
19	37.6	1	0	21	0	98%	0	Mild
20	38.4	1	1	32	2	89%	0	Severe

Fig. 13. The traditional procedures for the use of monitor in hospitals.

Table 6
The criterions considered in discussion and results.

Criteria	Symptoms
C_1	Dry Cough
C_2	Fever
C_3	Fatigue
C_4	Shortness of breath
C_5	Anorexia
C_6	Sputum production
C_7	Headache
C_8	Myalgias
C_9	Confusion
C_{10}	Rhinorrhea
C_{11}	Sore throat
C_{12}	Vomiting
C_{13}	Diarrhea
C_{14}	Hemoptysis
C_{15}	Loss of smell (anosmia)
C_{16}	Loss of taste (ageusia)

5.5. How to prove the justification and suitability of the proposed intelligent framework?

Paul et al. (2020) evaluate the justification, suitability, and institutional bottlenecks relative to the framework according to health system building Blocks. THE WHO conceptual framework based on six health system building blocks: 1) Health Services, 2) Health workforce, 3) Health information, 4) Medical technologies, 5) health financing and 6) Leadership and governance (WHO, 2020). In order to show the justification and suitability for the proposed intelligent framework, the standard health systems blocks are tested as follows:

1. *Health services*: The framework can provide medical healthcare services anytime, anywhere, anyplace to the competent authorities with minimum waste of resources.
2. *Health workforce*: The framework provides complete transparency to the competent authorities and provides the best healthcare services with the available resources and any circumstances.

3. *Health Information:* The framework supports the competent authorities with on time and well-functioned information to perform analysis to enhance health system performance and status.

4. *Medical technologies:* The framework can maintain a sustainable health role in developing medical devices and equipment to improve healthcare services.

5. *Health Financial:* The framework concerned with facilities that can be reflected in healthcare services in the pandemic of COVID-19 to provide incentives for financial funds.

6. *Leadership and governance:* The framework ensures the strategic policy with effective oversight and attention to system-design and accountability.

6. Discussion

6.1. Managerial insights

The study adopted an intelligent framework that merges smart technological issues to assist governments, especially healthcare disciplines. The intelligent framework takes a considerable burden from the healthcare team to reduce human intervention. The reduction of human intervention should help increase the use of full PPE. The challenges of the COVID-19 pandemic are the rapid spread in 213 counties and most of the manufacturing is a lockdown (Kumar et al., 2020; Mandel et al., 2020), so the production of PPE is limited. The technological capabilities support governments in making home isolation for mild and moderate COVID-19 cases to reduce the massive pressure in hospitals and track recovered patients to treat COVID-19 patients.

The intelligent framework provides patients in-home quarantine with remote connection and telemedicine with robotic and drone technologies to support the physical and physiological healthcare. Some features of the intelligent framework applied in Kuwait include the home quarantine patients who are provided with smartwatch connected with online governmental applications. The aim is to detect the patient location to ensure that the patient would not transfer to another site and spread the COVID-19 and be a cause for more outbreaks. In addition to tracking the emergent case, if patients change location, the system can request a nearby police station to move patients for check-ups. The use of smartwatches provides patients with an excellent physiological condition due to the feel of remote tracking. Besides, in Egypt, Mansoura University is developing a robot model to serve food to patients to reduce the human intervention and give patients feel that systematic procedures are performing to enhance services tracking all patients' vital activities.

By applying the intelligent framework, patients can be monitored with the aid of leading technologies of AI, industry 4.0, IoT, IoMT, big data, VR, Drone technology and Autonomous Robots, 5 G, and blockchain to diagnose the disease, record the health status and receive advice on telemedicine. The system can track the evolution case for patients, served with robots and drones. The combined big data is standardized with blockchain technology to be useful for further analysis purposes applied from the governmental sides. Besides, governments can track the recovered patients to denote with plasma according to certain medical conditions, can be extracted from the medical system, to treat patients of COVID-19. In the cases that patients do not need to denote, the competent authorities, e.g., the ministry of interior affairs, takes appropriate actions.

6.2. Disruptive technologies leading the fight against COVID-19

The disruptive technologies combat against the pandemic of COVID-19. The disruptive technologies can replace the traditional methods in the healthcare system of diagnosis, direct communication between patient and healthcare team, overcrowding in hospitals, shortage of PPE, etc. with intelligent solutions. The use of AI, IoT, and IoMT technologies via 5 G and cloud platforms promote the healthcare system to perform

day-to-day routine remotely. The remote services take a large burden from healthcare teams and patients, leading to the limit of the spread of COVID-19. The diagnosis can be remotely detected according to data captured to take the decision to treat patients in-home quarantine, hospitalized, or identify or treat patients with typical cold or flu.

The disruptive technologies fight COVID-19, either for patients treated at home quarantine or hospital using robot or drone technology. The AI, big data, and blockchain models can be used to valuable and predictable analysis results.

6.3. Future trends and expectations for COVID-19 analysis

The pandemic of COVID-19 provides novel research indications to treat and to limit the negative impact on the economy and humanity. The future research vision is mentioned as follows in the light of the proposed framework technologies, as follows in Fig. 14:

1. *Data Science and big data:* apply the power of data science to extract knowledge from big data generated from healthcare systems or smart health care (Stuhler et al., 2020).

2. *Predictive methodology:* the use of predicting methods to forecast the COVID-19 treatment outbreaks and produce statistical reports (Smailhodzic et al., 2016).

3. *The power of social media:* the data generated from social media can be analyzed to produce consistent results served by the government to try to manage the crisis efficiently (Ma et al., 2013).

4. *Multiple-criteria decision-making (MCDM):* the researchers can apply the MCDM to support governments with well-formed decisions (Ma et al., 2013). Neutrosophic theory: as the COVID-19 is a problem definition surrounded by vague impression, inconsistency, and uncertainty, and researchers can help decision-makers with consistent and optimized decisions to manage the current pandemic (Abdel-Basset et al., 2019; Nabeeh et al., 2019a, 2019b; Nabeeh, 2020; Nabeeh et al., 2020a, 2020b).

7. Conclusion and future work

The world is fighting severely with COVID-19; researchers from different disciplines can provide governments with appropriate solutions to restrict the COVID-19 outbreak. The study illustrated a review of COVID-19 guidelines as follows: the explanation for the COVID-19, the
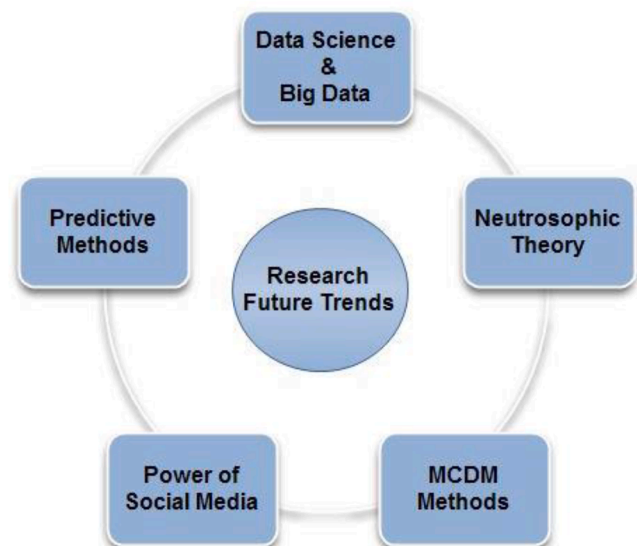

Fig. 14. The future trends of research in the light of the proposed intelligent framework.

transmission mechanisms, clinical presentation, laboratory diagnosis, and categories and management. The study proposed an intelligent framework using disruptive technologies to aid government and humanity during the epidemic to reduce COVID-19 outbreaks. The proposed framework demonstrated five main goals: 1) keeping the medical teams safe; 2) maintaining the patients; physical and psychological healthcare conditions; 3) managing a severe shortage of PPE for the medical team; 4) reducing the massive pressure on hospitals, and 5) tracking recovered patients to treat COVID-19 patients. The proposed framework integrated different disruptive technologies of AI, industry 4.0, IoT, IoMT, big data, VR, Drone technology and Autonomous Robots, 5 G, and blockchain to provide governance with an integrated vision to manage the pandemic of COVID-19. The study showed a numerical of COVID-19 patients to present the importance of the proposed intelligence to limit the current outbreaks for COVID-19. The proposed intelligent framework uses the hybrid methodology of neutrosophic theory with TOPSIS results. The results showed an aided list for the healthcare team to treat COVID-19 patients in the hospital, home quarantine, or identifying and treating with typical cold or flu. Our future work will include the use of pioneering AI and Data Science techniques to explore COVID-19 further and publicize our analysis.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Declaration of Competing Interest

The authors declare that there is no conflict of interest in the research

Acknowledgments

Appendix A

This section contains additional literature and analysis related to this research.

In Abdel-Basset et al., (2019); Nabeeh et al., (2019a); (Nabeeh et al., 2019b), a neutrosophic theory is applied to handle the uncertainty conditions to achieve a consistent decision. The decision judgments of the healthcare system, team, and givers are modeled in neutrosophic scale format and integrated. The AHP is used to prioritize weights for criteria as the following consequences: $C_2 \rightarrow C_1$
$\rightarrow C_3 \rightarrow C_5 \rightarrow C_4 \rightarrow C_6 \rightarrow C_8 \rightarrow C_7 \rightarrow C_9 \rightarrow C_{10} \rightarrow C_{11} \rightarrow C_{13} \rightarrow C_{12} \rightarrow C_{14} \rightarrow C_{13} \rightarrow C_{15} \rightarrow C_{16}$.

The 20 patients, as problem alternatives, are ranked according to the hybrid methodology of neutrosophic and TOPSIS (Nabeeh et al., 2019b). The healthcare system, team, and care giver's perspectives are collected and integrated into the neutrosophic scale. The TOPSIS compares alternatives according to relative closeness concerning the weights for criteria symptoms produced from applying the AHP method. The neutrosophic theory is used to handle uncertainty conditions. The patients are prioritized according to the relative closeness of TOPSIS as follows:
$A_{17} \rightarrow A_1 \rightarrow A_{18} \rightarrow A_5 \rightarrow A_4 \rightarrow A_6 \rightarrow A_8 \rightarrow A_7 \rightarrow A_{19} \rightarrow A_{10} \rightarrow A_{11}$
$\rightarrow A_{13} \rightarrow A_{12} \rightarrow A_{20} \rightarrow A_{15} \rightarrow A_{16} \rightarrow A_2 \rightarrow A_3 \rightarrow A_9 \rightarrow A_{14}$

In Kapoor et al., (2020), the virtual reality in healthcare for COVID-19 outbreaks adopt eight effective applications which are VR for
Physical therapy,
Management of pain,
Mobile application,

Hospitalized patient,
Physical rehabilitation,
Cognitive rehabilitation,
Distracting patients and
Psychological treatment.

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