Chapter 2

Internet of Things-based smart helmet to detect possible COVID-19 infections

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2.1 Introduction

Presently, the world faced COVID-19, a new disease of the coronavirus family. A new virus was announced by the World Health Organization (WHO) named as 2019-nCoV in January 2020 (World Health Organization, 2020a). The world has detected a large number of COVID-19 cases from December 2019 onward. As of now there is no vaccine for COVID-19, but the recovery rate without any treatment is about 80% (Hageman, 2020). People with low immunity, old age, and medical problems, especially related to the lungs, are more prone to COVID-19 disease. COVID-19 symptoms are much similar to the symptoms of normal flu. In normal flu cough, cold, and breathing problems are common. The recovery rate of a person suffering from COVID-19 can take 14−16 days due to its incubation period of 14 days. As all of us know that prevention is better than cure; therefore for prevention of COVID-19 one should wash hands frequently, avoid touching the mouth, nose, and face, and avoid any type of physical contact with others, that is social distancing should be kept in mind (1 meter or 3 feet). COVID-19 has been declared a pandemic by the WHO. Till now there is no vaccine available in the market. But according to different studies, it has been found that this virus is susceptible to ultraviolet rays and heat (Cascella, Rajnik, Cuomo, Dulebohn, & Di Napoli, 2020). Therefore all the preparations regarding medical facilities from hospitals to the masks, PPE kits, and ventilators should be adequate worldwide. As the number of patients is increasing at a great pace, the need for all these medical facilities is in priority to make it possible for health workers to operate efficiently. To deal with COVID-19 one has to know the accurate growth rate of COVID-19 cases of other countries and

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which country has the highest growth rate, what is the reason behind this, and how they are handling the current situation? It can help the medical and administrative authorities.

The origin of this deadly virus is situated in China's city called Wuhan. Wuhan has a wholesale market especially for sea foods and other animals and this virus came from the intake of one of these animals (Singhal, 2020). Initially it spread to over 37 countries globally, with around 8000 confirmed cases and about 774 death cases (Centers for Disease Control Prevention, 2017). According to the WHO, the total number of confirmed cases worldwide is about 13,876,441cases, and 593,087 are the total number of deaths till July 17, 2020. COVID-19 wreaked havoc in many regions, the United States stands at 7,306,376 confirmed cases, Europe stands at 3,042,330 confirmed cases, and the East Mediterranean region stands at1,360,791 confirmed cases (https://COVID19.who.int/?gclid = Cj0KCQjwu8r4BRCzARIsAA21i_DGpHh9yJeQSHGLxoPJI0rhmCYgtrYKdA4BcXJQpmFVtAUUJQcGbUaAoWhEALw_wcB).

To overcome the growing rate of COVID-19 pandemic several actions have been taken worldwide. All the countries are doing their best to deal with this virus. For example India's state and central governments have taken various strict actions earlier like imposing lockdowns. One of the vital actions taken by the government of Delhi is by having 5T plan as shown in Fig. 2.1.

In the current pandemic circumstances, countries worldwide are trying to maneuver to fight against COVID-19 and to obtain a fixed and cost-effective solution to get rid of this. The situations are getting worse day by day even after taking various vigorous steps to control this deadly virus. This situation is the same worldwide. In Fig. 2.2 the condition of active cases from the months of February to June 2020 are shown. Therefore the requirement of technology arises to get control over this virus by descrying the infectious body. One such technology is "Internet of Things" (IoT), which can interconnect various physical devices such as sensor, actuators, mobile, etc and allow them to interact with each other over a defined network and requires no human intervention during the whole process. All devices are allied with a unique identification code (Bai, Yang, Wang, Tong, & Zhu, 2020; Haleem, Javaid, & Khan, 2019). IoT has already accustomed to the various domains for accomplishing different motives like smart home, smart power grid, smart vehicles, industries, and healthcare department. As IoT can facilitate in the healthcare sector, it can be used to get rid of or to handle COVID-19 (Singh, Javaid, Haleem, & Suman, 2020). The key contributions of this chapter are as follows:

- To discuss the necessity of the IoT-based solutions approach toward handling COVID-19.
- This chapter describes the in-depth study on technology of IoT-based devices and IoT-based smart helmet to detect the infectee of COVID-19.

FIGURE 2.1 5T plan for COVID-19 pandemic.

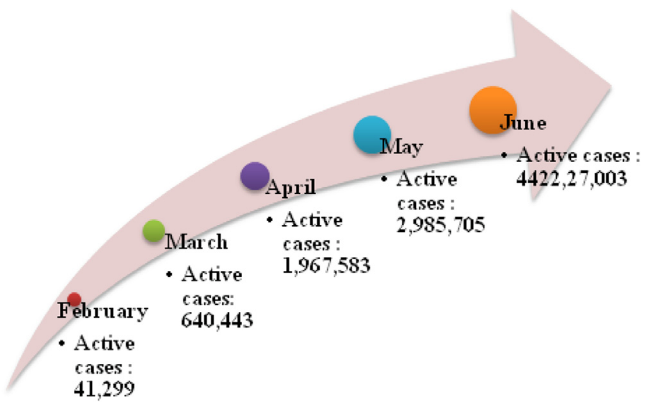

FIGURE 2.2 Timeline of total number of active infected cases from February to June 2020 worldwide.

- Also, it discusses about the future possibilities and applications of IoT-based devices in the healthcare sector.

2.1.1 Epidemiology

At the end of the year December 2019, a virus was reported at the "Wuhan city" of China, amidst people associated with the local seafood market

(Adhikari et al., 2020; Li et al., 2020). After that various researches started to know the severity, characteristics, effectiveness, and transmission capabilities of this virus (CDC, 2020). It came out that the initial cases had its connection with the wet market (seafood market) and later it was found that transmission of the virus was through close contact with the infected person. Various people of the healthcare department got infected while treating the COVID-19 patients (Li, Wei, Li, Hongwei, & Shi, 2020; Liu et al., 2020; Medical Expert Group of Tongji Hospital, 2020; Zhou et al., 2020). Also it was found that people with immunodeficiency and normal people were both prone to this virus, and age distribution between young and old was 25−89 years. Children and even infants cases were also detected (Medical Expert Group of Tongji Hospital, 2020; Wang & Wang, 2020). Further studies showed the median age of patients between 15 years and 89 years was 59 years. The incubation period means the time interval between when an individual got infected for the first time and when he/she shows the first symptoms. According to Chinese health authorities, the patient has 7 days of an average incubation period from 2 to 14 days (National Health Commission of People's Republic of China, 2020). On January 2020, China had 11,791 confirmed cases. Soon COVID-19 blast affect was shown in every country and part of the world (National Health Commission of People's Republic of China, 2020). According to the WHO Emergency Dashboard, the situation of COVID-19 till July 22, 2020 was that there have been 14,562,550 confirmed cases of COVID-19, including 607,781 deaths. Outside China the situation of confirmed cases in different countries are as follows: the United States (374,248), Brazil (2,098,389), India (1,155,191), Russia Federation (783,328), South Africa (373,628), Peru (353,590), Mexico (344,224), Chile (333,029), the United Kingdom (295,3760), Iran (276,202), Pakistan (266,096), and Spain (264,836).

2.1.2 Treatment

Due to the outbreak of the coronavirus, the whole world tends to be in an unprecedented state of austere confusion. Till now, there is neither specific treatment for the virus found nor any preventive vaccine invented to prevent the coronavirus. COVID-19 can be symptomatic or asymptomatic; therefore treatment depends on the symptoms shown by the individual patient (Chamola, Hassija, Gupta, & Guizani, 2020). Some patients having asymptomatic behavior require no treatment and can recover on their own. While patients with minor symptoms can go for home isolation and require minor medications. However, patients with critical conditions such as breathing disorder, asthma, low immune system, etc. need to be hospitalized. In conditions like hypoxemia patients require extra oxygen supply or ventilators. Various antibiotics and antifungals are provided to the patients according to the situations. Therapy called renal replacement can be required if kidney patients suffer from the coronavirus (Wang, Hu, et al., 2020).

Due to the severity of COVID-19, various researches are being made to control the virus as soon as possible. Some of the potential vaccines and drugs are—Moderna's Mrna-1273 (Moderna, 2020; Park, 2020), Pittcovacc (Pittsburgh Coronavirus Vaccine) (UPMC, 2020; Kim et al.), Johnson & Johnson's COVID-19 lead vaccine (Johnson & Johnson, 2020). Drugs such as hydroxychloroquine and arbidol have shown good effects on the patients, and many hospitals are undergoing the trial of these drugs (Holshue et al., 2020; Wang, Cao, et al., 2020). Similarly, favipiravir, bromhexine with hydroxychloroquine, remdesivir, ritonavir, etc. are drugs which are in the different phases of the clinical trial [Source: United States National Library of Medicine (trial phase as on April 29, 2020)]. There are around 99% COVID-19 patients from Wuhan. 76% of patients require oxygen, 13% need noninvasive ventilation, 4% need mechanical ventilation, 9% require continuous renal-replacement therapy, 71% require antibiotics, and 15% require antifungal drugs (Chen, Zhou, & Dong, 2020; Singhal, 2020).

Technologies such as the IoT has been used by researchers to treat COVID-19. Bai et al. (2020) introduced a system called "COVID-19 Intelligent Diagnosis and Treatment Assistant Program" (nCapp) for diagnosis and treatment of COVID-19 patients. The nCapp has three levels "Comprehensive Perception," "Reliable Transmission," and "Intelligent Processing" of the IoT. Fifteen questionnaires have been made for the diagnosis and detection purpose, and based on that patients marked as confirmed or suspected are automatically sent to the nearby doctors. The doctors use a smartphone with nCapp assistant software to connect with the three levels of the cloud. Doctors or physicians have eight functions to manage different activities, that is register, consultations, treatment, map, diagnosis, specialist, protection, and information. nCapp also suggests some treatment to the patient. nCapp system is capable to treat the patient in their home itself and can avoid transmission and prevention (Bai et al., 2020).

2.1.3 Prevention

Prevention of any disease is an essential measure to take. Since till now no specific treatment is available to control this infectious disease, the prevention of COVID-19 is a difficult task. It may be symptomatic or asymptomatic and can spread from the day the individual got infected or even after recovery from the virus (Singhal, 2020). Medical institutes like WHO, Centers for Disease Control and Prevention (CDC) issued some guidelines to prevent this virus (Centers for Disease Control and Prevention, 2020; World Health Organization, 2020b). They suggest to avoid visiting the containment zones (higher risk of COVID-19), try to maintain distance from symptomatic individuals, and also to avoid the nonvegetarian items from the higher risk zones.

Various research has been undergoing to control this pandemic but some researchers and authors also provide prevention techniques (for different fields) or applications. A chat boot (Beboot) has been introduced by a Japanese company based on artificial intelligence that will hand over all the updated information about the outbreak of coronavirus (Bespoke, 2020). Basile et al. (2020) also defined the preventive measures for the hemodialysis centers. As hemodialysis centers' patients are more prone to infection so extra care or preventive measures have to be taken. According to a report (Ma, Diao, & Lv, 2019), Wuhan city of China had 37 cases out of 233 in hemodialysis centers from 14 January to 17 February, among which four staff members out of 33 were found infected. The most effective preventive measure is the isolation of hemodialysis patients from COVID-19 patients.

Therefore isolation is the most appropriate preventive measure of COVID-19 and control of infection that includes effective measures at the time of diagnosis and provisioning of infected patient (CDC, 2020). Fig. 2.3 shows some preventive measures for COVID-19.

To prevent this pandemic the first thing that we have to do is to limit the transmission of cases. To limit the cases some preventive measures are introduced by various standard organizations such as the WHO, which are as follows (Cascella et al., 2020):

- Avoid the direct contact from the person who has symptoms like fever, cold, breathing problem.
- Follow social distancing.
- Use of PPE kit.
- Wash your hands frequently, or sanitize whenever going outside.
- Wear mask whenever going outside and proper disposal of used mask.
- Avoid unprotected contact with farm or wild animals.
- Try to improve your immune system.
- Cover the face with tissue/handkerchief while sneezing or coughing and dispose off properly.
- Can cover your face with flexed elbow while sneezing (CDC, 2020).

These preventive measures should be followed by everyone, should carry hand sanitizer having 80% alcohol, avoid touching your face, eyes, nose

FIGURE 2.3 Preventive measures for COVID-19.

frequently if you are going outside into the environment or in containment zones. Proper use of PPE kit containing N95 mask, gloves, face shield, and gown by the healthcare department (Cascella et al., 2020).

Various technologies also help us to prevent the COVID-19 in enormous ways. One of the technologies like IoT has been adopted in various fields to make things smart like smart home automation, smart grid, and smart healthcare system. Although IoT has its effects on the healthcare system, it is necessary to have IoT to deal with this pandemic. Therefore an idea for IoT-based smart helmet proves to be a promising IoT-enabled device to prevent the coronavirus transmission and detection of infectee becomes easier.

2.1.4 Symptoms

Symptoms of COVID-19 may vary from individual to individual. Some may show asymptomatic behavior (Singhal, 2020). Some situations may arise where an individual has no symptoms but suffering from acute respiratory distress syndrome and multiorder dysfunction syndrome (Chamola et al., 2020). The WHO along with China collaboration and about 55,924 labs found similar clinical characteristics in COVID-19 patients such as fever, cough, and fatigue whereas some cases have symptoms like headache, sore throat, and breathing difficulty. Some symptoms are found rarely in a patient like diarrhea, nausea, and nasal congestion. People having a medical history of diabetes, asthma, hypertension, etc. are more prone to COVID-19 (Centers for Disease Control Prevention (CDC), 2020). Table 2.1 gives a view of the types of symptoms with the percentage of having these symptoms in the infectee.

2.1.5 Stages of COVID-19

According to the WHO, the pandemic COVID-19 has four stages of transmission in every country worldwide and does not show any variations in the stages of transmission (Chamola et al., 2020; WHO, 2020c). With the help of these stages, other countries try to implement preventive measures to deal with this pandemic, the most appropriate example of this being a lockdown. Fig. 2.4 consists of four transmission stages of COVID-19. The four stages description is as follows:

- Imported cases only—This is the first stage of COVID-19. In this stage, only few people got infected by this virus, based on their travel history to the infected area (WHO, 2020d).
- Local transmission—The second stage of COVID-19 exists when there is erratic infection of the virus between the people. Contact tracing becomes easier as the infection came from nearby people such as neighbors,

TABLE 2.1 Symptoms of COVID-19.

S. no	Types of symptoms	Symptoms	Percentage (%)
1	Most common symptoms	• Fever	87.9
		• Dry cough	67.7
		• Fatigue	38.1
		• Sputum production	33.4
2	Less common symptoms	• Breathing disorder	18.6
		• Sore throat	13.9
		• Headache	13.6
		• Chills	11.4
		• Myalgia	14.8
3	Rare symptoms	• Nausea	5.0
		• Diarrhea	3.7
		• Hypostasis	0.8
		• Conjunctional congestion	0.9

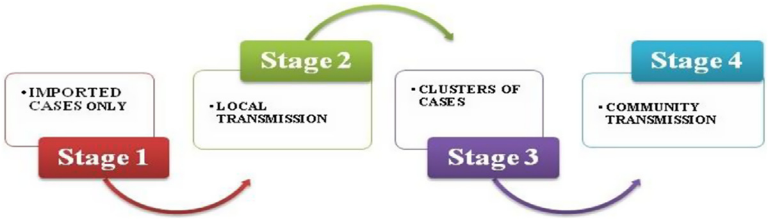

FIGURE 2.4 Four transmission stages of COVID-19.

family, relatives, colleagues, etc. A proper quarantine process can be done easily.

- Clusters of cases—The third stage in any country is considered when some group cases persist in a particular zone in a different area of the country. Tracing the contact of the individual patient becomes hard as the infectee does not have any history of travel or not even have contact with the other infected. The area where such a group of cases are found has to be converted into a containment zone.

- Community spread—The last stage of COVID-19 is the stage of community spread, that is extreme increase in the COVID-19 cases with an increase in the number of deaths. The outbreak of the patients becomes out of control and no prevention techniques seem to be effective. Vaccination is the only way to get control over this outbreak. Community spread like situation can be seen in various countries such as the United States, Turkey, and Canada (WHO, 2020c).

2.1.6 Key merits of IoT for COVID-19 pandemic

IoT is one of the technologies that can be used in every field. When it comes to the healthcare sector IoT is already being used by various hospitals. Now when the world is facing a COVID-19 outbreak there is a need to have an innovative technology that helps us to deal with COVID-19. IoT can assure that infectees are in quarantine. With the help of a proper IoT-based monitoring system we can monitor the infectees. IoT can enhance the efficiency of all the workers with essential duties such as doctors, nurses, police, and other medical staff by declining their workload. Various applications or devices have been developed to control or to prevent the spread of COVID-19, which is discussed in a later section.

Using IoT for COVID-19 can deduct the possibility of mistakes, lower the expenses, provide superior treatment, meliorate diagnosis, effectual control, and able to measure the blood pressure, heart rate, and sugar levels (Mohammed, Syamsudin, et al., 2020; Singh, Javaid, et al., 2020; Vaishya, Javaid, Khan, & Haleem, 2020).

2.1.7 Internet of Things process required for COVID-19

Due to the various challenges in the way to control, prevent, or diagnose COVID-19, IoT seems to be a very innovative technology. IoT is capable to sense the real-time data efficiently, which can help to get or to sense the real-time data of the COVID-19 infected patient and able to gather all the required information. Also, it collects the real-time information of various areas during the lockdown period (Allam & Jones, 2020; Dewey, Hingle, Goelz, & Linzer, 2020; Javaid, Vaishya, Bahl, Suman, & Vaish, 2020; Singh, Javaid, et al., 2020).

The process to grapple with COVID-19 using IoT consists of four steps. In the initial step, IoT is used to collect the health data or to collect the information regarding the crowd during lockdown via drones. In the second step, collected information can be managed by using virtual management. In the third step, analysis of the received data is done to take necessary actions. In the final step, a report will be generated, and timely follow-up has to be done (Gupta, Abdelsalam, & Mittal, 2020; Stoessl, Bhatia, & Merello, 2020).

2.1.8 IoT applications for COVID-19

The areas of application of IoT are very vast. There are different applications of IoT used in the healthcare sector. IoT consists of a huge number of interconnected devices and forms a network that can be used in the healthcare sector for the health management system. It can trace the disease of the patient by using any wearable like fitness band, which is able to get the temperature, heartbeat, etc., and can send alerts or messages to their concerned doctors or hospital. All this information can be collected without any human intervention and can use this data for analysis or for making the decision for the treatment of the patient (Ghosh, Gupta, & Misra, 2020; Gupta & Misra, 2020; Gupta, Ghosh, Singh, & Misra, 2020; Singh, Javaid, et al., 2020; Yang, Gentile, Shen, & Cheng, 2020; Zheng et al., 2020). IoT is capable to predict the imminent condition by using the sensed data. Various fraud claims can be made by the fraudsters to verify the details; hence insurance companies can also make use of this technology. Table 2.2 provides the details of the IoT applications with its usage.

2.2 Related work

Although the survey on COVID-19 is not very vast as it was found in December 2019, medical teams of various countries are trying to find out the solution to this virus but have not succeeded yet. But researchers are also giving their contribution.

Dong and Du (2020) present an online interactive dashboard to envision and track the overall cases of COVID-19 in real-time. On January 22, the dashboard has been shared to show the information about the current situations, that is number of deaths, the number of infected patients, and number of recoveries. And it is freely available online. From January 22–31, all the collection of data and updating is done manually twice a day, that is morning and night. A platform called DXY is used by the Chinese government and medical staff.

Maanak Gupta et al. (Khanna and Anand, 2016) presented an architecture and some use case of COVID-19 to implement social distancing using smart city and intelligent transport system. The architecture contains physical devices like smart transport, sensor devices, and smart traffic light system, responsible for exchanging data with nearby smart devices and at the same time sends data to the cloud for further processing for communication Message Queuing Telemetry Transport protocols. To implement social distancing a drone can be used to track the different areas and if in any community social distancing is not followed then messages are sent to the nearby traffic controllers. So that action can be taken. Similarly, some use cases are defined by the author to maintain social distancing like monitoring large gatherings, rerouting traffic to reduce footprint, smart parking (Khanna &

TABLE 2.2 The IoT applications for healthcare sector (Bai et al., 2020; Hassen, Ayari, & Hamdi, 2020; Singh, Javaid, et al., 2020; Swayamsiddha & Mohanty, 2020).

S. no.	IoT applications	Usage
1	Inter connecting hospital via IoT.	To fulfill the requirement of integrated network of hospital using IoT.
2	Transparent COVID-19 treatment.	To get the treatment of COVID-19 pandemic in a fair manner.
3	Smart tracing of infected patients,	To trace the COVID-19 patients in the starting days of infection.
4	Connect all medical tools and devices through the internet.	To transmit the real-time treatment information, IoT connection of medical tools and devices via internet is necessary.
5	Accurate forecasting of virus.	To predict the current situations some statistical methods are used so that data can be helpful for medical teams for the treatment of COVID-19 patient.
6	Wireless healthcare network to identify COVID-19 patient.	To identify the patient infected with COVID-19 by using various authentic applications in smart phones.
7	Rapid COVID-19 screening.	To diagnose the infection at the very initial stage by using the smart devices in IoT environment.
8	IoT-based home hospitalization system.	To treat the disease at home by monitoring patient information via mobile applications by the doctors.
9	Application of cognitive Internet of Medical Things.	For tracing patient in real-time, prevention, remote monitoring, rapid diagnosis, screening, and surveillance.
10	COVID-19 Intelligent Diagnosis and Treatment Assistant Program (nCapp).	Diagnosis of the patient in real-time and make treatment available by sending the data to the doctors.

Anand, 2016), intelligent transport system, and big data and artificial intelligence.

Singh, Javaid, et al. (2020) presented a review of different IoT applications to show the effectiveness of using IoT applications for the COVID-19 pandemic. The author collected the data from different sources like Google Scholar by using different keywords like “IoT,” “COVID-19” etc., and also used various blogs. This review is beneficial to handle or to understand the advantages of having IoT applications.

Greco, Percannella, Ritrovato, Tortorella, and Vento (2020) overviewed the trends in the healthcare sector by using the IoT. They discussed how the integration of IoT and cloud computing leads to sustaining real-time applications. By sensing the real-time data from a wearable sensor, the processing and analysis of the received enormous data help to obtain the real condition of the patient. The authors reviewed various papers on IoT solution in the field of healthcare, initially from sensing the patient via wearable sensors to the latest trends for smart health by suing emerging IoT technology called Fog and edge computing.

Kummitha (2020) presented a literature survey to show the discrepancy between practices to control the COVID-19 pandemic. The author analogizes two contrasting approaches, that is human-driven approach and techno-driven approach to know which approach shows effective preventive measures for COVID-19. The techno-driven approach was adopted by China while the human-driven approach was followed by the western democracies. Literature focuses on understanding the relationship between humans and technology, which provides some observations for prevention and control of COVID-19.

Wang, Sun, Duong, Nguyen, and Hanzo (2020) presented a scheme to diagnose infected cases of COVID-19. The authors used a weighted undirected graph to propose the social IoT network topology evolving during the outbreak of a pandemic. They proposed a framework for the minimum-weight vertex cover problem of graph theory (He et al., 2017) and an algorithm for risk-aware adaptive identification. Simulation has been performed on a realistic dataset to show the suppression of transmission in a large and small area.

Angurala, Bala, Bamber, Kaur, and Singh (2020) proposed a system called Drone-based COVID-19 Medical Service (DBCMS), especially for the healthcare workers as they are susceptible to COVID-19 infection while treatment of the infected individuals. To control or prevent the infection, the drone plays an important role in the proposed mechanism. The author showed the overall infected healthcare workers till April 22, 2020 (https://www.thehindu.com/data/how-many-doctors-and-nurses-have-tested-positive-for coronavirus-in-india/article31410464.ece). DBCMS architecture consists of three layers. The first layer gathers the samples, second stage is responsible for the serious patients that require immediate consultation and medication by the expert doctors. Stage three is for the top-level authority to alert them for the alarming COVID-19 situations.

Chamola et al. (2020) provided a detailed review of COVID-19. The main aim is to eliminate the false report and to showcase the real facts about the COVID-19 pandemic. They also discussed the technologies such as IoT, artificial intelligence, 5 G, and Machine Learning, which can be useful to control or prevent the COVID-19 outbreak. Various applications also related to these technologies are also mentioned by the authors.

Song, Jiang, Wang, Yang, and Bai (2020) described the role of the IoT for control and prevention of Severe Acute Respiratory Infection by using IoT with AI, sensors, and other network devices. IoT is able to communicate between different hospitals, patients, and other healthcare devices, by which existing medical situations would improve. The authors also discussed the variety of applications in the field of medicine, especially respiratory diseases or infection. They also elaborated on the prevention, development, and prospects of the medical IoT.

2.3 IoT-based smart helmet to detect the infection of COVID-19

2.3.1 Objective

Due to the outbreak of COVID-19, the exigency of the hour is to control and to avert the transmission of the virus. COVID-19 spreads rapidly from individual to individual. All preventive measures are lacking as the thermal screening process to check the temperature of the body takes much time. Also, the people doing the thermal screening process have a higher chance to get infected. Therefore the requisite to do more screening processes at the early stage of the infection and screening process should be done efficiently and by maintaining social distance. Therefore to detect the virus automatically a smart device is introduced, that is “smart helmet.”

2.3.2 Methodology

The solution of the IoT is to develop smart helmet and to detect possible COVID-19 infections. IoT applications in the healthcare sector light up the hope for better services and resource availability at the time of requirement for the patients. IoT consists of sensors to sense the biometrics of the patients, big data, and cloud computing for analysis of the data received through telemedicine, and hospital management system. Till now, various researchers are doing their best to use the innovative technologies to cure or prevent the infection, such as monitoring of hand wash via sensor enable devices, health monitoring devices, remote tracking and monitoring of the infectee, etc. (Fong, Wui Yung Chin, Abbas, Jamal, & Ahmed, 2019; Hu, Xie, & Shen, 2013; Mohammed, Desyansah, Al-Zubaidi, & Yusuf; Zamani, Mohammed, & Al-Zubaidi, 2020). Hassen et al. (2020) introduced an application called the hospital management system using IoT to treat the disease at home by monitoring patient information via mobile applications by the doctors. Similarly, Bai et al. (2020) proposed a COVID-19 Intelligent Diagnosis and Treatment Assistant Program (nCapp) that diagnoses the patient in real-time and makes treatment available by sending the data to the doctors. Mohammed, Hazairin, et al. (2020) proposed a system capable to detect and diagnose the COVID-19 using IoT technology. The authors introduced a smart glass to detect the infectious body in the suspected area and send the gathered data to the health officer.

To suspect the infected cases smart helmet is introduced. Smart helmet is fitted with two cameras: thermal camera and normal camera (optical). Thermal cameras do the screening process and are installed on the side of the helmet, which is capable to screen 13 people in 1 minute. An optical camera takes photographs. A sensor device is also installed to the helmet, which is connected to the smart watch to get the temperature of the suspect. Based on the displayed temperature in the smart watch it can be decided if the suspect is COVID-19 positive or not (http://timesofindia.indiatimes.com/articleshow/77168216.cms?utm_source = contentofinterest&utm_medium = text&utm_campaign = cppst).

2.3.2.1 Efficiency of smart helmet

- Capable of doing mass screening.
- Screening can be done by following social distancing.
- Using IoT can enable to send information to the health officer.
- Capable of storing the infectee data using IoT.

A smart helmet (Mohammed, Hazairin, et al., 2020) has been proposed using IoT solutions, which is capable to automatically detect if the patient is infected by COVID-19 or not using thermal camera. With help of IoT, real-time data are collected after proper screening process.

2.3.2.2 Components of smart helmet

2.3.2.2.1 Thermal camera

A thermal camera also known as an infrared camera uses infrared waves to capture an image similar to the normal camera that exploits light to create an image. It aims to detect the high-temperature bodies by comparing the temperature with other bodies in the containment zone. Therefore when envisaging the body with high temperature it generates the infrared spectra of high intensity.

2.3.2.2.2 Optical camera

An optical camera is a normal camera used to capture the image of the infected or containment zone to use it later for the verification purpose by the concerned authorities.

2.3.2.2.3 Arduino Integrated Development Environment (IDE)

It is a platform written in JAVA. It consists of many characteristics like brace matching, libraries, multiple file compilation, syntax highlighting, etc.

Arduino IDE is loaded up with the Arduino board and uses a one-click process to compile and upload the program. Languages like C and C++ are also supported. It also consists of various input – output methods for software libraries.

2.3.2.2.4 Proteus software

To provide real-time simulation a software is used which is called the Proteus software that offers the simulation, schematics, and circuit design to permit the human to acquire access for the duration of running phase (Jamal, AL Narayanasamy, MohdZaki, & Abbas Helmi, 2019; Mohammed, Syamsudin, et al., 2020).

2.3.2.2.5 Google Location History

Google Location History is the service provided by Google that stores every location of the user visited with each mobile device. The proper management of the data is handled by the Google account and user's routine and mobility can be accessed by the Google Location History (Fong, Chin Wui Yung, Ahmed, & Jamal, 2019).

Smart helmet processing has three modules; all the modules are interconnected with each other. Image processing is the module that processes all the data received from the thermal and optical cameras. Fig. 2.5 shows the design of a smart helmet. The main task of data collection is handled by the smart helmet. The interfacing between the modules happens via the IoT communication links and GSM. The working process of the smart helmet is shown in Fig. 2.6.

Smart helmet is outfitted with two cameras to get the detailed data of body temperature and face detection. This information is provided by the thermal camera and optical camera, respectively. Both the cameras are incorporated in the smart helmet. The process started with the screening process by scanning the area or containment zone by using a thermal camera. After screening of the suspected area and the people, if the temperature is found to

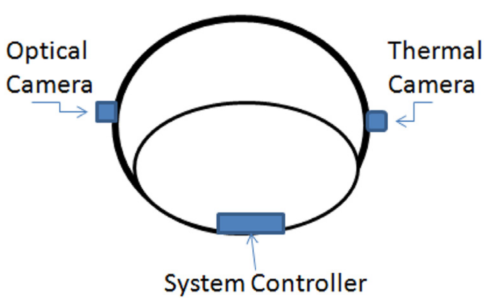

FIGURE 2.5 Design of overall system with system controller, thermal camera, and optical camera.

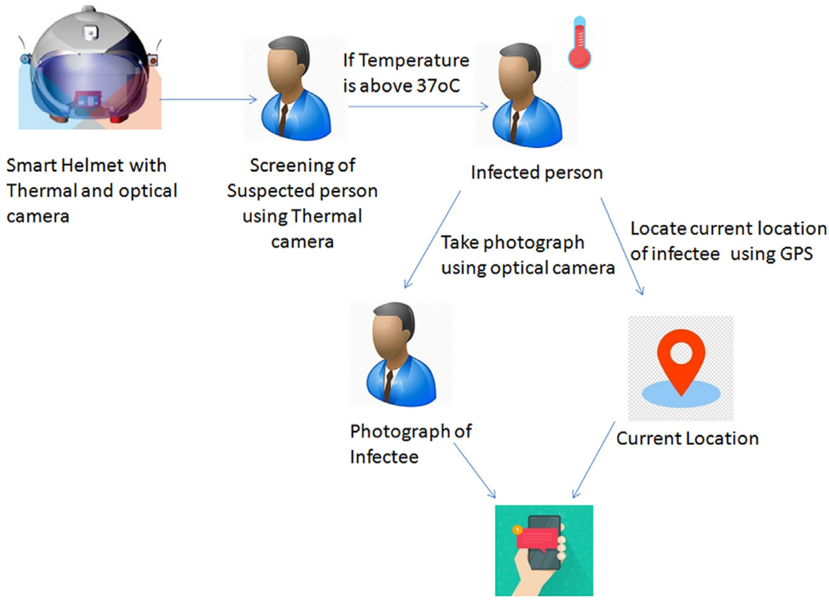

FIGURE 2.6 Working process of the smart helmet.

be higher than 37°C then the chances of COVID-19 infection increases, and the picture will be taken with the help of an optical camera. Now the current location of the infectee or the containment zone is determined by using GPS. Gathered data, that is photographs and location, are sent to the concerned authority and a notification is sent to the mobile phone via GSM with collected information to verify the infectee. A smart helmet mechanism is categorized into three parts. The first part is responsible for the input taken by the two cameras, that is thermal camera and optical camera, and with the application installed on the mobile phone. In the second part processor development is involved in which integration is involved using Arduino DE software. Arduino IDE carries out the coding of the source code and compiles the commands and source code into the NODEMCU V2 processor. The third part is responsible for the output mechanism (Mohammed, Hazairin, et al., 2020).

Cascade classification algorithm is used to face the detection process (Viola & Jones, 2001). Positive and negative images are trained with the use of cascade function in machine learning algorithms. Open CV library used for APIs and cascade object detection that perceive the face of the image is taken by the camera. The face recognition process is a process largely focused for many years. Also, performance and processing from computer vision prospects in video or online streaming become possible in the transferable device. As COVID-19 is a transferable infection, it is necessary to know the history of the infection. Therefore when a suspected person is found to be infected, the history of the visited place needs to be found out. For this, Google Location History was used to obtain a detailed history of the infectee (Ruktanonchai, Ruktanonchai, Floyd, & Tatem, 2018; Sardianos, Varlamis, & Bouras, 2018). Sequential communication used by the Arduino to deliver the collected data, that is infectee body temperature, face recognition, GPS location, NodeMcu a micro-controller have the data and transmit it to the network, to make information available for the worldwide access. Blynk was used as an external server (Bhatnagar et al., 2020; Kumari et al., 2020; Singh, Poonia, et al., 2020).

2.4 Conclusion

The IoT provides a wide-ranging network to the healthcare sector. In the COVID-19 outbreak an infectious and transferable virus hit the world in the last month of 2019 and millions of people have lost their lives. IoT technology provides a way to fasten the preventive and screening process by connecting all devices related to healthcare to the internet and automatically transfer the message to the medical team. IoT make it possible to treat the infected people remotely and can make aware of the impending situations. An innovative smart helmet, integrated with a thermal camera, has come into existence to automatically detect the infectee. Therefore thermography is used, which is a process of thermal screening of an individual or cluster of people. Artificial intelligence and IoT are used to analyze the COVID-19. The diagnosis process using a smart helmet takes less amount of time compared to the normal screening process. In future, applications of IoT-enabled devices can be used to handle this type of pandemic or any other medical emergencies and will able to handle the healthcare sectors or hospitals more efficiently in a cost-effective manner. Therefore it can be concluded that to satisfy the requirement of the healthcare sector to identify, monitor, and to control the COVID-19 remote sensing procedures provides assurance and potential.

References

Adhikari S. P., Meng S., Wu Y. -J., Mao Y. -P., Ye R. -X., Wang Q. -Z., . . . Zhoul H. (2020), Epidemiology, causes, clinical manifestation and diagnosis, prevention and control of coronavirus disease (COVID-19) during the early outbreak period: A scoping review. Available from: https://doi.org/10.1186/s40249-020-00646-x.

Allam, Z., & Jones, D. S. (2020). On the coronavirus (COVID-19) outbreak and the smart city-network: Universal data sharing standards coupled with artificial intelligence(AI) to benefit urban health monitoring and management. *Healthcare*, *8*(1), 46, Multidisciplinary Digital Publishing Institute.

Angurala, M., Bala, M., Bamber, S. S., Kaur, R., & Singh, P. (2020). An internet of things assisted drone based approach to reduce rapid spread of COVID-19. *Journal of Safety Science and Resilience*, *1*, 31−35.

Bai, L., Yang, D., Wang, X., Tong, L., Zhu, X., et al. (2020). Chinese experts' consensus on the Internet of Things-aided diagnosis and treatment of coronavirus disease 2019 (COVID-19). *Clinical e Health*, *3*, 7−15.

Basile, C., Combe, C., Pizzarelli, F., Covic, A., Davenport, A., Kanbay, M., . . . Mitra, S. (2020). Recommendations for the prevention, mitigation and containment of the emerging SARS-CoV-2 (COVID-19) pandemic in haemodialysiscentres. *Nephrology, Dialysis, Transplantation: Official Publication of the European Dialysis and Transplant Association - European Renal Association*, *35*, 737−741.

Bespoke. (2020). Bebot launches free coronavirus information bot. Available from: https://www.be-spoke.io/index.html.

Bhatnagar, V., Poonia, R. C., Nagar, P., Kumar, S., Singh, V., Raja, L., & Dass, P. (2020). Descriptive analysis of COVID-19 patients in the context of India. *Journal of Interdisciplinary Mathematics*, 1−16. Available from https://doi.org/10.1080/09720502.2020.1761635.

Cascella, M., Rajnik, M., Cuomo, A., Dulebohn, S. C., & Di Napoli, R. (2020). *Features, evaluation and treatment coronavirus (COVID-19) [updated April 6, 2020]'. StatPearls [Internet]*. Treasure Island, FL, USA: StatPearls Publishing. 2020. Available from: https://www.ncbi.nlm.nih.gov/books/NBK554776/.

CDC (2020). 2019 novel coronavirus, Wuhan, China. https://www.cdc.gov/coronavirus/2019-nCoV/summary.html. Accessed July 22, 2020.

Centers for Disease Control and Prevention (2020). 2019 novel coronavirus. Available from: https://www.cdc.gov/coronavirus/2019-ncov/about/transmission.html.

Chamola, V., Hassija, V., Gupta, V., & Guizani, M. (2020). A comprehensive review of the COVID-19 pandemic and the role of IoT, drones, AIi, blockchain, and 5G in managing its impact. Special section on deep learning algorithms for internet of medical things, May 26, 2020.

Chen, N., Zhou, M., Dong, X., et al. (2020). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: A descriptive study. *Lancet*, *395*, 507−513.

UPMC. (April 2020). COVID-19 vaccine candidate shows promise. Available from: https://www.upmc.com/media/news/040220-falogambotto-sars-cov2-vaccine.

Dewey, C., Hingle, S., Goelz, E., & Linzer, M. Supporting clinicians during the COVID-19 pandemic. Annals of Internal Medicine 2020. In press.

Dong, E., & Du, H. (2020), An interactive web-baseddashboard to trackCOVID-19 in real time. Available from: https://doi.org/10.1016/S1473-3099(20)30120-1.

Fong, S. L., Yung, D. C. W., Ahmed, F. Y. H., & Jamal, A. (2019). Smart city bus application with Quick Response (QR) code payment, in ICSCA '19 Proceedings of the 2019 8th *International Conference on Software and Computer Applications*, pp. 248−252, Penang, Malaysia—February 19−21.

Fong, S. L., Chin, D. W. Y., Abbas, R. A., Jamal, A., & Ahmed, F. Y. (2019). Smart city bus application with QR code: A review, 2019 IEEE IEEE *International Conference on Automatic Control and Intelligent Systems* I2CACIS 2019 - Proc., no. June, pp. 34−39.

Ghosh, A., Gupta, R., & Misra, A. (2020). Telemedicine for diabetes care in India during COVID19 pandemic and national lockdown period: guidelines for physicians. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(4), 273−276.

Greco, L., Percannella, G., Ritrovato, P., Tortorella, F., & Vento, M. (2020). Trends in IoT based solutions for health care: Moving AI to the edge. *Pattern Recognition Letters*, *135*, 346−353.

Gupta, M., Abdelsalam, M., & Mittal, S. (2020). Enabling and enforcing social distancingmeasures using smart city and its infrastructures: A COVID-19 use case. arXivpreprint arXiv:2004.09246. April 13.

Gupta, R., Ghosh, A., Singh, A. K., & Misra, A. (2020). Clinical considerations for patients with diabetes in times of COVID-19 epidemic. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(3), 211e2.

Gupta, R., & Misra, A. (2020). Contentious issues and evolving concepts in the clinicalpresentation and management of patients with COVID-19 infection withreference to use of therapeutic and other drugs used in co-morbid diseases (hypertension, diabetes etc.). *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(3), 251e4.

Hageman, J. R. (2020). The coronavirus disease 2019 (COVID-19). *Pediatric Annals*, *49*(3), e99−e100.

Haleem, A., Javaid, M., & Khan, I. H. (2019). Internet of things (IoT) applications in orthopaedics. *Journal of Clinical Orthopaedics and Trauma*. Available from https://doi.org/10.1016/j.jcot.2019.07.003.

Hassen, H. B., Ayari, N., & Hamdi, B. (2020). A home hospitalization system based on the Internet of things, fog computing and cloud computing. *Informatics in Medicine Unlocked 20*, 100368.

He, Z., Cai, Z., Yu, J., Wang, X., Sun, Y., & Li, Y. (2017). Cost-efficient strategiesfor restraining rumor spreading in mobile social networks. *IEEE Transactions on Vehicular Technology*, *66*(3), 2789−2800.

Holshue, M. L., DeBolt, C., Lindquist, S., Lofy, K. H., Wiesman, J., Bruce, H., . . . Tural, A. (2020). First case of 2019 novel coronavirus in the United States. *The New England Journal of Medicine*, *382*, 929−936. Available from https://doi.org/10.1056/NEJMoa2001191.

Hu, F., Xie, D., & Shen, S. (2013). On the application of the internet of things in the field of medical and health care, Proc. - 2013 IEEE International Conference on Green Computing and Communications and IEEE Internet of Things and IEEE Cyber, Physical and Social Computing. *Green Com-iThings-CPS Com*, 2013, no. August 2013, pp. 2053−2058.

Jamal, A., Narayanasamy, D. D. A. L., Mohd Zaki, N. Q. & Abbas Helmi, R. A. (2019). Large hall temperature monitoring portal, in 2019 IEEE *International Conference on Automatic Control and Intelligent Systems* (I2CACIS), Selangor, Malaysia, pp. 62−67.

Javaid, M., Vaishya, R., Bahl, S., Suman, R., & Vaish, A. (2020). Industry 4.0 technologies and their applications in fighting COVID-19 pandemic. *Diabetes & Mmetabolic Syndrome. Clinical Research & Reviews*. Available from https://doi.org/10.1016/j.dsx.2020.04.032.

Johnson & Johnson. (March 2020). Johnson & Johnson announces a lead vaccine candidate for COVID-19. Available from: https://www.jnj.com/johnson-johnson-announces-a-lead-vaccinecandidate-%25for-COVID-19-landmark-new-partnership-with-u-sdepartment-of-health-human-serv%25ices-and-commitment-to-supplyone-billion-vaccines-worldwide-for-emergency-pan%demic-use.

Khanna, A. & Anand, R. (2016). IoT based smart parking system. In 2016 International Conference on Internet of Things and Applications (IOTA), pp. 266−270. IEEE.

Kim, E., Erdos, G., Huang, S., Kenniston, T. W., Balmert, S. C., Carey, C. D., . . . Gambotto, A., Microneedle array delivered recombinant coronavirus vaccines: Immunogenicity and rapid translational development. *EBioMedicine, 55*, 102743. Available from https://doi.org/10.1016/j.ebiom.2020.102743.

Kumari, R., Kumar, S., Poonia, R. C., Singh, V., Raja, L., Bhatnagar, V., & Agarwal, P. (2020). Analysis and predictions of spread, recovery, and death caused by COVID 19 in India. *Big*

Data Mining and Analytics. Available from https://doi.org/10.26599/BDMA.2020.9020013, IEEE.

Kummitha, R. K. R. (2020). Smart technologies for fighting pandemics: The techno- and human-driven approaches in controlling the virus transmission. *Government Information Quarterly*.

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., et al. (2020). Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *The New England Journal of Medicine*. Available from https://doi.org/10.1056/NEJMoa2001316.

Li, T., Wei, C., Li, W., Hongwei, F., & Shi, J. (2020). Beijing Union Medical College Hospital on "pneumonia of novel coronavirus infection" diagnosis and treatment proposal (V2.0). *Medicine Journal of Peking Union Medical College Hospital*. Available from http://kns.cnki.net/kcms/detail/11.5882.r.20200130.1430.002.html. Accessed 2 Feb 2020.

Liu, T., Hu, J., Kang, M., Lin, L., Zhong, H., Xiao, J., et al. (2020). Transmission dynamics of 2019 novel coronavirus (2019-nCoV). Available from: https://doi.org/10.1101/2020.01.25.919787.

Ma, Y., Diao, B., Lv, X. et al. (2020). Novel coronavirus disease in hemodialysis(HD) patients: Report from one HD center in Wuhan, China. Available from: https://www.medrxiv.org/content/10.1101/2020.02.24.20027201v2. Accessed 14 March 2020.

Medical expert group of Tongji hospital. (2020). Quick guide to the diagnosis and treatment of pneumonia for novel coronavirus infections (third edition). Herald of Medicine. http://kns.cnki.net/kcms/detail/42.1293.r.20200130.1803.002.html. Accessed February, 2020.

Moderna. (March 2020). Moderna's work on a potential vaccine against COVID-19. Available from: https://modernatx.com/modernaswork-potential-vaccine-against-COVID%-19.

Mohammed, M. N., Desyansah, S. F., Al-Zubaidi S., & Yusuf, E. (2020). An internet of things-based smart homes and healthcare monitoring and management system, *Journal of Physics: Conference Series*, 1450, 012079.

Mohammed, M. N., Hazairin, N. A., Syamsudin, H., Al-Zubaidi, S., Sairah, A. K., Mustapha, S., & Yusuf, E. (2020). 2019 novel coronavirus disease (COVID-19): Detection and diagnosis system using IoT based smart glasses. *International Journal of Advanced Science and Technology*, *29*(7s), 954−960.

Mohammed, M. N., Syamsudin, H., Al-Zubaidi, S., Sairah, A. K., Ramli, R., & Yusuf, E. (2020). Novel COVID-19 detection and diagnosis system using IoT based smart helmet. *International Journal of Psychosocial Rehabilitation*, *24*(7).

National Health Commission of People's Republic of China (2020). Prevent guideline of 2019-nCoV. Available from: https://www.nhc.gov.cn/xcs/yqfkdt/202001/bc661e49b5bc487dba182f5c49ac445b.shtml. Accessed February 1, 2020.

Park, A. (March 2020). As the first coronavirus vaccine human trials begin, manufacturer is already preparing to scale production to millions. Available from: https://time.com/5807669/coronavirusvaccine-moderna/.

Centers for Disease Control Prevention (CDC) (April 2020). People who are at higher risk for severe illness. Available from: https://www.cdc.gov/coronavirus/2019-ncov/need-extraprecautions/people%-at-higher-risk.html.

Ruktanonchai, N. W., Ruktanonchai, C. W., Floyd, J. R., & Tatem, A. J. (2018). Using Google Location History data to quantify fine-scale human mobility. *International Journal of Health Geographics*, *17*(1), 1−13.

Sardianos, C., Varlamis, I., & Bouras, G. (2018). Extracting user habits from google maps history logs, Proc. 2018 IEEE/ACM *International Conference on Advances in Social Network Analysis and Mining*, ASONAM 2018, pp. 690−697.

Centers for Disease Control Prevention (CDC). (December 2017). SARS Basics Fact Sheet. Available from: https://www.cdc.gov/sars/about/fssars.Html.

Singh, R. P., Javaid, M., Haleem, A., & Suman, R. (2020). Internet of things (IoT) applications to fight against COVID-19 pandemic. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*, 521−524.

Singh, V., Poonia, R. C., Kumar, S., Dass, P., Agarwal, P., Bhatnagar, V., & Raja, L. (2020). Prediction of COVID-19 coronavirus pandemic based on time series data using support vector machine. *Journal of Discrete Mathematical Sciences & Cryptography*. Available from https://doi.org/10.1080/09720529.2020.1784525.

Singhal, T. (2020). A review of coronavirus disease-2019 (COVID-19). *Indian Journal of Pediatrics*, *87*(4), 281−286.

Song, Y., Jiang, J., Wang, X., Yang, D., & Bai, C. (2020). Prospect and application of Internet of Things technology for preventionof SARIs. *Clinical eHealth*, *3*, 1−4.

Stoessl, A. J., Bhatia, K. P., & Merello, M. (2020). Movement disorders in the world of COVID-19. Movement Disorders Clinical Practice. In press.

Swayamsiddha, S., & Mohanty, C. (2020). Application of cognitive Internet of Medical Things for COVID-19 pandemic, Diabetes & Metabolic Syndrome: Clinical Research & Reviews.

Vaishya, R., Javaid, M., Khan, I. H., & Haleem, A. (2020). Artificial Intelligence (AI) applications for COVID-19 pandemic. *Diabetes & Metabolic Syndrome. Clinical Research & Reviews*. Available from https://doi.org/10.1016/j.dsx.2020.04.012.

Viola, P., & Jones, M., (2001). Rapid object detection using a boosted cascade of simple Features, Proc. 2001 IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognition. CVPR 2001, pp. 511−518.

Wang, B., Sun, Y., Duong, T. Q., Nguyen, L. D., & Hanzo, L. (2020). Risk-aware identification of highly suspected COVID-19 cases in social IoT: A joint graph theory and reinforcement learning approach, VOLUME 8, 10.1109/ACCESS.2020.3003750.

Wang, C., & Wang, X. (2020). Prevalence, nosocomial infection and psychological prevention of novel coronavirus infection. *Chinese General Practice and Nursing*, *18*, 2−3.

Wang, D., Hu, B., Hu, C., Zhu, F., Liu, X., Zhang, J., ... Peng, Z. (2020). Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus_infected pneumonia in Wuhan, China. *Journal of the American Medical Association*, *323*(11), 1061.

Wang, M., Cao, R., Zhang, L., Yang, X., Liu, J., Xu, M., ... Xiao, G. (2020). Remdesivir and chloroquine effectively inhibit the recently emerged novel coronavirus (2019-nCoV) in vitro. *Cell Research*, *30*(3), 269−271.

World Health Organization (2020a). Laboratory testing for 2019 novel coronavirus (2019-nCoV) in suspected human cases, vol. 2019, no. January, pp. 1−7.

World Health Organization (2020b). Novel coronavirus (2019-nCoV) advice for the public. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public.

WHO (April 2020c). *Coronavirus Disease 2019 (COVID-19) SituationReport 87*. Available from: https://www.who.int/docs/defaultsource/coronaviruse/situation-reports/%20200416-sitrep-87-COVID-19.pdf?sfvrsn = 9523115a_2.

WHO. (April 2020d). *Coronavirus Disease 2019 (COVID-19) SituationReport 79*. Available from: https://www.who.int/docs/defaultsource/coronaviruse/situation-reports/%20200408-sitrep-79-COVID-19.pdf?sfvrsn = 4796b143_6.

WHO Emergency Dashboard. Available from: https://COVID19.who.int/?gclid = CjwKCAjwx9_4BRAHEiwApAt0zh1NF5dqq002bZYmIVgSIRygPi1dT1wVLtsYzY379-f3eti8SPK4T-xoCbbgQAvD_BwE.

Yang, T., Gentile, M., Shen, C. F., & Cheng, C. M. (2020). Combining point-of-care diagnostics and internet of medical things (IoMT) to combat the COVID-19 pandemic. *Diagnostics*. Available from https://doi.org/10.3390/diagnostics10040224.

Zamani, N. S., Mohammed, M. N., & Al-Zubaidi, S. (2020). Design and development of portable digital microscope platform using IoT tTechnology, in IEEE International Colloquium on Signal Processing & Its Applications (CSPA 2020).

Zheng, S. Q., Yang, L., Zhou, P. X., Li, H. B., Liu, F., & Zhao, R. S. (2020). Recommendations andguidance for providing pharmaceutical care services during COVID-19 pandemic: A China perspective. *Research in Social and Administrative Pharmacy*.

Zhou, P., Yang, X. L., Wang, X. G., Hu, B., Zhang, L., Zhang, W., et al. (2020) Discovery of a novel coronavirus associated with the recent pneumonia outbreak in humans and its potential bat origin. bioRxiv. Available from: https://doi.org/10.1101/2020.01.22.914952.