A Survey on COVID-19 Pandemic Management

Rachana Radhakrishnan
Department of ISE
JSSATE-B
Bangalore

Sowmya K N
Department of ISE
JSSATE-B
Bangalore

Abstract **- In the digital ecosystem we live in, the healthcare domain has been benefited to a larger extent since real time monitoring, tracking of patients have all been made possible and has enabled the healthcare industry in a notable manner. Disaster management that focuses on large outbreaks and medical emergencies that may arise due to bio-terrorism, biological pathogen disaster and pandemics. In this internet era where data is king it is apparent that technology, the internet and the use of smartphones is becoming ubiquitous. Technological health care options are becoming more apparent and have shown exponential growth in the past decade. This has been useful in the treatment of diseases especially in the COVID 19 pandemic situation at hand. These digital technologies include the internet of things (IoT) with next-gen telecommunication networks like 5G, artificial intelligence (AI) that integrates deep learning and block chain technology and most importantly big-data analytics. They are highly interrelated: the escalation of the usage of IoT (e.g., devices and instruments) in healthcare eases the establishment of a highly integrated digital ecosystem, which enables real time data collection that can be utilized by AI models to obtain a better understanding of healthcare trends, related risks and also in outcome prediction.**

Keywords - healthcare; technology; artificial intelligence; digital ecosystem; COVID-19 pandemic.

I. INTRODUCTION

COVID-19 is a contagious disease caused by the family of viruses called SARS-CoV-2. It is transmittable from person-to-person and has caused global alarm. Hospitals and health centers all over the world are being overloaded by the number of cases flowing in everyday. Doctors and scientists all across the globe are trying to incorporate virtual treatments that eliminate contact between infected victims and physicians. In practice the most readily available source of data for detection are images of the lungs such as CTs and X-Rays. The process of acquiring these images can be made contactless with ease using AI technology which alleviates some of the risk imposed on health technicians. Artificial Intelligence being an upcoming technology in the medical field has provided largely in the fight against COVID-19. Compared to the traditional imaging workflow that heavily relies on human labors, AI enables more safe, accurate and efficient imaging solutions. The purpose of medical imaging improved by integration of AI has improved the contactless process of acquiring image data for diagnosis. Other technologies like deep learning, machine learning, face recognition, thermal imaging, GPS and bluetooth have been used to detect and diagnose symptoms and to track suspected patients while simultaneously alleviating risk of spread and infection. Various types of work have been carried out after the COVID-19 outbreak related to epidemic tracking and management. In this article a brief review of them has been carried out.

II. MATERIALS AND METHODS

The major source of data for the diagnosis of the virus is chest X-Rays or thoracic CTs of suspects that are available from healthcare sources. The JHU dashboard has a good collection of such images that are used in the study and analysis of the virus with different imaging workflows and analysis tools to make informed predictions. Scans of uninfected patients are available on Kaggle and these are used for comparative training and testing processes in machine learning models. The various methods and models used in previous pandemics/epidemics are also a vital source of data from which decisions can be made to choose the more successful ones and more importantly what to avoid during such a situation.

A. Dataset Sources (Heading 2)

A large number of datasets of scans of COVID-19 infected patients are vital in the process of identification and diagnosis of this disease. These datasets must be collected from reliable sources. This study identifies some major sources for COVID-19 related datasets as Johns Hopkins University data, WHO - World Health Organization data and data from health bulletins updated by the governments of respective areas. The JHU-Johns Hopkins University Dashboard and their GitHub repository has periodically updated accurate datasets for COVID-19 which are extracted and presented in Kaggle as well. These Kaggle datasets are clearly organized and contain information on the number of affected cases, deaths and recovery from the 2019 coronavirus. The main file is a CSV-Comma Separated Values file that has data under the following columns- serial number, observation date, province/state, country/region, last update, confirmed, deaths, recovered. A country wise collection of data is also provided.

B. Epidemic/Pandmeic History

This study identifies the usage of technology in similar pandemics/epidemics that have surfaced over centuries. Some examples of these are Ebola virus, Zika virus, SARS-Severe Acute Respiratory Syndrome of 2003 and malaria. Technologies like IOT, AI and block chain have played a major role in the containment and management of these outbreaks which can be improved upon and utilized for the COVID-19 pandemic at hand.

Ernest Tambo et al [8], has discussed the use of the internet and social media to healthcare workers to be better prepared to deal with cross border pandemic containment and control. Public awareness and health education based on surveillance technologies to monitor further transmission is a common goal during epidemic/pandemic situations. Mapping was an important feature that helped in contact tracing and early warning to implement appropriate defensive measures in areas infected with Ebola. There are still many features about Zika and Ebola that are still unknown and real-time frontline digitization and ICTs go a long way in aiding control strategies that help to curb the rapid spread of such viruses. This will also help in building a better understanding to deal with future outbreaks in a better prepared manner. HealthMaps are a brilliant way to keep track of the number of people infected in specific locations for epidemiologists to track. Infected patients can be contacted using ICT services and aid in the effective containment of the virus. The author mentions that despite the many advantages of mobile technology and social media, these methods may raise ethical and legal issues that violate security and privacy. There may also be cases of inaccuracies and inequality in accessing data leading to distrust.

Edward Anderson et al [9], has recognized the value of use of satellite technology in the tracking, detection and containment of epidemics. It is important in the malaria model to map mosquito densities since it is the biggest vector borne disease spread by the anopheles' mosquito. EPIDEMIO was a project initiated by the European Space Agency in 2004 in which satellites are utilized to collect environmental parameters like temperature, elevation and presence of water bodies that control the malaria vector. EPIDEMIO's mapping data of vegetation and presence infected animals aided in recognition of areas with similar characteristics to prioritize for further study in various other countries. HISTAR solutions was another European-based initiative that had three main objectives- providing low cost- real time data transmission, geopositioning and a portal for online access of useful epidemiological data. These satellite based surveillance technologies aid in recognizing the most important step in reducing impact of these epidemics that is early identification and timely response. The integration of these satellite based technologies must be undertaken by the government to provide sufficient data for monitoring of pandemic/epidemic factors and their containment measures.

Daniel Shu Wei Ting et al [10], has discussed some of the digital tools that have been developed in the past decade that have been of use in remedying the COVID-19 outbreak. Emergence and development of technologies like IOT, Big Data, Artificial Intelligence and Deep Learning have played an important role in handling and management of the pandemic outbreak. IOT has provided public health agencies to access pandemic-related data. Big Data, AI and Deep Learning techniques have helped to improve detection and diagnosis of the novel virus at lower costs. Virtual clinics can be set up using tele-medical consultations and online chatbots could help contactless consultations and detection of symptoms earlier. Partnering with blockchain companies and pharmacies has helped in doorstep delivery of medication. Although public acceptance of technology may be a challenge in some parts of the world, use of digital technology in a pandemic situation can go a long way in containing the spread of the virus.

III. METHODOLOGIES

The primary approach involved in pandemic management like covid involves effective identification, analysis and diagnosis and tracking of suspects as shown in Figure 1. The identification of affected people through symptom recognition is the first step in the basic screening process of suspected cases. This study also recognizes the importance of the analysis of the data obtained from identification in the detection and diagnosis of the virus. Post detection and conformation of the virus in suspected cases involve tracking the progression of the virus spread in the suspect during recovery. Technologies like deep learning, artificial intelligence and exploratory data analysis are some of the methods that have been observed to have promising results.

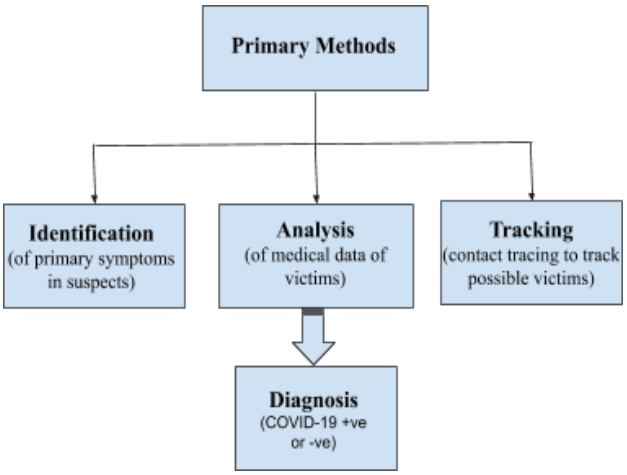

Fig. 1. Primary Methods in Pandemic Management.

A. *Identification*

Jorg Guttler et al [2], after studying about the covid-19 pandemic and its symptomatic indications, focus is now towards identification of subjects. Fever is one such prime symptom. Due to its viral transmission nature from human to human, thermal imaging sensors are used to avoid human intervention. The authors implement a face recognition and temperature detection algorithm that takes input from an FLIR camera and uses OpenCV and Tesseract OCR to work on the image and obtain a range of temperatures whose average gives a nearly accurate reading of the temperature of the subject. A deviation detection routine rules out false measurement. Although it may not be reliable always due to changes in ambient environmental factors and human tampering, the work carried out by

Jorg Guttler's technique can be utilized in present scenario for covidian identification. The authors also put forth a portable device to measure fever which can be used for screening at places like offices, airports, railway stations and other such places with ease.

Feng Shi et al [1], have discussed medical image analysis in terms of acquiring segmenting CT and X-Ray images to detect the presence of the virus. Artificial Intelligence empowered techniques prove to be efficient in making the image acquisition process contactless, deep learning convolutional neural networks help in segmentation and analysis of the patient's scans and machine learning helps in diagnosing the disease. Deep learning models like U-Net, ResNet50, InceptionV3 are majorly used in medical imaging analysis. The authors discuss and review some of the more efficient techniques that aid this process of reducing workload on radiologists by 65%. These techniques are also invaluable in monitoring and follow up of infected patients. These techniques provide higher accuracy and can detect symptoms in the earlier stages than humans.

The spread of the virus is exponential. In the initial stages, there are fewer cases and over time the number of cases increase exponentially due to more and more exposure. The different stages of the transmission of the virus is shown in Figure 2.

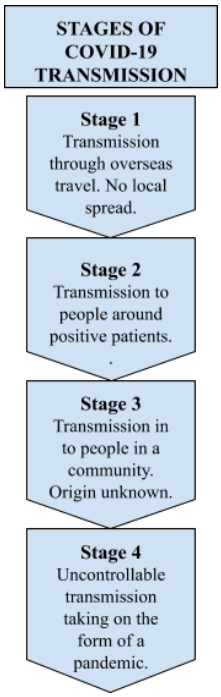

Fig. 2. Stages of Transmission of COVID-19.

B. Analysis and Diagnosis

The analysis of data obtained from the various sources mentioned in this study plays a very important role in the accuracy of the detection and diagnosis of the virus. This study stresses the importance of understanding and usage of data in an efficient manner so as to enable the building of accurate and efficient models that can help in diagnosing COVID-19. There may be shortage of data in the initial stages of the outbreak that may cause difficulties in predictions. The goal is to realise methods that can work with limited amounts of data and still provide satisfactory results.

Becky McCall et al [11], has drawn comparisons between COVID-19 and SARS(of 2003) and the COVID-19 cases have far exceeded those of SARS. Although the basic tactical response for these viruses are very similar, the development of a new tool called AI in the past decade could make a huge difference in limiting the spread of the virus. High quality input data is an important requirement that could help in mapping the outbreak based on area, time and disease agent. The challenge is to obtain adequate and accurate data from social media platforms and government reports to train the machine learning models to enable them to predict the location of the next outbreak so that border restrictions can be put in place. This considerably reduces the burden on healthcare workers and curbs the spread of the virus.

Samrat Kumar Dey et al [7], highlights the importance of analyzing the epidemiological data of the novel virus and the risks it poses to people all over the world. The authors utilize daily level datasets provided by several sources like JHU, WHO, CDC and NHC and they are assembled each column for ease of access. Exploratory Data Analysis is used to analyse and visualize all the data in real-time. A worldwide map is built to visualize the spread of the virus for the selected time period. This visualization done for three categories of data- confirmed, death and recovered helps to gain a better understanding of the behaviour of the epidemic. Although raw data from some sources can be inadequate, visualization aids better understanding of large data repositories. Many websites and apps have been used to keep the public informed on the number of cases around the globe. Statistical data like total number of confirmed cases, deaths and recovered cases are used to make mappings that provide a visual representation - VEDA-Visual Exploratory Data Analysis.The Worldometer is a reference website that provides counters and real-time statistics for COVID-19. The COVID Visualizer is another website that maps the counter statistics from Worldometer onto an interactive globe enabling people to view real-time statistics of each geographical area and refreshes every two minutes.

K. C. Santosh et al [3], discussed how Artificial Intelligence tools have opened many doors in healthcare and provide new innovative ways of working with large amounts of data and generating predictions. The fundamental nature of these algorithms and their rate of success is dependent on the presence of sufficient training data from various sources. Real time data also plays a vital role in building train and test models with high confidence levels in Active Learning models. Cross population training data and data of various types must be employed by scientists for the decision making process to achieve better results. They have concluded that to detect COVID 19, active learning models trained using cross population data and data of various types are expected.

The analyzed data must be put in appropriate training and testing models that are suited for medical analytic purposes so as to obtain nearly perfect diagnosis for every input. Such models use deep learning techniques specializing in biomedical data to generate predictions and play a vital role in speeding up the diagnostic process and reducing burden on

health workers. This study observes that artificial intelligence based deep learning models provide the best results and hence, are the best fit for this application. The input data mainly consists of scans from suspected patients. These scans include chest X-Rays and Thoracic CTs-Computerized Tomography.

Ophir Gozes et al [4], the authors have developed an AI-based automated thoracic CT image analysis tool to detect COVID positive patients from multiple international datasets including Chinese disease-infected areas. Two major steps are discussed by the author, 1) Classification 2) Evaluation Over Time. Deep learning models integrated with clinical techniques are used for classification and study of evaluation of virus over time.GGO-Ground Glass Opacities and abnormalities in CT scans are used for detection. GGO abnormalities are studied in 2D slice data or 3D volume images and are classified as 'positive' or 'negative' based on opacity values. The system outputs opacities in a slice based heatmap or a 3D volume display and a corona score for positive cases that monitor progress of the virus in the patient.

Ali Narin et al [5], has brought to light the drawbacks of using CT scans for the detection of COVID-19 and suggested using a faster, easier, cheaper and less harmful alternative i.e, X-rays which provides a quick diagnosis. SARS CoV. In the study of MERS-Middle Eastern Respiratory Syndrome and SARS showed that there are features in the chest X-ray and CT that are like the manifestations of pneumonia. Dataset of 50 chest X-ray images of COVID-19 patients having ARDS-Acute Respiratory Distress Syndrome, MERS or SARS from github was considered. 50 more chest X-ray images of patients having pneumonia was taken from Kaggle. They have used three convolutional neural network based models namely ResNet50, InceptionV3 and Inception-ResNetV2 for the detection of CoV pneumonia infected patients using chest X-rays. Training was carried for all 3 models up to the 30th epoch to prevent overfitting and it was observed that ResNest50 showed highest accuracy in classification.

Shuai Wang et al [6], discussed an approach using CNN that may have the capability to extract COVID-19 features from CT images to provide an accurate basic diagnosis before the pathogenic test to save time. A dataset containing 99 images- 55 of typical pneumonia and 44 of confirmed cases of COVID-19 obtained from a hospital are used. Their proposed architecture(3 steps) uses a deep learning framework that chooses a random ROI for each patients' CT and an Inception Network to extract features and provide predictions. Additionally CNN brings to light some features that may slip the attention of the human eye. This deep learning method is much more efficient and fool proof in comparison to the unstable detection kits. Large numbers of variable objects in the CT images cause difficulty in classification.

Raju Vaishya et al [12], consolidated the major applications of Artificial Intelligence to help tackle the COVID-19 pandemic. The author has discussed seven major fields of application.

1. Early detection and diagnosis aided by AI to help identify abnormal symptoms or 'red flags' and warn patients and healthcare workers.
2. Monitoring treatment efficiently and automatically and reducing human-human contact.
3. Contact tracing of people to identify hotspots of the infection and forecast the likely pattern of infection.
4. Help in estimating the mortality rate and identifying potential vulnerable areas so preventive measures can be put in place.
5. AI aids in speeding up the process of drug delivery design, vaccine development and drug testing.
6. The diagnosis techniques and AI triage systems play an important role in reduction of workload for healthcare workers especially in situations where there is a high influx of positive cases.
7. Real-time data analysis helps in forecasting and preventing future viruses and implementing better healthcare policies.

Charmaine Butt et al [16] and [17] has discussed the use of deep learning models with higher accuracy to identify the presence of virus through radiographic patterns on CT chest scans. A dataset of 618 transverse-section images were considered for the study of which 219 were from patients with COVID-19. Of the rest, 224 samples belong to patients with Influenza-A viral pneumonia and 175 from healthy people. The CT were first preprocessed to gather the ROIs. Then a 3D CNN model was utilized to segment multiple candidate images. An image classification model breaks down the image patches into one of the following- Influenza-A viral pneumonia, COVID-19 or Unrelated. An overall analysis report is finally calculated using Noisy-or Bayesian function.

In view of all the techniques discussed, it is apparent that the usage of technologies like AI and Deep Learning in tackling the pandemic can be of an enormous help to doctors and technicians who are exposed to risks day in and day out. The development of technology to an extent where direct human interaction can be prevented is a huge boon especially in outbreaks that are transmittable from one human to another.

C. Tracking

Contact tracing and patient monitoring also play a vital role in tracking patients and possible suspects who may have come in contact with an infected person. Since the virus can be transmitted due to close proximity, technology has been identified as an important tool to help contain the spread of the virus. Coronavirus apps have been developed to help the governments and health physicians to keep track of active cases, recovered patients and quarantined citizens. These apps majorly make use of bluetooth and the "bluetooth handshake" technique for contact tracing. Geo-tracing is another feature of cell phones used by these apps. The cellphones log their locations and when the user is tested positive, the logged details are shared with health officials of the respective government to stem the spread of the virus. The governments of many countries have launched similar apps that have played a major role in tracking and monitoring which is especially

when there is a problem with human recall. The major challenge of using smartphone apps is that there may be a situation in which the owner travels without the phone on his/her person.in such a situation, gaps in data may arise leading inaccurate predictions.

Some of the apps launched across the globe for contact tracing and monitoring are mentioned in Table 1.

TABLE 1

APP NAME	REGION	NUMBER OF DOWNLOADS	KEY DETAILS
Arogya Setu	India	100M+	It is available in 11 languages. Uses bluetooth and GPS-Global Positioning System. Notifies users that come within 6 feet of an infected patient.
Quarantine Monitor	Tamil Nadu, India	100k+	Monitors people with a travel history in the past two months. Utilizes live location tracking to push notifications and alerts. Aids the Department of Health and the Tamil Nadu Police to track and monitor people.
MahaKavach	Maharashtra, India	10k+	It is a geo-fencing app that utilizes the live location of the user. It is used by government officials to track any rule breaking and to ensure that people stay within the quarantine radius.
COVA Punjab	Punjab, India	1M+	Users can view their distance from the nearest COVID-19 patient. It is available in 3 languages. Includes features that allows users to have essential goods delivered to their doorstep.
TraceTogether	Singapore	500k+	Works solely with bluetooth for tracking and monitoring. It uses bluetooth to generate and exchange a temporary ID when two phones are in close proximity. These IDs help in contact tracing.
HaMagen	Israel	1M+	Movements of the user are tracked using location and save in a database. This data is utilized to identify if the user has been proximity to anyone that has been infected.
CovidSafe	Australia	1M+	Traces people that may have been in proximity for the last three weeks. It uses SMS, signal strength and other data in the contact tracing process.
MyTrace	Malaysia	100k+	Performs contact tracing in an area with a confirmed COVID- 19 case. The hotspot tracker allows users to view if there have been any positive cases reported in the last 14 days.

IV. RESULTS AND DISCUSSION

In this study, the various technologies used in the management of the COVID-19 pandemic is explored. There are many advantages and limitations of using technology in the healthcare industry. Questions of privacy and validity may arise in the minds of the people.

Lindsay Ramey et al [14], discussed the advantages and disadvantages of the use of popular wireless technologies for health management. In the last decade availability of mHealth apps has increased and gone by 25% in the span of one year. 96%of mHealth apps have received positive feedback from the users making it a viable option for healthcare during pandemics. mHealth techniques integrated with health care delivery are a cost effective way to expand reach in terms quality of life and adherence to health related recommendations. Despite the issues reported in this kind of a system amid People With Disabilities due to lack of awareness and training for usage, mHealth apps have gained enormous popularity in the healthcare sector.

Marcello Ienca et al [15], brings to light the importance of responsible use of the large amounts of data used to tackle the virus. It is known that quality and quantity of the data used in AI and ML models play an important role in the accuracy of the predictions and output of these models. A lot of this data is obtained from sources such as social media platforms, mobile phones and other digital devices especially in the initial stages when official data is scarce. Since big data plays a vital role in the management of the pandemic, the collection of data should be responsible and the conditions must be clear. It should not neglect the privacy of any individual and cause distrust among the public. Distrust will make it unlikely that people follow government regulations and advice and turn out to be disadvantageous.

Ningning Tang et al [13], mentioned the ways in which AI can help fill gaps and uncertainties that still exist in the epidemic management system by utilizing big data. Some of the methods discussed are automated whole genome sequencing, faster protein screening and drug development, image processing algorithms, speech recognizing robots and telemedical systems, systems to perform routine tasks by eliminating human-human contact. While the paper limits its discussion to a small dataset limited to Chinese population, the applications would be tremendous with worldwide sharing of data and information communication technologies.

Despite some of the disadvantages discussed, the pros of using technology to manage the pandemic seem to outweigh the cons. The success of so many methods in tackling the pandemic will also boost the public's confidence in the usage of similar methods for future pandemics. It will also encourage the use of new technologies in the treatment of chronic diseases and cancer. These methods are a major milestone in the biomedical industry and could achieve better results in the future.

V. CONCLUSION

In the present day, there are multiple technologies from which public health paradigms can be improved. Some of them, as discussed, have had a huge role in fighting against the COVID-19 pandemic that the world is witnessing currently. These technologies have been a major milestone and helping hand to the doctors and healthcare workers by mitigating the risk imposed on them and lifting some of the workload from their daily lives. Data science, machine learning and deep learning techniques along with traditional neural networks approach are serving society in managing COVID-19 across the world. Virtual clinics, tele-medical technology, contactless imaging and detection of fever, automated triage systems and detection techniques discussed, have played a major role in tackling the pandemic in a safer and more efficient manner. The success of these methods also pave the way for the usage of such techniques in the future for other diseases and illness with higher confidence and success rates.

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