

Prediction and Treatment of Covid-19 Patients through Telemedicine in Indian Scenario using AI

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ABSTRACT

Outbreak of Covid-19 pandemic has proved highly disruptive to the order of world. With countries coming at standstill and economy reeling under the pressure, producing negative growth rate. Simultaneous it proved to be blessing in disguise in providing an opportunity for faster adaption of ICT especially into education and healthcare fields. Countries are coming with new acts, laws and rules to facilitate this. National Digital Health Mission, Telemedicine Practice Guidelines and CoWIN driven largest vaccination drive on the earth are some of such instances. ICT integration to healthcare can also help to control the impact and spread of pandemic. So, it the ripe time to implement ICT in healthcare to make maximum benefit out of it on one hand and to overcome scarcity of resource on other side. It can bring speed, convenience, and reliability in various aspects of healthcare ranging from prediction to treatment. In this paper authors have proposed one such comprehensive Covid management schema, for health infrastructure constrained countries like India, based on digitization of healthcare data, its intelligent analysis using Artificial Intelligence and remote patient care though telemedicine-based home treatment. Proposed schema considers historical EHR data comprising of structured health parameter data, unstructured imaging/genomic data and live semi structured critical parameter data collected through IoT devices. The proposed schema may relieve the extra burden on healthcare system by raising warning/alarm based on automated intelligent analysis of data. During this work authors have identified the critical role of Artificial Intelligence and need to tap its true potential in processing huge & inconsistent data produced by different sources. Real time analysis of data through some brute force method is not feasible, so we need intelligent solutions in detection and management of Covid. AI act as savior in this situation.

Keywords

Covid-19, Electronic Health Records, Internet of Things (IoT), Artificial Intelligence.

1. Introduction

Covid-19, a viral disease that originated from Wuhan in China has literally brought this whole world to standstill. Technically, it is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), a Betacoronavirus [1]. Coronaviruses belong to a family of viruses that cause illnesses like the common cold, severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS). This new strain of Coronavirus in Covid-19 is highly infectious. The infectivity and impact of this disease can be gauged from the fact that WHO has to declare it as a global pandemic [2] on March 11, 2020 i.e. within three months of its outbreak. One primary reason behind high infectivity lies behind ease of transmission owing to its mode of inter-human transmission namely close contacts like sneezing, coughing, talking while in proximity, touching infected items etc. Till now it has caused more 4 million deaths worldwide and infected more than 189 million peoples. During its initial outbreak the world was caught by an unprecedented fear/suspense so much so that most of the countries around the

International Conference on Emerging Technologies: AI, IoT, and CPS for Science & Technology Applications, September 06–07, 2021, NITTTR Chandigarh, India

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CEUR Workshop Proceedings (CEUR-WS.org)

world had to declare complete lockdown, streets went bizarre and markets were closed. Thereby the life as well as world economy came to a standstill. Impact of Covid on population has been multi facet apart from physical health being it also affected mental health beings. [3] have studied the psychological impact in term of happiness, gratitude etc through analysis of twitter tweets in reaction to some positive news in public domain. Another type of impact on the software development was studied by [4]. During this work they analyzed result of 26 project teams and observed the new trend in software development. They highlighted that even after lifting of lockdown high-tech IT companies refused to return in shared offices.

The principal purpose behind lockdown was to buy time for understanding the disease and discover vaccine. Unfortunately, the virus is too fragile and keep on mutating thereby mesmerizing the research fraternity leading to fresh waves of infection around the globe. As of now most of the countries have experienced two waves of Covid-19. In case of India, second wave peaked around May 2021. It proved to much more lethal as compared to the first wave that peaked around Sept 2020 (Figure 1). As a result of this second wave India jumped to second position in number of infections worldwide (Table 1).

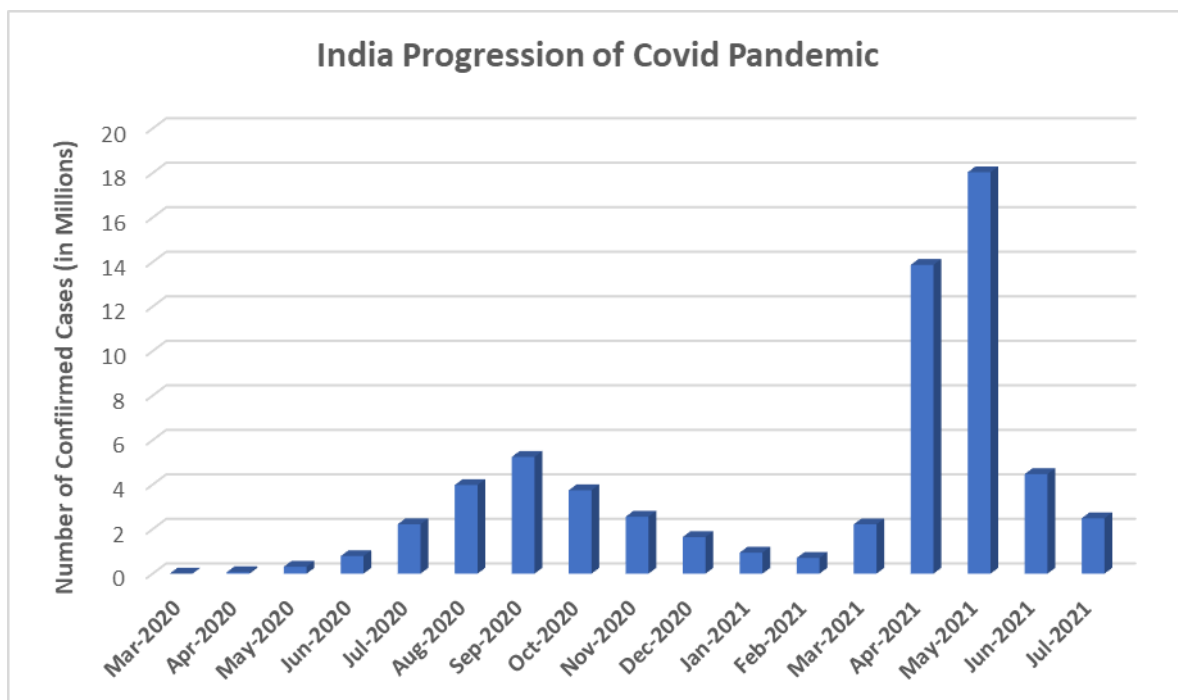


Figure 1: Progression of Covid-19 in India (Source: Source: <https://Covid19.who.int/>)

Table 1

Top 5 countries with respect of number of Covid-19 cases*

SNo	Country	Total Cases	Total Deaths	Death Rate
01	USA	33,723,155	603,790	1.79%
02	India	31,106,065	413,609	1.32%
03	Brazil	19,342,448	541,266	2.79%
04	Russia	5,958,133	148,419	2.49%
05	France	5,737,097	110,492	1.92%

*Source: <https://Covid19.who.int/> as on 19.07.2021

Table 1 provide data for 5 most affected countries and table 2 presents impact of Covid-19 on India compared to the worldwide effect. These tables also highlight the fact that Covid-19 death rate is pretty low at around 2% of infected peoples so home isolation may be the best treatment option against Covid. The inherent requirement of social distancing for taming the spread of pandemic has proved to be

bleasing in disguise and governments across the globe have created conducive environment and framed favorable laws, guidelines for alternatives ways of doctor-patient interactions. Moreover, for countries like India with constrained medical facilities in terms of doctors per person resorting to alternate ways of patient counselling becomes imperative. Home isolation with telemedicine proposes a viable solution to stop the spread of disease. But to implement telemedicine and proper home treatment, a robust intermediate IT infrastructure is required. Further, home isolation and telemedicine poses a new type of challenge in form security and privacy of patients. [5] have proposed a solution for this that not only protect sensor nodes from unauthorized intrusion but also verifies the doctor's legitimacy and sensor node before establishing a session key.

Government of India has taken some concrete initiative towards digitization of healthcare system. A National Digital Health Mission (NDHM) has been created. It proposes complete digitization of health system including Unique Health ID for every citizen and maintenance of their Electronic Medical Records (EMR). Further, amid Covid pandemic, Telemedicine Practice Guidelines have been released. After successful digitalization, the volume and variety of healthcare data, especially in populous country like India, would pose next challenge. Using traditional webspace approach, based on two tier client-server technology and brute force algorithms, it may not be possible to store, analyze and make real time predictions through the digitized healthcare system data. So, the research fraternity has to ponder over some novel robust systems that may tackle this humongous data and derive real time inferences from it. That would not only be helpful in Covid patient management but also help curtail the spread of disease further. Hence this work.

During this work, an outlay of comprehensive Covid patient management system is proposed based on telemedicine thereby hindering the spread of disease. Critical to the proposal would be digitization of omnipotent healthcare data which is regularly updated and accessible to all stakeholders. A backbone IoMT (Internet of Medical Things) system comprising of sensors may be deployed at suitable places, including individual bodies, to capture data automatically without much of human intervention. It would play the role of data feeding to proposed system. Moreover, to make prediction health history is critical but it may not be feasible to capture each & every minute health details of such large population. To overcome this constraint family lever healthcare data is proposed. It may be beneficiary in prediction and treatment of disease that run along families. Diabetes is one such disease which plays critical role while deciding upon patient treatment options. To tackle the challenge of data volume and make it ubiquitous, cloud-based storage system is proposed. Next, we need to process and analyze this huge volume of data comprising structured, semi-structured and unstructured data items including X-ray images, CT scans which play huge role in Covid detection. So, there is a need of intelligent systems for making real time predictions. AI based prediction & management of Covid patient is proposed in this work. Organization of this work is as follows:

In next section recent works related to the problem domain are discussed. Afterwards digitization of healthcare data, role of IoT (IoMT) in data capturing, cloud computing for storage & analysis of this data and utilizing AI for making prediction & Covid patient management are presented in subsequent sections. Beside these, outlay of comprehensive Covid patient management system is proposed in section 7.

Table 2
Impact of Covid-19*

SNo	Geographical Region	Total Cases	Total Deaths	Death Rate
01	Worldwide	189,921,964	4,088,281	2.15%
02	India	31,106,065	413,609	1.32%

*Source: <https://Covid19.who.int/> as on 19.07.2021

2. Related Work

Whole of the research fraternity around the globe irrespective of its academic discipline have been working overtime during these difficult times to overtime and resolve the threat posed by the pandemic.

Some much sought after areas of research in this directions includes identification of gene sequence & mutations, mode of spread & containment, methods for early & accurate detection of infection in human subjects, medicine & vaccine to eliminate the threat permanently. The amount of data available in public domain since the outbreak is humongous. Accordingly, researchers have proposed differentiating schemes to manage different aspects. [6] have proposed X-ray processing using Contrast Limited Adaptive Histogram Equalization (CLAHE) and observed that this methodology produce better result in prediction and classification of Covid among human subjects. [7] puts an stress upon need of early identification of Covid cases to break the chain of spread. They have proposed a deep learning model to diagnose the disease with focal loss technique to overcome the imbalanced dataset. [8] have worked on altogether different aspect of threat viz secure vaccine distribution and tracking in an environment comprising Internet of Medical Things (IoMT). Authors have exploited the potential of AI and block chain technology for this. [9] have proposed to delegate the processing at edge node level. They have proposed statistical data aggregation through random forests to overcome major challenges including data redundancy and issues of learning in edge nodes. In [10] authors have proposed a methodology to warn about the people density through IoT devices measuring air quality, thereby assessing the transmission risk.

3. Digitization of healthcare & HER: historical health data

Digitization of patient data in form of EHR can help in timely decisions during healthcare. The Health Insurance Portability and Accountability Act of 1996 (HIPAA) was probably the first US enactment towards creation of patient EHR database. It provided provisions for ensuring the privacy of data as well inaccessibility of data until consent is granted by the patient. Another important piece of legislation in this direction was 2014 US act called Health Information Technology for Economic and Clinical Health (HITECH). With the assurance of enactments like these, there has been a growing faith among citizens towards creation of their EHR comprising various health parameters.

Outbreak of Covid-19 has given India an opportunity to rethink its healthcare system and strengthen it further. It was felt as need of hour to utilize information technology in. In this direction a National Digital Health Mission (NDHM) has been created and strengthened with six objectives of efficient, accessible, inclusive, affordable, timely and safe healthcare to citizens. It provides an interface for collaboration among various stakeholders like central government, hospitals, labs, insurers, doctors, regulators, program managers etc. Digital systems under NDHM comprises of Unique Health ID for citizens, registry of healthcare professionals, registry of health facility, health records and EMR (Electronic Medical Records). One example of the success of digitization in healthcare system of India is the largest vaccine drive of the world being run and implemented through digital platform, CoWIN. The whole vaccination process is integrated with unique citizen identifier in AADHAR. Yet true potential of digitization in healthcare cannot be realized unless healthcare data pertaining to every citizen is digitized. But digitizing healthcare data of 1.35 trillion people would require proper mechanism to maintain and ensure security cum privacy.

The critical data elements of EHR for management of Covid-19 cases can be structured data like Complete Hemogram, CRP, ESR, Blood sugar levels, Blood Pressure, HbA1c, semi structured coming out of monitoring IoT devices and unstructured data like HRCT scan, X-ray images. For effective management of Covid-19 patients, continuous monitoring of critical parameters like blood pressure, pulse rate, blood sugar levels, oxygen saturation level must be ensured. The visualization of critical parameters stored in EHR can help in providing effective telemedicine/teleconsultation to the patients. This data can be shared anonymously with researchers for further advancement of healthcare and medical sciences.

Various important initiative taken by India includes National health portal, e-Hospital, online registration system, patient feedback application, online drugs application including clinical trial, vaccine tracker (support parents in tracking immunization status of their children and helps them in ensuring complete and timely vaccination), online dengue symptom checking, information dissemination about diseases, application for stress management, maternal healthcare application. India has specified EHR standards which were notified in December 2016.

4. IoT in healthcare environment: live health data

IoT refers to a computing environment with number of physical devices having sensors, microcontrollers, transceivers to collect real time data which is forwarded usually to some cloud for storage and analysis [11]. IoT in health care setting can prove to be path breaking where diverse distributed devices receiving health related data is aggregated and analyzed into useful medical information [12]. IoT can prove to be beneficial in continuous health status management by measuring of physiological status of patients through sensors deployed in vicinity of or on in his body [13]. A number of IoT devices equipped with sensors including fitness bands, blood pressure monitors, glucometers, ingestible smart pills, smart contact lenses, connected inhalers, have been designed during last few years that may have lasting effect on overall healthcare system and Covid patient management.

5. Cloud Computing: storage & analysis of data

Cloud hosting is the most preferred storage and analysis environment for IoT data especially health care data. All devices from sensors upto cloud work in tandem in providing reliable storage of data, its processing and analysis, forecasting, ensuring security and privacy. Cloud acts as an interface for data/information/result interchange with other stake holders including doctors, patients, family members, labs, government etc. It provide access to data from anywhere and over heterogenous device types connected through the Internet making the healthcare data ubiquitous. Although with the advent of new faster and more capable IoT devices in terms of processing power, memory and battery life, the processing in now a day is being moved more towards data source through fog/edge computing [14][15][16]. Yet when it comes to processing of huge data (especially healthcare data which can be classified as big data due to underlying variety, volume, velocity, and veracity) there is no substitute for cloud computing yet, especially for certain data processing like gene sequencing, time series analysis over long duration etc. Moreover, cloud environment can provide an important intermediary environment for Covid management between patients/family members and doctors/hospitals/labs.

6. AI in prediction & management of Covid-19

Unprecedented advancement of artificial intelligence and machine learning has made huge impact on various application areas of computer science including healthcare [17][18]. With ever increasing amount of healthcare data and other unstructured data especially imaging data i.e. CT/MRI/X-Ray, genomic information it would be more beneficially, cost effective and optimal to utilize artificial intelligence for making timely prediction about the health status of subjects. Machine learning has already proved its worth in the field of medical science in interpretation of imaging data and prediction of disease during older ages. In the dearth of qualified medical personals AI can help other medical staff in making prediction and taking decisions.

Continuous data being generated by the sensors may be monitored through applications. Analysis of different clinical data by some machine learning application may help in taking timely critical healthcare decisions thereby saving lives. E.g if the patient is diabetic then the decision to hospitalize may be preponed compared to a person without any such comorbidity.

Complete family EHR data, if linked, may be analyzed to identify probable contacts that are at high risk to deadly form of Covid-19. Accordingly, their Covid test may be performed. Early decision regarding their treatment may help in better management of disease.

Numerous researchers have conducted work on exploiting AI in prediction of Covid. One approach for early and accurate prediction of Covid using AI can be multimodal based on deep learning framework [19]. Authors have proposed to integrate point of care modalities with DNN based RT-PCR test giving more dimensions to the prediction. [20] have proposed a deep learning model over X-ray and CT scan to classify datasets into Covid and non-Covid groups.

7. Comprehensive Covid patient management

Any comprehensive Covid management system through telemedicine should be equipped with the following:

1. Doctor accesses the structured historical EHR data [21] and unstructured imaging data, if required, to identify high risk patient.
2. Classify patient based on the symptoms into asymptotic, mild, moderate, severe or very severe/critical category.
3. Continuous logging of critical parameters, collected through automated IoT health devices like connected oximeter, connected blood sugar measuring devices, into cloud repository with historical EHR data starts.
4. The amount of data stored and being continuously generated can be best handled through some AI algorithm. It may be programmed to issue critical alarm/messages to the doctor based on the health parameters being monitored.
5. Doctor may change and adapt the prescription based on visualization of critical health parameters being monitored thereby leading a step towards realization of personalized medicine.

8. Conclusion:

For last 18 months, world as whole has been gripped by the Covid-19 pandemic. It has made unprecedented, unparallel and unforeseen impact on all walks of life. It is highly infectious and can spread exponentially. Due to regular mutation of underlying virus it is difficult to find its cure as well as discovered vaccines may not be 100% effective. The best way to curtail its spread is to avoid exposure of healthy person with the Covid patients i.e. isolation of Covid suspects. So, an early identification of Covid patient is imperative. In order to ensure minimal contact of suspects with healthy person telemedicine (online consultation) under home isolation is proved to be the best treatment option in given scenario.

Another aspect of the problem apart from ease of spread is its varying impact on the health of individuals. The disease proves to be deadly if the patient is having some underlying health complications (comorbidity) like diabetes, old age, heart disease. So, the treatment depends on the patient and its health background i.e. sort of personalized treatment is required.

In this paper authors have proposed a comprehensive Covid management schema to make telemedicine and home treatment more effective, relieving pressure on healthcare system & doctors using artificial intelligence. Different aspects of the problem studied during this work includes:

In telemedicine scenario where the doctor may not have any opportunity to do physical examination of the patient, some reliable alternate is required. Patient as well as family health history plays a pivotal role in effective patient management. It can be realized through maintenance of Electronic Health Records. So duly maintained, ubiquitous EHR databases with varying access options is the first requirement to realize telemedicine based Covid patient management. These may be maintained over cloud-based database.

Next, previous experience shows small mistakes can make the disease deadly in no times. Most of the countries were caught unaware, on wrong foot, by the second wave inspite having gained experience while dealing with first wave. So, the IoT based sensors are deployed around the patients which provide critical inputs and may even send alarm during emergency situation. So, a comprehensive system is needed right from maintenance of HER to capturing of live health data and then to data analysis and access to doctor for telemedicine over various modes like PC, mobile etc.

Further, the amount of data produced, stored and analyzed is not only huge but also is variant and comprises of all types viz. structured, semi-structure and unstructured. Moreover, the ratio of doctor per patient in India is quite small meaning a constrained healthcare system is in existence. So, to make real time decision AI based analysis and prediction is required. All these have been studied during this work.

To conclude the observations of this work, digitalization of healthcare data can prove to be steppingstone in the direction of realization of telemedicine. The historical EHR data is complemented with semi structured live IoT data about critical parameters. Artificial intelligence may be exploited to process the huge health data thus generated. AI analysis may also provide an insight into patient health

for taking personalized decisions. Such system can prove to be helpful in decreasing death rate due to Covid even further.

9. Limitations

During this work a comprehensive Covid patient management system is proposed keeping an eye on the highly infectivity nature of Covid. It purposes different building blocks for the problem. All aspects studied during the work may have other alternative which may be studied by other researchers. Also, the work is confined to theoretical proposal and has not been implemented practically so during implementation some unforeseen issues may arise that are not discussed during this work.

10.Future Work

Researchers interested to work in the area may try to implement the proposed schema through some simulation. More detailed analysis of EHR data items can also be done. Decentralization of processing from cloud to edge may also be studied for setting real time alarms. During early stages of infection, the disease cause symptoms similar to those caused by normal flu, so early identification of Covid patients is one of the areas which has been under the radar of researchers around the globe. It needs more investigation before a concrete mechanism to differentiate Covid from flu (may be using X-ray images) is approved. Different sensors that can be deployed and processing of their data in another area where work is being done and still exists a lot of prospects.

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