

Leveraging Of Technology in Containment of Covid -19 Pandemic across the World

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ABSTRACT— *Technology may not be able to foretell the beginning of a pandemic, it may even have limitation in eradicating it. However, it can surely help in preventing its spread, create awareness and empower those working at the forefront and remarkably mitigate its impact. The entire world has been confronted with a unprecedented health crisis: the outbreak of Novel Coronavirus-caused respiratory disease (COVID-19). The new form of Corona Virus, which was originated from the Wuhan province of China during December 2019 has reached all the inhabited continents and has infected innumerable number of persons in almost all countries of the world in a very short span of time. The medical research fraternity across the world has been striving very hard to develop a medical cure for the disease with help of various technological interventions. In this Paper, we have endeavored to explore the role played by IT and IT Enabled Technologies, especially four inter-related digital technologies (the IoT, Big Data Analytics, Artificial Intelligence and Blockchain) in supplementing three traditional epidemic management strategies for tackling COVID-19 viz Monitoring & Detection to prevent the spread of COVID-19, Improving the efficiency of Healthcare infrastructure, and Mitigation of the impact of the pandemic.*

Keywords:-Covid19, Internet of Things, Artificial intelligence, Big Data, Video Surveillance, Drones.

1. INTRODUCTION

World over, the COVID-19 outbreak has hit the lives of millions and has caused death of thousands. World Health Organization has referred it as a Pandemic calling for concerted efforts of all the Countries to eradicate disease. As the situation keeps escalating every day, the affected countries are sparing no effort to bring the situation under control and to mitigate the hardships of its citizens. This has given a renewed vigour to the medical research fraternity to pursue a medical cure for the disease with the help of advanced technological tools.

COVID-19 is a highly infectious disease caused by a mutant form of Corona virus. The infection triggers

respiratory illness (like the flu) with any one or more accompanied symptoms like a cough, fever and difficulty breathing etc. Coronavirus disease spreads mainly by way of proximity to an infected person when they cough or sneeze. The recent studies have found that the virus can remain viable in various types of surfaces.

This increases the risk of infection even through the physical contact with the infected surroundings. In the initial phase no vaccine was available to prevent coronavirus disease (COVID-19), However, Scientists are in the pursuit for developing a medical cure for the deadly disease. By the end of March 2020 almost all countries have come under the grip of the virus spread.

In the absence of vaccine for disease, the only option left is containment of the pandemic. The effective ways for containment of its spread is through implementing a strict social distancing regime in the society and also isolating the infected and susceptible / suspected cases.

Almost all countries across the globe have adopted these containment measures in various degrees. While some countries chose to allow business as usual with certain restrictions in place, other countries went for a total lockdown so as not to take any chance of spreading the disease. India is one among the few countries that have proactively responded to the challenge and has implemented a 21-day national lockdown to prevent the outbreak of the disease in the country which was later extended for another 19 days.

As there is inherent difficulty in close personal interaction and coordination owing to the contagious nature of the disease, technology has come handy to bridge this gap and aid the effort of the countries in its containment measures.

Technology plays a pivotal role in the fight against COVID-19 and other future pandemics. Besides supporting modeling efforts and predicting the flow of a pandemic, with big data, machine learning, and other technology, data can be analyzed quickly and effectively to help people on the frontlines figure out how best to prepare and respond to this and future disease outbreaks.

Various Countries around the world have deployed a variety of technological tools that are aimed at identifying whereabouts of infected / suspected / susceptible cases, and monitoring their quarantines, surveillance of the social distancing norms stipulated by the administration, ensuring law and order, dissemination of authentic information to citizens etc. Medical Researchers are increasingly making use of various IT and IT enabled tools such as machine learning, artificial intelligence, big data and natural language processing to track and contain the virus, to improve the efficiency of medical services delivery and also to Obtain a more thorough understanding of the disease.

2. ROLE PLAYED BY DIFFERENT TECHNOLOGIES

A host of IT and IT enabled technologies play different roles in the decisive fight against the pandemic. The most pivotal among them are the following seven technologies portrayed in the figure below:

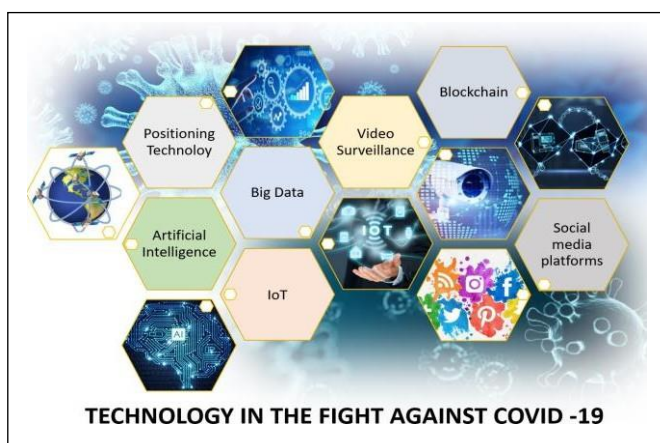


Fig:-1 Technology in the fight against Covid

2.1 Internet Of Things (Iot)

The Internet of Things (IoT) technology has been widely used to detect, track and help prevent the spread of a deadly virus. IoT, especially when combined with other transformative technologies such as Cloud and AI, has been used in a wide range of applications during the crisis. Looking forward, the most important role of IoT in related to COVID-19 is likely to be in the areas of detection of cases and extrapolating the data to predict outbreaks before they reach mass scale.

The interconnection of computing devices embedded in everyday objects using Internet, popularly known as Internet of Things, provides a platform that allows for accessing enormous amount of data which in turn help in

the research in the field of COVID-19 pandemic and also in its containment measures.

Connected thermometers has become very prevalent. during COVID crisis, Many hospitals across the world are using this IoT tool to screen patients and staff. Kinsa Health, a US based Medical Equipment Manufacturer, is supporting the civil administration in early detection and early response to the disease. It is using the data gathered from its over one million connected thermometers to produce daily maps showing which US provinces / cities are seeing an increase in high fevers. These data points are capable of providing unparalleled real-time disease surveillance and could serve as an early warning signs about formation of new clusters of the disease and a potential outbreak.

Connected wearable's are helping the disease control in more ways in different countries. Patients & Hospital staff at a field hospital in Wuhan City Province, China, are mandated to wear bracelets and rings synced with an AI platform from CloudMinds —an operator of cloud-based systems for intelligent robots— this inter connected system provides constant monitoring of vital signs such as body temperature, heart rate, blood pressure and blood oxygen levels.

Hong kong is one of the few cosmopolitan cities that has leveraged the potential of IoT in combating the pandemic. In Hong Kong. The government of Hong Kong has introduced electronic tracker wristbands to alert authorities when individuals, especially those who have recently arrived from other foreign countries, do not comply with compulsory home quarantines rules. In another curious development, a team of entrepreneurs based in Hong Kong have developed a smart wristband that vibrates if the person wearing it tries to touch his or her face or even other surfaces, an action which health authorities deem as being a major trigger for the virus infection.

The ecommerce leader Alibaba has introduced the Alipay Health Code app. The Government has mandated every Chinese citizen to install the App on their phones. It works on a three-color code, which tell the user by analyzing their risk profile if they are permitted for unrestricted movement in public places and public transportation. The three color codes i.e. Green - free movement, Yellow - limited movement, or Red - total quarantine are used to classify the risk profile. There are checkpoints throughout China where authorities usually ask for health status displayed in the App.

2.1.1 Drones & Autonomous Vehicles

Drones have revolutionized the use of IoT in everyday

contexts. Today, the application areas of drones are beyond any limits. From wildlife conservation to disease control, emergency response, insurance to mapping, UAVs are being used in multiple sectors. During the COVID-19 outbreak, drones are being used by different countries to deliver medical supplies and samples to and from COVID-19 hotspots. The Japanese Technology Terra Drone has pressed into service its special-purpose drones to transport supplies in China. The company claims that logistics using drones has drastically increased speed of delivery in affected areas in comparison to road transportation.

Many Indian states have been successfully deploying drones to monitor and ensure compliance with lockdown orders imposed to prevent public gathering in a measure to prevent the spread of the disease. These drones while flying over the places where people tend to gather, air announcements directing people to disperse and to follow social distancing in regulated areas. Governments and law enforcement agencies of China, France, Spain and the US are also using drones for keeping track of the gatherings and to persuade people to stay at home. Drones are also being used by authorities for spraying chemical disinfectants in some public spaces and on vehicles traveling in the affected areas.

The Draganfly, a North American drone services in collaboration with Defence Dept. of Australia & other agencies, has developed drones that are designed to carry a range of sensors and high-definition cameras functioning on IoT platform that will be able to detect infectious and respiratory conditions, look for symptoms including coughing and monitor other vital statistics of the subjects including heartbeat, temperatures etc. within its field range spanning up to 100 feet. Apart from tracking persons who are infected, the new technology helps in predicting likelihood of outbreaks in different regions.

The special-purpose drones deployed by Chinese government keep a watch on the disposal of biomedical wastes by various hospitals and other quarantine facilities, as these wastes, if not properly disposed, can give rise to more infection.

Drones were also flying with QR code placards beaming announcements advising the residents of the locality in Hubei province of China to scan the QR codes using their smart phones for updates from the administration and also for registration to furnish health information.

Self-driving cars and other autonomous vehicles can help carry out logistics service by reducing human contact. The self-driving special purpose developed by Tesla

Corporation and Google are being deployed by US Administration to transport medical supplies and other essential goods to infected areas.

2.1.2 Robotics

Robots played a crucial role in the delivery of healthcare in countries like China. From preparing hospital meals, serving as waiters in restaurants, spraying disinfectants and vending rice and dispensing of hand sanitizers, robots were on the front line to prevent coronavirus from spreading. Robots were also engaged by many hospitals for diagnosis and conducting thermal imaging. Multicopter, a technology firm, based in Shenzhen, China has deployed an array of robots to move medical samples.

Wuchang Hospital, another hospital in Wuhan, which was the epicenter of the outbreak, engaged more number of robots than humans for delivering different medical services. The hospital in collaboration with China Mobile, China's leading mobile telephone technology & service provider and Cloud Minds, a manufacturer of cloud-based robotics systems, to implement this ambitious project with an objective of making the hospital facility completely smart and digital. Most of the devices in the hospital are IoT enabled and services are carried out by robots. The patients' initial screening is done via 5G-enabled thermometers which send instant updates. There are also rings and bracelets linked to the CloudMinds AI network for tracking all body changes.

A tiny robot called Little Peanut was deployed by the hotel to deliver food to passengers of a flight from Singapore to Hangzhou, China who were believed to have been contacted with corona infected persons and was being held under quarantine in a hotel.

Robots are being pressed into service to mitigate the workload on healthcare staff and to support in treatments. The field hospital in Wuhan province, which finds a mention in the foregoing para, is a best case study in this respect. The hospital in a joint venture between involving Cloud Minds, China Mobile and the Wuhan Wuchang Hospital, has deployed 5G connected robots that goes door to door, greets the patients and delivers food, drinks and medicines to them. This intervention not only gives a much-needed break to staff, but also reduces their exposure to infected patients.

Robots developed by technology giants like UVD Robots and Xenex are also being used to disinfect hospitals and other risk-prone areas in China, Italy and the US.

Hospitals in Vancouver, Canada have successfully deployed

its IoT buttons, known as Wanda Quick touch, developed by Visionstate Corp, in major hospitals and other buildings of civil administration witnessing high footfalls. These IoT enabled buttons are battery operated and connect through LTE-M network. The buttons send alerts to management of cleaning or maintenance issues that if left unattended, may pose risks to public safety. Facility managers equipped with data consoles can track alerts and assess staff response times thereby improving the hygiene of huge areas.

These wide ranging applications goes to prove that IoT is an effective weapon in the fight against COVID-19.

2.2 Artificial Intelligence and Deep Learning

Artificial Intelligence has enabled more accurate forecasting about disease spread, medication, treatment, etc. in the field of epidemiology and other branches of medical research. The enormous amount of data captured during the first wave of COVID outbreak in Wuhan province has given a lot of insights to rest of the world which in turn helped them to improve their preparedness.

World Health Organization (WHO) has underlined the significant role played by Artificial Intelligence (AI) and Big Data to control COVID-19 pandemic. Studies based on Artificial-intelligence systems are believed to be first to throw light on outbreak of the disease, at a time when it was still limited to the Chinese city of Wuhan. It is now reasonably established that that AI-driven HealthMap, a collaborative project of Boston Children's Hospital, was first to pick up signs of the growing cluster of mysterious pneumonia cases soon before human researchers, even though it ranked the outbreak's severity as 'Medium'.

The world now is in the pursuit of a panacea to check the spread of the coronavirus. AI plays a crucial role in determining components of a vaccine by decoding viral protein structures. It also support medical researchers to sift through huge cache of relevant research papers at an unprecedented pace. The collaborative efforts of the Allen Institute for AI, Google DeepMind have shaped a slew of powerful AI tools, shared data repositories and research results. Recently, Google DeepMind introduced AlphaFold, a trailblazing system that predict the shape and impart visual effect in the form of 3D structure of a protein based on its genetic sequence. In a separate initiative, The University of Texas and the US National Institutes of Health created the first 3D atomic map of the virus and its parts, which binds and infects human cells-the spike protein based on the strength of the series of research findings reported as a large cache of independent datasets. It is imperative to streamline the procedure for the

diagnosis of COVID-19 so as to devise an easy and affordable method. Many hospitals in developing countries in Asia and Africa do not have the resources to exactly differentiate COVID-19 from the 'common flu'. Even if most patients have symptoms that are common in case of 'Common Flue' or COVID-19, physicians have to ensure intensive methods to quarantine, treat and observe patients. The Scientists at National Institute of Health, USA, is in the pursuit of a more robust set of AI algorithms that would help physicians to easily segregate Flues caused by different strains of virus from that of COVID cases and to proceed with triaging COVID-19 patients into potentially 3 groups that is, the 80% who has mild symptoms; 15% who have moderate illnesses; and 5% who have serious illnesses, including those at high risk of mortality. AI is also aiding the researches concurrently happening in different countries aimed at developing an effective vaccine that can treat COVID-19.

In Healthcare systems, adoption of different types of AI-based triage systems can mitigate the clinical load of physicians. A connected medical 'chat bot' can help detect early symptoms in people and refer such people for medical treatment if symptoms tend to get severe. Similarly, IVRS-supported phone-based software that monitors and records data from patients (e.g. temperature and symptoms) may pre-empt unnecessary hospital visits for patients with mild flu-like signs.

AI has also played a crucial role in Shedding light on the structure of COVID-19. DeepMind, the AI arm of Google's parent company Alphabet, is working on comprehensive genome data to predict and envision the structure of viral proteins, which could theoretically contribute to drug discovery to remove COVID-19.

DeepMind has added to the public domain a deep-learning library, called AlphaFold, which is built on neural networks to predict how the proteins that curve or crinkle a micro-organism based on its genome. Its protein structures determine the form of receptors in an organism's cells. If we can make out the shape of the receptor, developing drugs that attaches to them and disturb vital processes within the cells becomes easy. The is applicable in the case of SARS-CoV-2 virus as well.

DeepMind has built the capability in AlphaFold to analyze COVID-19's genome after training AlphaFold on huge cache of genomic datasets, which establish the connection between genome structure of an organism and how its proteins are developed.

The data generated by HealthMap, the collaborative project of Boston Children's Hospital, is also available in public

domain. It is open for scientists and researchers searching for links between the disease and different ethnic groups. The data has already been superimposed with data obtained from Baidu on human movements. It helps them to look at how population mobility and control measures have influenced the spread of the virus in China.. HealthMap has been tracking the spread of coronavirus from the onset of the outbreak in China, capturing and visualizing its spread across the globe.

Darwin AI, a Canadian startup firm, has developed a neural network that is trained to scan & decode X-rays for signs of COVID-19 infection. Though the default method for ascertaining the presence of coronavirus is through testing the swabs taken from patients, analysing chest X-rays can be an alternative method, which would give tremendous relief to hospitals to relieve the stress on limited conventional testing set ups. Having testing kits to process all their patients quickly. Darwin AI has launched COVID-Net as an open-source system in public domain. The datasets containing X-ray details that were used to train the system is also available in public domain.

Darwin AI is now working on extending COVID-Net 's scope from a technical tool to a system that can be universalized for employing healthcare workers. It also aims to build a neural network for patients who have acquired COVID-19 and predict who will be best suited for home quarantine / self-isolation and who need hospital treatment.

AI also played a crucial role in Monitoring how the virus and lockdown is affecting mental health. Johannes Eichstaedt, A Research Scholar in the field of Psychology at Stanford University, has been analyzing Twitter posts using a dedicated algorithm that scans through huge cache of tweets to estimate how COVID-19, changed the way we live our lives and how it is affecting the mental health. Using AI- supported text analysis, Eichstaedt sifted through more than two million hash tweets tagged with COVID and other related words up to March 2020 and overlaid it with data sets on other relevant factors, including the region-wise spread of illness, deaths, recovery, etc., to shed light on its mental health effects. The study inferred that majority of the COVID-19-related chat in urban areas was on topics such as 'adapting to living with, and preventing the spread of the infection .At the same time, rural areas rarely discussed these topics, which the psychologist attributes to the relative severity of the disease in urban viz-a-viz rural populations, underlining the importance of psychological counseling and other therapies in the affected areas.

2.3 . Big Data

Big Data plays a vital role in the fight against Coronavirus. Back in 2003 when SARS epidemic hit many countries in the world, digital infrastructure and technology was not very robust for the medical researchers to rely on. However, the digital records of those periods, though not comprehensive, has provided a lot of insights for the medical researchers to enhance their preparedness for another outbreak. The wealth of medical research data that has been evolved over the years since then and cutting edge tools for analyzing big data is proving to be a major boon in the fight against coronavirus.

The Center for Systems Science and Engineering at Johns Hopkins University has developed a real-time tracking map for tracking and collecting updates of COVID-19 cases worldwide, using data collected from government agencies of various nations as well as from the World Health Organization. An online portal by name 'Worldometer' provides a real-time report on the total number of people worldwide reported to have been infected with COVID-19, including frequent new cases of the disease, country distribution of disease and disease severity (recovered, critical condition or death). This provides a huge, credible database to analyze the patterns and trends of epidemic spread in specific regions.

Official Dashboards Track the Virus and Outbreak Analytics .Dashboards of World Health Organization (WHO), which provides real-time statistics is very helpful for government policy-makers and medical researchers for assessing the spread of the disease. These dashboards capture data from different parts of the world to project confirmed cases and deaths from coronavirus. This comprehensive data set forms input for developing models and predicting hotspots of infection, which aid the administrators to issue public notices for staying at home and also to help healthcare systems to prepare for an uptake of cases.

Aarogya Setu is a government initiative for spreading awareness of COVID-19 in India.COVID-19 tracking mobile application launched by Government of India, Aarogya Setu has been one of the most widely downloaded mobile apps till date in India. The main objective of this initiative is to spread awareness of COVID-19 and to e-enable essential COVID-19 - related health services to the people of India. Government of India has issued several advisories promoting use of Aarogya Setu app, which is available in Android and iOS platforms.

The App uses the GPS and Bluetooth features of the smartphone to track the spread of COVID-19. The App scans the surroundings of the Smartphone using Bluetooth to

ascertain the risk of proximity to a COVID 19 infected positive person within six feet of, by sifting through a comprehensive database of known cases in India. Making use of GPS services, the App determines whether the User's location is classified as a Hotspot by scanning the data pertaining to geographical spread of infection.

Users are advised to check the status on the 'Aarogya Setu' App and travel only if 'free' and 'low risk' are indicated. If the App shows a warning that the user has a 'moderate' or 'extreme chance' measured based on proximity to Bluetooth or otherwise recent interaction with the infected person

The App while being a useful at the hands of citizens giving them important COVID updates, it also collect huge amount of data by way of periodical self assessment being done by its users. This huge cache of data throws light on the vulnerability areas and geographic spread of the infection, which in turn aid the Government to formulate action plans in the fight against COVID-19 epidemic in the Country.

Outbreak analytics sift through the data made available by such global agencies that includes number of confirmed infection cases, recoveries, deaths, contact tracing of infected persons, population densities across different geographical regions, maps, people and vehicular flow and then analyze it through machine learning to create customized models of the disease. The models arrived at using comprehensive and holistically representative dataset tend to give most precise predictions regarding peak infection rates, hospitalization and intensive medical care requirements etc.

When COVID-19 began to spread in China, it was feared that Taiwan would be badly affected due to its proximity to China, huge air passenger traffic between both countries on daily basis, which included daily business travellers. However, Taiwan shielded the impact of the outbreak using a robust technology involving data analytics tools and a fool-proof pandemic action plan prepared after from the learning's of 2003 SARS outbreak, which helped them to minimize the virus' impact on its land.

The core of their plan was to combine the massive database held for the national health insurance system with data collected from their database of immigration and customs. This helped Taiwan authorities do realistic projection and make use of alerts regarding possibility of infection based on symptoms and travel history when faced with coronavirus. Further, the administration captured other in-land travel and health details by widely deploying QR code scanning and online reporting and popularizing

toll-free hotline numbers. All these initiatives came handy while profiling the infection risks of its citizens.

Big data opens up avenues in the field of modeling of viral activity, which guides Policymakers of different countries in the field of healthcare to chart out preventive strategy in the case of an outbreak. Supported by 3 international databases—the Official Aviation Guide, a location data service providing arm of Tencent, China and the Wuhan Municipal Transportation Management Bureau, China, carried out a modeling study in the form of 'nowcasting' & 'forecasting' COVID-19 disease trajectory in China and also in other countries. The outcome of the study is made available to medical researchers and civic and medical administrators across the world for effective public-health planning & control.

Rensselaer Polytechnic Institute (RPI), the oldest technological university in US, the researchers are working on big data and analytics to understand the infectious SARS-CoV-2 virus from different perspectives. One such study is focused on biomedical research. The Research Scholars are also in the pursuit for developing a vaccine. They are also looking at the possibility of making use of any current drugs against COVID-19, by means of AI and machine learning tools.

In the process of capturing symptoms, unfolding the characteristics of the virus, and monitoring the treatment response, the researchers come across enormous amounts of data – impossible for human comprehension. Advanced analytics technologies help to analyze these complex data, brings out trends, correlations and inferences and present it in a way that is humanly comprehensible.

Many of the IT Giants providing specialized services such as Amazon Web Services, Google Cloud etc. have provided their Big Data & AI tools, cloud computing platforms and free access to open datasets and analytics tools to Researchers to help them develop COVID-19 solutions faster. Google Cloud provides researchers free access to crucial information relating to COVID-19 by way of its COVID-19 Public Dataset Program, facilitating them to leverage from these cutting edge analytics solutions in their studies. the company in a recent blog, has stated that it has placed its 'AWS COVID-19 data lake' in public domain to fight this disease. 'AWS COVID-19 data lake' is a premium repository of up-to-date and curated centralized datasets on SARS-CoV-2 generated as a result of systematic discrete research efforts in different parts of the world.

Verizon, a US based telecommunication service provider has come out with a big data search engine tailor-made for COVID-19 research. It is an open-source program

facilitating academic research that enables research on more than 50,000 authentic articles on the subject. The research documents it encompasses are regularly updated and peer-reviewed. It also facilitates for collaborative projects using Microsoft Academic, another specialized search engine for research studies.

The data sets relating to the COVID-19 is being systematically built in different parts of the world, inculcating enormous details and inferences on pandemic as it being played out still in different parts of the world. These datasets will surely help the Governments and Medical fraternity to enhance their level of preparedness to face the onset of another pandemic. Such records would therefore remain an easily retrievable database and set a standard for potential use of data in similar circumstances. 'Big data makes it possible for the world to monitor and prepare for more epidemiological outbreaks.'

2.4 . Blockchain

Blockchain technology, also referred to as Distributed Ledger Technology (DLT), is a new system of accounting transactions of a digital asset by ensuring its history unalterable and transparent through the use of decentralization and cryptographic hashing. The World Health Organization is building on a blockchain-based control and communications network, in collaboration with other technology firms , government agencies and other global health organizations, that can be used to track COVID-19 carriers and their hotspots quickly and precisely. The advantage of blockchain-enabled platform over other forms of data structures is that it provides verifiable data ensured through the distributed ledger technology enabling collaboration of multiple parties to collaborate on of rapidly updating data which gets authenticated by the peers.

In China, several hospitals and pharmaceutical companies are joining hands with blockchain technology providers improve the delivery of medicines to their doorsteps of patients, which enables accurate tracking and channelizing of the consignments dispatched in huge quantities till its final delivery to the patients.

IBM, a US based multinational technology company has launched a project christened as MiPasa. MiPasa leverages data analytics and privacy tools that were largely used by only Hi-Tech financial institutions. The platform has now been adapted for a wider use in public health context. The new data streaming platform make use of IBM Blockchain Platform and IBM Cloud. MiPasa enables the researchers to synthesize data sources, even out the inconsistencies and

flawlessly assimilate reliable and verifiable updates. This block-chain driven tool helps researchers, data scientists and medical fraternity by providing them the data they need at scale to plan the interventions at medical and administrative levels so as to bring the outbreak and its consequences under control.

MiPasa is intended to provide a solution to a big problem faced by scientists and researchers: 'the lack of convergence of validated data sources that can be used with confidence.' MiPasa facilitates safe sharing between various users of previously siloed location & health information. Tech giants including Microsoft , Oracle, IBM and Hacer, "an enterprise-level blockchain-powered provider of applications"

MiPasa enables and supports open availability of data analytics and privacy tools on a Hyperledger platform and provides an assimilated source of verified cases using IBM Blockchain Platform and IBM Cloud. Users will be able to trace back data sources -- fixing the inconsistencies & errors in the process and flawlessly integrate verified new feeds as per the requirements of the User.

The block chain enabled data assimilation enables the Users from medical research and public administration side to feed data about the time and exact location of virus infections. Huge volume of gathered data would then be translated to of personally identifiable information that enables projection of exposure risk, rate of spread, coverage of geographic areas etc. intuitive interpretation and projection of such data enables medical and public health authorities prioritize resources and make decision on the sample testing for early detection of the infection.

MiPasa deploys top rated encryption modules to ensure the security of the highly critical data resources. MiPasa invites individuals and organisations to assist in the app creation together with "data warriors" in reporting data sources.

2.5. Video Surveillance

Countries are adopting different methods to fight against the pandemic, which includes the use of surveillance tools. One of the most common surveillance tools being engaged around the world has been video surveillance.

China responded very quickly to during the initial phase of the outbreak and carried out strict containment measures early on. The Country succeeded in its efforts to seal the City of Wuhan totally from outside world. It deployed facial recognition cameras for tracking the movements of infected persons. It is reported that using

facial recognition cameras, the authorities were able to track quarantine violation of a resident from Hangzhou, who was suspect to be infected.

Further, Guangzhou City in China has introduced thermometers on its city buses, which by using facial recognition technique scan passengers while taking body temperature measurements. The system rapidly identify symptoms of fever and send alerts to the authorities in case of any anomaly.

During the initial period of evolution of facial recognition enabled video surveillance was not effective in cases where the subjects wearing face masks or head scarfs. However, a Research Firm in China has is in the process of bring out a technology for identify people even while their facial features are partially covered.

Similarly, Dubai administration has introduced Cameras with thermal technology built into them to identify potential cases of the virus in strategic locations one of such being the Dubai world Trade Centre .Most of these camera systems are configured with features that are capable of assessing individuals' internal body temperature as they move through their field of view. the video analytics software separately analyses the body temperature viz-a-viz the predefined norms to identify any abnormal body temperature that could alert the authorities for further screening and check of the individuals at subsequent checkpoints.

New York , one of the largest metropolitan city in the world is using its network of surveillance cameras in the city's fight against the coronavirus to track social distancing behaviors and to ensure that no public congregation against the law.

In Indian Metropolitan cities like Bangalore, surveillance cameras originally intended for traffic monitoring and management has been repurposed for monitoring the enforcement of lockdown and social distancing norms. Further some of the cities in India have successfully deployed number plate recognition in surveillance cameras to track the vehicles that violate lockdown norms.

Further, Tunisia's civil administration has pressed in to service the patrol robots on the streets of Tunis to persuade people to stay home during the lockdown. The robot, which is remote controlled, uses video surveillance cameras and a interactive voice system to communicate with the public.

Dubai police has announced that radar patrols and other monitoring tools will be pressed into service during the

curfew imposed to track people's movement and to discourage people from coming out of their residences during the curfew. The authorities are also planning to publishing photos of individuals who violate curfew norms without obscuring their faces.

2.6. Social Media Platforms

The total number of registered users on various social media platforms combined stood at 3 billion people just before onset of the pandemic. The screen time of these staggering number of users have significantly increased due to lockdown situation and movement restrictions imposed on different parts of the world. Thus, these platforms are an effective medium for targeting people with authentic information so as to prevent the spread of misinformation. Social Media majors are actively carrying out active interventions to ensure that its users are steered towards authentic information. Facebook has set up a 'COVID-19 information center tab' in its platform, Google Scholar, a specialized search engine for providing scholarly literature, is featuring research papers and articles on COVID-19, and Twitter is helping its users with reliable sources of information on searches related to COVID-19. Youtube also provides authentic videos related to the pandemic as recommendation on the basis of the search history of the users. Whereas, no such official endorsement is seen from other entertainment based social media platforms like Tiktok etc.

Similarly, social media influencers and celebrities around the world are taking to social media to reach across their follower base and to spread awareness among people. For instance, many of the Bollywood and Sports personalities celebrities in India have constructively engaged with their fans during the lockdown period in India and appealed to people to stay at home and to maintain social distancing. The music albums and short plays created by many celebrities on COVID-19 themes have become instant hits in India. Hollywood stars, Popstars and sports personalities of other countries are also in forefront to make maximum use of social media platforms to drive home the message. Julia Roberts, Justin Bieber, Taylor Swift, Ryan Reynolds, Michelle Obama... the list goes on.

Most of these celebrities and social media influencers have very huge follower base. Their messages and appeals create a massive positive impact on their followers as they are able

to instantly relate to these messages and try to follow their footsteps.

This capability of social media can be effectively used to enhance public-health awareness and education. In Singapore, the government is collaborating with WhatsApp to ensure that the public receives credible information on the effects of COVID-19 and the government's steps to test its spread.

Spreading of fake news masquerading as pandemic updates creates more fear and anxiety among the population. The fake home remedies promoted as cure for COVID-19 misguide people into believing them and experimenting the same. Most often, spreading of fake news result in confusion, panic buying, hoarding of commodities that are in short supply, hike in price etc. in an effort to contain false information, companies like Google, YouTube and Facebook are striving very hard to filter fake news and provide authentic and verifiable data published by authorities such as WHO and government.

2.7. Telemedicine

Telemedicine is a branch of medical science wherein patients are remotely diagnosed and treatment prescribed using telecommunications technology. Telemedicine has come handy during the COVID-19 epidemic by providing a powerful platform for interaction between health workers and patients. Telemedicine plays a very crucial role where medical infrastructure cannot cater to the growing population of infected persons. It is also found useful for individual who are afraid to venture out for treatment fearing infection. Apart from being a medical service forum, it also goes a long way in educating people and avoiding panic and runs in health centers and hospitals. Besides individual-level treatment, data obtained by telemedicine systems can be analyzed to forecast pattern and geographic-specific distribution of the progression of an outbreak within a population.

Digital technology can unlock the potential of Healthcare systems to broaden the accessibility of services. For example, 'virtual clinics' concept being popularized in USA, which uses tele-medicine consultations with imaging data captured by way of X-ray, CT Scan etc. the uploaded images and other audio-visual inputs are analysed and interpreted remotely. This ensures that patients receive uninterrupted medical care at the comfort of their homes. This reduces the burden of patient turnout in the hospital which is a real concern at the time of an epidemic outbreak.

The telehealth app called -MaNaDr, founded by family physician Dr. Siaw Tung Yeng is very popular in Singapore. Over a million people have used the App, which provides a platform for virtual visits. Around 20% of the physicians in the island country has been onboarded on the system. With an objective to control mounting cases of COVID-19 infection, people with mild symptoms of the infection are getting pre-screened by medical team on MaNaDr. As per the preliminary assessment, patients with low risk profile are advised to stay home if they don't need intensive care. Patients who are advised Home Quarantine 'check in' with their telehealth consultant pre-assigned time every and report updates on their symptoms and also the basic vital statistics. The patients whose symptoms worsen over time are brought immediately to hospital for intensive care. The platform allows Singapore's medical fraternity to deliver medical services across the nation.

Numerous apps are now available in the U.S. allowing Americans to calculate multiple times a day dozens of health metrics such as temperature, blood pressure, and blood sugar using connected devices. Such vital statistics are automatically stored on cloud servers, from which physicians receive alerts if the readings are inconsistent or abnormal.

G) Positioning Technologies And Satellite Monitoring

Positioning technologies play a vital role at the time of disasters. Government agencies and first responders working in the forefront of medical and administrative service require accurate location data for planning the logistics and to regulate people movement. In the case of present epidemic also, Global Navigation Satellite System (GNSS) proves to be highly useful. In China, BeiDou, the country's GNSS Hub, played a crucial role in disaster management efforts by helping in tracking the patients in affected areas. The locational data sets also helps in analyzing the pattern of the epidemic spread. Equipped with precise data sets and mapping & imagery, China was able to set up hundreds of makeshift hospitals across the country especially in Wuhan province.

BeiDou Navigation Satellite System is also being used by Provincial Administrators for transportation planning. Logistics companies working in the ground are using GNSS terminals to aid in the transport of essential relief goods. BeiDou system is also equipped with RDSS (Radio Determination Satellite Service) that relays information real-time. The BeiDou has played a remarkable role in the efforts of Chinese Governments that enabled them to construct two new hospitals in Wuhan province.

In Ruichang, Jiangxi province of China, the police forces are

provided with BeiDou-enabled drones for keeping track of public movements to ensure strict adherence of quarantine and social distancing norms. Further, the Chinese Transportation Department could quickly send emergency messages to 6 millions connected vehicles using BeiDou on the updates of the spreading disease. The Chinese e-commerce behemoth JD also supplied medical equipment in remote hospital areas in Wuhan, using BeiDou-based robots.

Geographical Indications (GIs) can be used to plot a Epidemic Thematic Service Map which provides a real-time visualization of data relating to epidemic. On a wider scale, it can present the geospatial positioning information of counties, townships, villages etc., It also serves as a precise base map foundation for creating a 'epidemic data-on-map' within the region.

The Epidemic situation awareness map developed using Geographical Indications (GIs) enables visual representation of the geographical distribution of confirmed infection cases, cumulative number of diagnosed cases and recovered cases 'through administrative divisions and community grid maps'. It also makes the use of aggregation, heat, and scattered points to display the epidemic trend through spatio-temporal evolution, and projects the epidemic 's development trend in various dimensions.

GaoFen, a group of high-resolution observation satellites, the Zhuhai-1 hyperspectral imaging satellite and the ESA Sentinel-1 were pressed to serve to track the progress of the temporary hospitals being established at lightning speed in response to the spreading disease.

The analytics and processing capabilities of powerful TFSTAR, a second generation AI satellite was leveraged by Chinese Authorities to scan the data. TFSTAR's data processing capability coupled with geocoding provides a real-time visualization of COVID-19 and the geo-spatial spread of the virus.

3. ISSUES IN TECHNOLOGY ENABLED FIGHT AGAINST THE PANDEMIC

In the foregoing section, we have seen a vast variety of digital tools and applications that has transformed the way pandemic are predicted, contained and mitigated. Though sky is the limit for technologies in the fight against COVID- 19, these technological interventions are not without its drawbacks. Here are few teething issues hampering the technological revolution in the field of epidemic control and research.

3.1. Technological Divide

Most of the currently evolving technologies in the field are centred around connected devices and crowd sourcing of data. A prerequisite for which are connected devices such as smart phones, smart wearable etc. universalization of such technologies are still a distant dream since barely 30% of world population has mobile phones. Further, the percentage of internet proliferation in developing and underdeveloped countries still remain to be abysmal. The lockdowns imposed by various countries like India has affected the livelihood of millions of citizens. When basic needs like food and shelter are in question, usage of smart phones and connectivity to internet naturally becomes far lesser priorities for the people. This hamper the reach of such technologies deployed in the fight against COVID-19 epidemic, that relies on various vital parameters and infection data collected from the targeted population. Such studies and projections can go wrong due to inadequate representation of all the sections of society.

Digital exclusion of vast sections of societies is a major stumbling block in the efforts of various Governments to disseminate information to its citizens through social media platforms and other digital tools. For example the Aarogya Setu App introduced by Government of India for communicating COVID-19 updates to its citizens requires smartphones and interconnection. However, the proliferation of connected smartphones in rural India is hugely inadequate to be demonstrative of such population.

3.2 Privacy Concerns

The unrestrained and widespread use of technology in the fight against spread of COVID-19 virus has brought to fore serious privacy and security concerns as well. Optimum utilization technology for leveraging the preventive efforts without unnecessarily poking nose into personal lives of citizens and without compromising the security valuable and strategic data is proving to be a tight rope walk for the Government and administrators of several countries.

For instance, US Federal Administration is in talks with IT behemoths like Google and Facebook to arrive at an optimum and ethical level of using personal data available in social media platforms, Medical History available with National Social Security schemes, Location data of Americans' by tracking their smartphones for aiding decision making process.

A project undertaken by Kerala Government in collaboration with US-based tech giant Sprinklr that is aimed at analyzing medical data of people under surveillance or treatment for COVID-19 has raised a big

debate in the country. While those who advocate for the use of digital technology emphasize the potential use of the data analysis, sceptics are raising issue of possible leak of personal data at the hands of foreign private entities for commercial gains.

The Aarogya Setu, one of the most widely downloaded mobile phone application introduced by Government of India as a digital safeguard mechanism for Indian Citizens has also given rise to debates in political circles about safety of the huge cache of information the project will be gathering during the epidemic season.

European countries such as Italy and Germany where stricter laws on data protection are in place, are relying on anonymized location data to track people gathering in public places and lockdown violations.

Every single byte of personal data comes with privacy issues. Yet, there is no doubt about the usefulness of digital technologies that immensely help in predicting the spread of the infection which in turn enables the medical fraternity and administrators to cope up with the crisis and improve the efficiency of its service delivery. It is upto the Governments to judiciously use the precious data without compromising the safety and privacy of its citizens.

4. CONCLUSION

Today, the technological advancement and connectivity enables the countries to tackle the COVID-19 pandemic in ways we never earlier imagined possible. However, as of now, the medical response world over in the face of COVID-19 onslaught has only scratched the surface of what these new digital tools can potentially offer. Building on them will be critical for ensuring that the next outbreak never gets the chance to explode from epidemic to global pandemic. The important take away from the current COVID-19 situation is that there are now cutting edge tools available that can foretell, predict, tackle and if required, contain to a great extent the infectious disease before resorting to measures such as curfews and quarantines. The modus operandi in such a situation a decade ago and what we are upto right now are hugely different. The IT and IT enabled tools offers enormous opportunity in the field of epidemic response and control and going by the rapid progress in these areas, humankind will be far better equipped before another epidemic strikes the world.

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