Integration of Adaptive Technologies with Healthcare for the Early Identification and Control of COVID-19 Pandemic Disease

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ABSTRACT

The impact of the COVID-19 pandemic has spread all over the world and it has affected voluminously everyday lives of billions. Social consequences and virus spread that needs to be addressed to take proper action to resolve the challenges faced during this pandemic period. The pandemic needs proper surveillance, monitoring, diagnosis, and identification of infected patients. Most researchers continue to give ways to detect and control the pandemic diseases of this type. Pandemic has made researchers from all areas and virologists consider cross-disciplinary approaches to combat with COVID-19. It needs to be immediate decisions to deal with uncertain conditions. During such a pandemic, the incorporation of healthcare technologies would bring about many solutions with high benefits. Reliable, sustainable, and accessible approaches can be the emphasis of the new digital healthcare approach. In this direction, IoT based smart solutions are introduced and analyzed. The emergencies spanning the globe demand a smart healthcare solution to manage people's lives at every stage. The first pandemic break-out in any part of the world needs early detection of disease and infected individuals to take reasonable measures forward to contain the spread. Web and Mobile based IoT system integrated with healthcare to support the solution that needs to be solved by the emergency posed during this pandemic. To locate COVID-19 cases and reduce the effects of the pandemic, IoT-enabled cognitive solutions are provided. It also addresses new ubiquitous technologies such as AI, Machine Learning, and Big Data Analytics with new innovative methods to integrate the solutions, including wearable devices, RFID, GPS, mobile apps, etc. Concerning the COVID-19 pandemic, the benefits and operational difficulties faced in digitizing these healthcare-cognitive IoT approaches are analyzed. The study would also address internal and external concerns such as practicality, cost, time to measure and execute, and coverage for implementation of this solution. These solutions may include human-machine interaction with the right decision-making capabilities. The paper also focuses on the ethical issues raised in introducing modern interoperable and predictive Healthcare IoT solutions.

Keywords: COVID-19, Healthcare, IoT, Pandemic, Technology, AI, ML, Cloud, Web Technology, Mobile Technology.

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1. INTRODUCTION:

During the current situation of the **co**rona**vi**rus **d**isease of 2019 (COVID-19) pandemic, all countries including India are trying hard to fight against the adversities related to it. Every country is looking for cost-effective solutions especially in the field of healthcare to meet different challenges posed by the disease. The problems and challenges faced by humankind led to the invention of new theories, techniques, and methods. These days, the whole planet is witnessing enormous changes. Health has been redefined as the body's capacity to adjust to new intimidation and infirmity. These days, diseases and deaths have become a huge hindrance to the human race. Altogether a new era in the history of healthcare was created by the pandemic [1].

Good health is part of almost any worship: it is daunting to have to overcome feelings of loneliness, low mood, and low self-esteem. Wellness is regarded as a term that is a multi-dimensional one. Emotional, physical, mental, economic, environmental, social, professional, intellectual, and spiritual elements are involved. Even during situations of immense stress, if a person can manage emotions, he/she is considered to be emotionally stable or emotionally well. If a person without panic can manage tension, problems, and all kinds of emergencies, then he/she can be considered emotionally well. Techniques of self-relaxation, such as meditation, empower one to be emotionally powerful. Financial wellness is the capacity of an individual to administer financial matters. Since money is the key factor in everyone's lives, there is a great need for good management of that though. Financial instability is the primary source of stress and anxiety. Proper planning of revenue, expenditure, and investment can reduce financial stress optimally. Occupational wellbeing is connected to one's career. It is all about how the profession is enjoyed by a person. A lot of emotional imbalances can be created by the unfriendly and stressful environment in the workplace. Employment stress can be reduced by peer collaboration, workforce-friendly policies, a flexible working climate, etc. Social wellness is linked to one's friends and family. This creates an emotional bond with the members of one's family. People are made more stress-free and happier with the help of strong contact with family and friends. There will be a lot of tension and depression if there is a lack of intimacy between friends or family members. Environmental wellness is associated with the lifestyle and environment of an individual. To a greater level, the use of alternative energy sources, the protection of natural resources, etc., can help to sustain environmental well-being. Intellectual wellness is connected to an individual's intelligence gained. Active involvement in informative discussions, reading scholarly books and articles, etc., can improve an individual's intellectual well-being. It is closely linked to one's mental health.

Spiritual well-being is all about following principles and virtues. This is associated with one's soul. In daily life, spiritual wellbeing will help an individual to cope with stressful and unexpected difficulties. Maintaining a fit and healthy body is all about physical fitness. By maintaining a balanced diet, exercising regularly, and taking adequate rest, one can achieve this. If any signs of disease are detected, then it is best to seek adequate advice from health care providers. For all other wellnesses, it is the bedrock, but it relies to a greater degree on the rest of them. All phases of wellness are greatly affected by pandemic COVID-19 [2].

Because of its high rate of transmissibility and lack of availability of effective vaccine or therapy, the COVID-19 has created panic all over the world. The effective implementation of techniques for containment and mitigation requires extensive use of technologies. Technologies are adopted for pandemic management, tracking the infected, testing the suspected, etc. which otherwise would have been very difficult to carry out manually. As the number of infected is increasing exponentially every passing day, there is a huge demand for technological inventions [3].

Advanced analytics can significantly accelerate the process of decision-making as up-to-date data is readily available. Artificial Intelligence (AI) and Machine Learning (ML) techniques can be used to gain more insights into the infected and probable. Intelligent solutions can predict the progress of the disease and help people to contain and mitigate the global emergency. The virus-based disease spread at an alarming rate. The outbreak of an unfamiliar, fast-spreading disease has created global healthcare emergencies. Many countries are struggling to flatten the curve. The world is facing a scarcity of emergency services such as ventilators, test kits, beds in the Intensive Care Unit (ICU), etc. In

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addition to this, the asymptomatic carriers are contributing more to the disease outbreak. Emerging technologies such as AI, ML, data sciences, and advanced data analytics can access loads of records collected from diverse sources can predict several phases and facets of the disease in advance. The data analyzed can be visualized in the form of charts and reports to get a better understanding of the results.

In this paper, the authors attempted to examine how innovations for the early identification and control of COVID-19 pandemic disease benefited the healthcare industry. Research on the effect of COVID-19 on the IoT and healthcare industry was also carried out in this article. A few predictions or recommendations that are much needed during the post-COVID-19 era are also listed in this work [4].

2. OBJECTIVES OF THE STUDY:

This paper mainly focuses on various issues related to the application of adaptive technologies in the control and management of COVID-19 pandemic disease. The main objectives include:

- To analyze technologies commonly used in the COVID-19 period
- To comprehend the utilization of technology in COVID-19 management
- To review the impact of COVID-19 on Technology
- To familiarize the influence of COVID-19 on the Health Industry
- To study post-COVID-19 Healthcare trends

3. METHODOLOGY:

The authors attempted in this paper to analyze How the integration of adaptive technologies with healthcare for the early identification and control of pandemic diseases benefited to contain COVID-19 pandemic. This qualitative research paper is developed by observing and analyzing existing information on the topic using the keywords "COVID-19", "IOT and COVID-19", "Hospitality and COVID-19", "Technologies used in COVID-19", "COVID-19 management" and "Contain COVID-19", available in online articles, peer-reviewed journals, magazines, and a few official websites.

4. TECHNOLOGIES COMMONLY USED AT THE COVID-19 PERIOD:

Epidemics and pandemics are not new to humankind. They have been threatening the human race time and again. The outbreak of deadly diseases such as "Severe Acute Respiratory Syndrome (SARS)", influenza type A virus, known as H1N1, Ebola, etc. had enabled new ways of managing the disease. The use of technology can never prevent a pandemic but it is possible to educate and empower people to prevent them from becoming panic. Misinformation or wrong information about certain issues such as the number of fatalities, government policies such as lockdown, seal down, restriction on transportation, diagnosis, treatment options, etc. makes people extremely panic. This will result in panic buying and unnecessary hoarding of essential commodities. The impact of this will be prize hike, fights on the streets, and violence. It is possible to verify the truthfulness of the information circulated through social media. To do that the information published by institutions such as the World Health Organization (WHO) and the health ministry of a country is used. With the help of converging technologies such as cloud computing, 4G/5G, AI, ML, etc., several innovative approaches have been invented. Some of the technologies that are widely adopted during the outbreak of the pandemic are listed in this section [5].

4.1 Artificial Intelligence and Machine Learning

Several inventions are in progress to slow-down the spread of the virus and for effective treatment of infected people. Technology has catalyzed the process of inventing vaccines. AI and ML have transformed several sectors. AI and ML are playing a vital role in helping the medical researchers to analyze the structure of the protein. ML has also shown greater promise in the production of antigen. Technology can also be used to verify the reliability and safety of the vaccine [6]

4.2 Cloud Technology

Cloud computing has enabled the technological shift during COVID-19. The cloud technology ensures the availability of computing and processing resources on a virtual platform. The use of technology has enabled companies and business organizations to stay connected during the time of the pandemic. Since all the necessary data is available on the cloud platform the authorized users could make use of the same to carry out their job. Cloud computing made virtual conferences, remote work, online learning, etc. easy. The universal accessibility of real-time data has made remote working functions smoothly. The exceptional storage, hassle-free backup, and scalability of the

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cloud platform enabled the smooth functioning of business activities even during the critical time of lockdown. Cloud-enabled webinars and life-saving mobile apps were extensively used during the lockdown period [6].

4.3 Remote Working Technologies

Because of the pandemic, currently, the business world is experiencing turmoil. In this scenario, there is the utmost necessity for a technology to enable secure access and management of sensitive data, conduct virtual meetings, and cloud conferences. Several companies encouraged remote working or work from home for their employees [7].

The outbreak of COVID-19 enforced millions of employees to work from home. The institutions were forced to do so because of travel restrictions. This enabled them to reduce the infection rate. Virtual Private Networks (VPN) were upgraded to provide essential security and there was an increased demand for teleconferencing tools. These tools helped them engage in business meetings. It also saves travel time and offers more flexibility in addition to preventing virus spread. Some companies are offering virtual Disc Jockey (DJ) shows and entertainment facilities to keep their staff engaged in lockdown deprivation. The policies and schedules of the companies were changed to adapt to the remote work environment. Leveraging the advancement in technology, VPNs, teleconferencing tools, Pain Time Off (PTO) trackers, etc. homes were quickly and effectively transformed into offices to facilitate work from home [8].

4.4 Face Recognition and Big Data

COVID-19 has transformed the conventional surveillance system into a new digital big-data and facial recognition driven tracking system. Governments used the features of big data to improve the surveillance of infected people. Facial recognition techniques were used to identify the infected people and track them to analyze the spread of the disease. This technology was accurate enough to identify people even when they wear masks [6].

4.5 Online Shopping and Contactless Delivery

This technique was practiced by restaurants and shops throughout the outbreak of the COVID-19 pandemic. It is used to deliver essential items such as food, medical equipment, and medicine safely and securely. Companies used to display a digital menu and accept orders online. The

companies that offered online shopping facilities also experienced a lack of stock and delayed delivery because of restrictions on transport. Online shopping requires a strong and effective logistic network. Companies used a sensor-based system for tracking the goods to be delivered. The items are packed in a safe manner. The packing personnel was expected to wear protective equipment to avoid direct contact with the items. The idea is to minimize direct contact between customers and employees. This is done by encouraging the use of a contactless menu, contactless orders, contactless packaging, contactless delivery, and contactless payment. It is practiced by companies to retain their business, ensure the safety of customers, and improve customer satisfaction. The exchange of currency notes is reduced to a maximum extent and digital payment technology is encouraged. The delivery personnel will wear the sanitized protective equipment and drop the items at the customer's doorsteps [9].

4.6 Digital and Contactless Economy

The global pandemic COVID-19 taught even a common man a new way of living in all spheres of life. The proliferation of technology enforced people to switch to a new mode of payment knows and digital or contactless payment. A cashless economy is encouraged to a maximum extent to avoid direct handling of the currency note. This has led to a new wave of revolution in developing countries like India. Contactless payment can be practiced several techniques such as net banking, digital wallet, Unified Payments Interface (UPI), Quick Response (QR) code scan, contactless cards, etc. Even in small retail stores, there are multiple ways to practice contactless payment [1][3].

4.7 Contactless Treatment

COVID-19 has changed several aspects of our daily life. The routine checkups such as monthly health reports, annul examinations, frequent hospital visits for common illnesses such as muscle pain, sprain, ear pain, runny nose, cough, etc. are discouraged. Instead, doctors pay virtual visits using video conferencing or teleconferencing technology to reach their patients. Virtual appointments are issued to patients during which patients are encouraged to share their problems and get virtual prescriptions. Some pharmacies even offer contactless delivery for the customers who are uncomfortable to visit pharmacies because of their vulnerability. Mental and emotional wellbeing also plays an important role in addition to physical health. Doctors and experts offer free counseling sessions to the patients

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and suspects of COVID-19 to boost their confidence. Small tips during the critical time will be of great help for patients, suspect, and their family members. COVID-19 might have prevented people from accessing healthcare services directly but technology has not prevented them from accessing the services. Through technology, people can get the best healthcare services without leaving their residence [3][9].

4.8 Chatbots

Chatbots are nothing but software that uses artificial intelligence. They enable communication in natural language. They are used through mobile apps, websites, messaging platforms, and even telephone. They were extensively used by the Government and the healthcare organizations during the outbreak of the pandemic COVID-19. They were used to provide authentic information related to the disease which is published by organizations like WHO. They have proper answers to thousands and thousands of questions related to the disease. They were used as tools for financial and mental health consultancy. During the period of quarantine and isolation, people experienced depression. Chatbots could suggest they engage in different activities such as yoga, meditation, exercise to keep them active. Chatbots suggest healthy food habits and natural immunity-boosting food keep them fit and ready to face the battle with the disease. During the time of the pandemic, chatbots were extensively used in restaurants which were converted into take-outs. They were used to communicate the customers regarding the changed working hours, policies, menus, etc. Retailers used chatbots to disseminate information regarding their working hours, return policies, and many more. In many sectors such as healthcare, government, business, manufacturing, etc. chatbots were created to answer the Frequently Asked Questions (FAQ) of their customers. Resources such as Dialogflow enable develop-once-deploy- anywhere feature for chatbots. They also provide the user interface for websites as well as mobile applications. Chatbots use AI techniques such as natural language processing and they support several languages. This feature made them more user-friendly. As they enable serverless launch then concepts such as a server, network traffic did not come into the picture when installing them. The information that can

be delivered by a chatbot could be personalized depending on the needs and symptoms of the customers and patients. This way, the COVID-19 pandemic has accelerated the use of chatbots. They can also be used to provide ubiquitous healthcare even after COVID-19 so that FAQs of the patients regarding any disease can be answered by the authentic information provided [8].

4.9 Internet of Things

IoT is an ecosystem of interconnected devices that are capable of transferring information without human intervention. Through IoT ordinary devices can be transformed into smart objects and these objects can be referred to using a unique identification number. With the effective use of this technology, the workload of overburdened clinical staff can be reduced to a greater extent. With the support of technology, the real-time data of patients can be captured accurately [6]. When technology is applied for screening, the number of tests or screening of COVID-19 can be done at a faster rate and the accuracy of screening is high. The IoT devices can be used to track the patients easily. They are less expensive and accurate. To improve the quality of healthcare services in a cost-effective way IoT is extensively used. Using IoT medical resources and patient data of different hospitals can be integrated to use them effectively. Technology can be used to communicate the concerned authorities regarding the exact situation of the patient for effective treatment [10].

4.10 Blockchain Technology

During the outbreak of COVID-19, blockchain technology is used to store healthcare data more effectively and efficiently. It is extensively used by the government agencies for tracking the patients and their contacts. This will easy the detection of infected ones. This technology is also used to alert the public about the disease and send the guidelines of institutions like WHO using the concept called a smart contract. It can also be used to manage the medical supply chain effectively during the critical situation of the pandemic to avoid the out of the stock situation of essential medication. This distributed technology is used to store sensitive data in an utmost secured manner. This data can be accessed by multiple parties such as doctors, clinical staff, govt authorities, etc. Since the information is accurate and up to date it can be efficiently used for analysis [11].

4.11 3D Printing Technology

During the period of lockdown, the healthcare sector was in crisis because of the shortage of beds, life-

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saving equipment, medicines, etc. The manufacturing industry at the same time suffered from a lack of workforce. Because of social distancing, the manufacturing industry shifted digital solutions to retain productivity. 3D printing technology was leveraged for manufacturing the essential equipment on a very large scale. This technology was used to manufacture the respiratory support apparatus, ventilator valves, T connectors to share a single ventilator among multiple patients [6]. The most essential personal protection equipment, N95 masks, N90 masks, air-purifying respirators, specimen collection kits, etc. were manufactured using 3D printing technology. 3D printing technology creates models using computer-aided design (CAD). The versatility of prototyping using 3D technology was made use of in manufacturing the necessary tools needed for training healthcare professionals. 3D printing technology was also used to construct residences for people under isolation or quarantine. These dwellings can be easily transported and installed wherever necessary [12-13].

4.12 Online Education

The education sector was being affected to a greater extent because of the outbreak of COVID-19. Schools, colleges, and universities closed their shutters for almost six months. These days the education institutions experience a paradigm shift as they are focusing on online classes rather than conventional ones. Online education has become a powerful alternative to traditional face-to-face classes. Moodle and Google classrooms are considered as powerful platforms to conduct academic activities. They enable ubiquitous learning or learning anytime anywhere [7]. These platforms provide the facility to conduct online classes, share learning material check the progress of the students anytime. Several students made the best use of lockdown time and enrolled themselves in various courses offered by "Massive Open Online Course (MOOC)", "National Programme on Technology Enhanced Learning (NPTEL)", and Coursera. Virtual labs were created to facilitate a hands-on experiment-based learning atmosphere for the students. The extensive use of Augmented Reality (AR) and Virtual Reality (VR) technologies made online education more interesting and effective [14].

4.13 Supply Chain 4.0

The entire global supply chain is disrupted because of the measures taken to avoid the spread of COVID-19. Several factories are completely shut down to observe social distancing. Meanwhile, demand for food, essential products, and protective equipment has significantly increased. Heavy dependence on paper-based documents, lack of accountability, less flexibility, and slower operational speed have made the conventional supply chain inefficient. Industry revolution 4.0 has allowed a digital supply chain to solve the inherent shortcomings of the conventional supply chain, using emerging technologies. The successful use of new technologies improved the performance, accountability, and speed of the digital supply chain. Some manufacturers also use autonomous devices to transport items like food, thus preventing the virus from spreading to a large extent. The labor-intensive sectors like manufacturing, transportation, healthcare, and food rely to a greater degree on human interactions to make things work. These are the sectors that are heavily affected through the lockdown period. COVID-19 has inspired the use of robotics and drone technology to distribute food and essential material to isolated or quarantined individuals. IoT devices such as sensors were attached to the containers so that the company can track them to know their exact location. Predictive analytics applications were used to forecast the demand and to avoid out of stock and excess stock situations. COVID-19 has caused a paradigm shift in many companies. Those companies which adopted digital technologies such as IoT, robotic process automation, 3D printing, digital ledgers, smart manufacturing experienced a boom in their business [15].

4.14 Robotic Process Automation (RPA)

The manufacturing industry experienced the largest real-world experiment during the outbreak of COVID-19. People were asked to stay at home during a lockdown or travel restrictions refrained from moving. This resulted in a shortage of essential items. The only option that was left for the companies to balance the demand-supply chain was to adopt automation. RPA is a software that is configured to mimic human actions and carry out some business tasks. Robots can interpret the instructions and perform a variety of repetitive tasks tirelessly. RPA is used to automate monotonous tasks to improve the work efficiency and reliability of work outcomes. Automation played a crucial role in reducing the job stress of workers [16]. These 'digital workers' deployed in offices and factories are capable of working round the clock untiringly.

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Since they are machines controlled by software, they work efficiently and they are not infected by the virus, unlike human beings. Hence, they have no risk of COVID-19 infections and travel restrictions. When the manufacturing work was automated, the production got increased and the cost of items was reduced. Robots or bots are of two types namely unattended and attended. Attended bots work based on human instructions whereas unattended ones work automatically. Unattended bots are often used in back-office work for the automatic pupation of inventories and analysis of sensitive data [11].

4.15 Augmented Reality (AR) and Virtual Reality (VR)

COVID-19 pandemic has a noteworthy influence on the worldwide healthcare system. It has affected both the mental and physical health of millions of people across the globe. The healthcare professional were the ones who suffered a lot because of the adverse effect of work pressure. They are under high risk of getting infected or developing stress-related disorders as they were made to work round the clock. AR and VR are considered as effective tools for the prevention, assessment, and treatment of stress-related issues such as anxiety, depression, etc. There are numerous video games developed using these technologies which can be used to distract people under uncontrollable emotional pressure. When providing training sessions to the frontline COVID-19 warriors VR is proved to be an effective tool. During the outbreak of the disease, the healthcare industry experienced a shortage of experts. Hence thousands of healthcare professionals required quick and efficient hands-on training for using medical equipment and taking necessary precautions when handling the equipment and taking care of patients. AR is a powerful visualization tool. It allows bringing imaginary objects to the real world. It also contains a feature called annotation that helps the user navigate effectively. AR can be used to reduce direct contact between the patients and clinical staff enabling interaction through a virtual platform called no-touch interface. AR can also be used to provide effective training to the medical personnel [11]

4.16 Autonomous Vehicles

Autonomous vehicles are small driverless vehicles that are capable of operating by themselves. They can perform all necessary functions without any human intervention. They provide increased safety and are extensively used to transport essential items, food, and medicine. They can also be used by people who are not in a position to drive because of their physical disability or illness. They are eco-friendly they use electricity or other renewable sources of energy. They are energy-efficient [11][17].

4.17 Drones

Drones were used in all possible ways during the outbreak of COVID-19 disease. They were used to spray disinfectants in some areas. In most of the situations, they were used to deliver essential items such as medicines. Drones help to track large crowds, reduce person-to-person contact, and monitor narrow places where police vehicles are unable to access. They can also be used in public places and in residential areas to spray disinfectants [11].

4.18 Geo-Fencing

Geo-fencing is a mechanism that produces warnings when a system enters a given area. The government makes effective use of this to track individuals who violate quarantine or isolation. A COVID-19 infected or probable individual could be caught based on the cell tower location. The government uses a mobile application to check whether a person has violated isolation or quarantine restrictions by tracking his/her mobile location. Based on this alert message will be sent to the concerned authorities [3].

4.19 Mass Surveillance and Satellite Technology

The government is effectively using this solution to gather data about a person such as body temperature, travel history, contact information, etc. Such data can be processed in a centralized database that can be analyzed using data analytics or machine learning to identify people who have directly or indirectly contacted the infected person. Data stored on the cloud is used to create dashboards that monitor the virus continuously. There are thousands of Closed-circuit television (CCTV) cameras installed in quarantine and insulation centers. The government will use the data relating to an individual to assess the number of people with whom an infected individual was in contact and order them to isolate themselves [9][17].

4.20 Telemedicine

Telehealth or telemedicine played a crucial role during the outbreak of COVID-19. It is used to provide continuous healthcare to patients who have symptoms of COVID-19. It avoids the spread of the

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disease as there is no direct contact between patients and medical practitioners. It bridges the communication gap between patients and doctors [9]. Telehealth was also provided for people who suffer from other illnesses such as joint pains. Diabetes, hypertension, etc. It made people stay at home and obtain the best possible healthcare support form experts. Doctors provided counseling to patients who are in isolation. This made them feel more confident during their critical time [18-19].

4.21 Satellite-based Monitoring
During the outbreak of COVID-19, there was a growing demand for the construction of hospitals quickly. This required continuous monitoring. Earth can be monitored continuously and effectively utilizing satellites. Hence this feature is used to make them monitor the construction of hospitals. They click high-quality images automatically and send the same to the authorities. Satellites can also be used to monitor changes in the logistic network [20].

4.22 Online Training Sessions
Realizing the training needs of healthcare personnel governments launched several online training sessions for the frontline COVID-19 warriors. A dashboard containing all the necessary information related to the healthcare personnel was created and managed effectively. Many webinars were organized for the people who are a part of Non-Governmental Organizations (NGO) and other non-profitable organizations. They were trained effectively using an online platform and instructed to pass authentic information about the disease and create awareness among the public.

4.23 Online Entertainment
The lockdown, seal down, isolation, and quarantine measures adopted by the government made people remain indoors. During these days people made extensive use of online entertainment tools. There was a spike in the number of subscribers for Amazon Prime, Netflix, and Disney Play during the period of lockdown. Live concerts, online movies, multiplayer online games, video chatting, etc. were extensively used by people to get entertained [3].

4.24 Video Conferencing
Because of the travel restrictions and unavailability of proper transportation during the outbreak of COVID-19, companies made their employees work from home. To stay connected with peers, higher authorities, teammates, and clients video conferencing was extensively used. Video conferencing applications such as Zoom, Webex, Google Meet were downloaded extensively for this purpose [3].

4.25 Color Coded QR
A person is asked to enter his details in an application form. The software will generate a colored QR code by integrating this data with the data from travel agencies, healthcare institutions, and other firms. The method by which QR code was allocated was kept confidential. Individuals were assigned QR codes in red, yellow, or green based on their data from different sources [21]. The QR code also included personal details such as name, number of identifications, contact number, temperature, and history of travel. The QR code is scanned when people enter public places. If it is green, they are permitted to enter, if it is yellow, they are asked to follow the quarantine for seven days, if red, they are asked to observe the quarantine for fourteen days. QR code is used to identify possible virus carriers and it is used as an alert for others. The person with a red-colored QR code is more vulnerable to the virus.

4.26 Positioning Technologies
Positioning technology plays a critical role during the period of crisis and disaster. Government agencies and investigators need precise positions for assessing the situation, determining high-risk areas, and implementing recovery measures as necessary. "Global Navigation Satellite System (GNSS)" and "Global Positioning System (GPS)" are found to be more successful during pandemic outbreaks. Drones are used for monitoring overcrowded public areas and for the fast and efficient distribution of food, medical equipment, and medical samples [22].

4.27 Predictive Analytics
AI and predictive analytics are playing a vital role in the prediction of disease. They employ spatial and temporal data analytics by making use of advanced Geographic Information Systems (GIS). Multi-dimensional visualization using techniques such as Sankey diagrams help to visualize the flow of patients from various phases. The identification of 'super-spreaders' and 'super-spreading events' can easily be done by using graph analytics. There is a single device in the form of Personal Electronic Devices (PED) which is used by people of all ages, demographics, genders, and social levels. This device unknowingly creates footprints

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wherever the person moves. Usually, healthcare agencies collect data by providing a form to the user. In addition to this, they collect data from health records, travel agencies, and so on. The data related to an individual is not available directly in disease [23]. Table 1 below details a list of digital solutions with technologies adopted most of the cases other than personal records. Smart gadgets contain historical data, mobility data, personal information, browsing patterns, contact details, and many more. Sniffing this gold-mine of personal details will be of greater use in preventing the spread of with examples to contain the COVID-19 pandemic effect.

Table 1: List of digital solutions with technologies adopted to contain the COVID-19 pandemic effect.

SN	Digital Solutions	Technologies Adopted	Examples
1	Digital & Contactless Payments	NFC, RFID, Cloud Service, 4G/5G, Cyber Security	Google Pay, PayPal Beacon,
2	Geo-Fencing	GPS, GNSS, 4G/5G, RFID,	Waze, JetBlue, Sefora,
3	Positioning Technologies	GPS, GNSS, 4G/5G, IoT, Face recognition	GateGuru
4	Color-Coded QR	GPS, 4G/5G, Data Analytics	WeChat, AliPay
5	Mobile tracking/mass surveillance	GPS, GNSS, Face recognition, RFID, IoT	DRDO NETRA, NARGRID, BULLRUN, ICREACH
6	Autonomous vehicles	GPS, RFID, 4G/5G, AI, ML, IoT	nuTonomy, Zoox, DataRPM,
7	Telehealth	IoT, VR, AR, Robotics, 4G/5G	MDLIVE., Lemonaid, LiveHealth, PlushCare, Amwell, Babylon, Teladoc Health Inc
8	Chatbots	AI, 4G/5G, Cloud Computing, IoT, NLP	TRAS, COVID19 FAQ,
9	Online Training for Frontline Warriors	AI, Cloud Computing, 4G/5G,	iGOT, DIKSHA
10	VR for Stress Management	VR, 3D Technology, Cloud Computing, AI, 4G/5G	Pious, Calm,
11	VR for Training	VR, 3D Technology, Cloud Computing, Animation, 4G/5G	INCELL, NearPod, EonReality
12	Online Shopping and Robot Delivery	Sensors, AI, Robotics, Big Data Analytics, Cloud Service, AR/VR, Facial Recognition, Blockchain, 4G/5G, IoT	Aethojsn, Savioke, Blue Apron, Amazon
13	Remote Work	Cloud Computing, Mobile Apps, Business Applications, Project management tools, IoT	AirCall, DropBox, Skype, Anydesk, Workplace, Zoom, Folat
14	Distance Learning	IoT, VR,	Zoom, Google Class Room, Office 365
15	Supply Chain 4.0	Big Data, Cloud Computing, Predictive Analytics, Blockchain, IoT, 4G/5G, Automation, Cyber Security	Value-chain, Plex, IQMS,
16	Video Conferencing	Face recognition, 4G/5G, IoT, VPNs, VoIP	Skype, Google Hangouts, Cisco WebEx, join.me
17	Autonomous vehicles	GPS, RFID, 4G/5G, AI, ML, IoT	nuTonomy, Zoox, DataRPM,

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18	Online Entertainment	AR, VR, IoT	Pokémon GO, Roblox, Sago Mini World, NetFlix, TED
19	Social Networking	RFID, 4G/5G, Face Recognition, AR, VR,	Facebook, Twitter, Google+, LinkedIn
20	Satellite Monitoring	GNSS, GPS, QZSS	Sentinel-1, Zhuhai-1

5. UTILIZATION OF TECHNOLOGY IN IN PANDEMIC MANAGEMENT:

As the coronavirus overwhelms features around the globe, it is emerging as an unparalleled human tragedy that will have long-lasting and widespread implications. The pandemic will certainly change the contingency plans and organizational strategies for businesses and governments alike forever. Although the degree to which this emergency will last is still indistinct, the risk is accelerating the move towards grasping progress and putting digitized transition at the forefront of global business elements [24]. Advanced appliances are crucial today, and there is an urgent need to concentrate on putting resources into technology to create versatility over the long haul. The mere digitization of traditional procedures will not aid in cutting connexons. Within the post-COVID-19 era, the emphasis must be on using innovation to get things done in another, improved way, and fully understanding that technological change will be key in realigning their business [25]. Prospective of technology use in pandemic management and containment are illustrated in Figure-1 below.
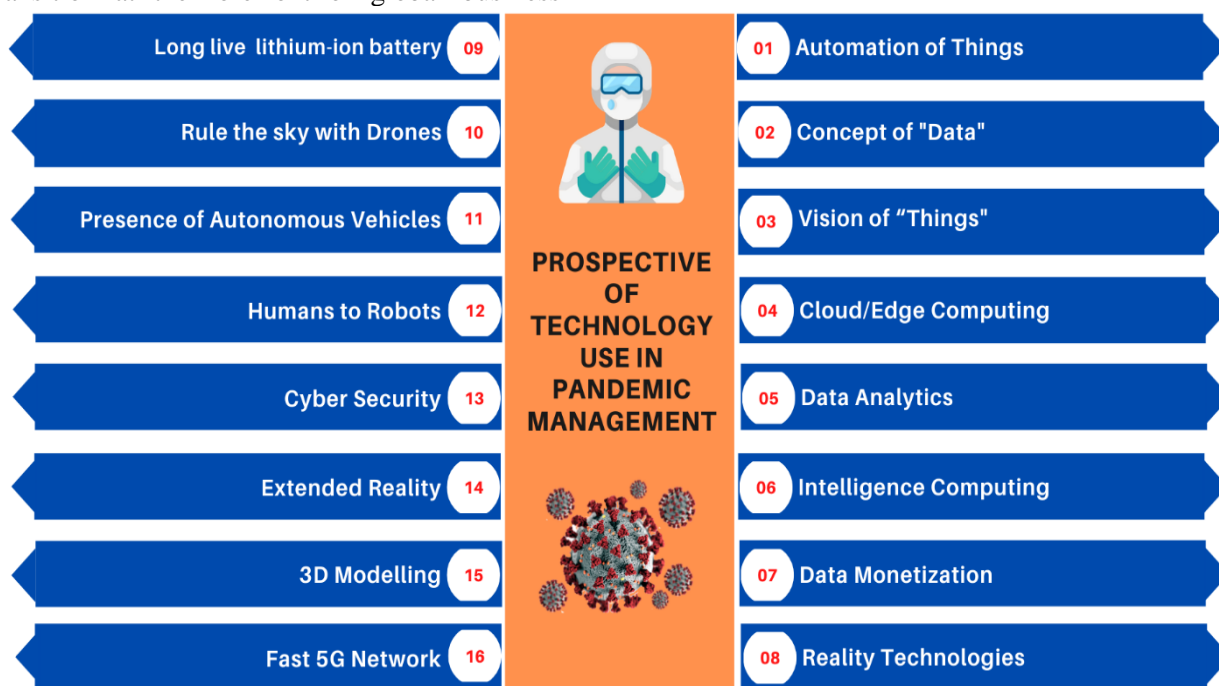

Fig. 1: Perspective of technology use in pandemic management

5.1 Automation of Things

With social separation turning into normal, however many organizations can automate their tasks as planned. It is especially important in the assembly division with the framework of Industry 4.0 enabling firms to continue their plant operations in the absence of a lot of human inclusion. Automation is also a key to increasing profitability, ensuring that products predominate when controlling costs. Besides, Robotics Process Automation helps by configuration, add-ins, and application-based frameworks to enhance the client experience. Automation of ordinary system undertakings will allow correspondence-specific organizations to reduce their workforce's contribution to coping with the method of reducing the degree of human error and enhancing the efficacy and efficiency of administrations [26]. Besides, construction, automation of engineering additionally lessen manual efforts of dreary errands

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in the life cycle of the item advancement. Automation extension by drafting, meshing, checking, technical journals, NC programming, first article inspection, and software checking is truly important [27].

5.2 Concept of 'Data'

Once businesses continue to operate in the new standard, the laggard leaders must distinguish between creating, developing, and adopting a technology viewpoint and understanding its strategic importance. Companies will strive to balance the four-dimensional concepts of data processing from collecting knowledge to having visibility into measurable returns:

- Collection – assembling and estimating data on focused factors in a built-up, organized framework
- Storage – changing how data is taken care of on the cloud or at the edge
- Analytics – assessing, purging, preparing, and demonstrating input. Dashboarding and producing bits of knowledge to act
- Monetization – creating quantifiable monetary advantages from accessible information sources and experiences

By using the right information, companies can be progressively proactive, envisioning potential events and consumer preferences, conveying increasingly relevant products, ensuring personalized management, streamlining processes and effectiveness, and alleviating hazards. Your knowledge result will be legitimately proportional to its length, range, and importance. Using knowledge ensures an enhanced client company, and is central to the updated client experience. Through setting up the right creativity, framework, and review, associations will open up the full potential of their knowledge to compelling business results [27].

5.3 The vision of "Things"

When the emergency coronavirus struck, the demand for IoT applications had recently collapsed in front of the theory testing stage it had been in for a few years. Organizations that transmitted IoT advances had risen from 13 percent in 2014 to about 25 percent in 2019. There were approximately 26 billion IoT gadgets in 2019, and statista.com predicts that their count will escalate to 30.73 billion per 2020 and 75.44 billion out of 2025. The market esteem for a person in the US by 2030 is about $150 billion with 15 IoT gadgets assessed. IoT would dramatically improve consumer behavior, throwing open doors that were not previously imaginable. The pandemic can constrain the picking up of this experience when individuals spend all of their energy at home. IoT gadgets can turn out to be very common, improving quality of life and increasingly pleasing everyday life [28]. Telemedicine and IoT gadgets assisting with checking individuals' wellbeing pointers may expand their prominence. A portion of the key dangers of this pattern is security, nonappearance of global similarity standard, and conceivable decrease of the work of manual undertakings. Simultaneously, IoT gives great control and computerization, sets aside cash and time, and may give superior personal satisfaction. Nonetheless, organizations that keep on utilizing the intensity of IoT will rise as the champs in empowering perceive-ability into assembling or field activities. This is particularly valid for remote checking and item and procedure diagnostics when even neighborhood travel isn't an alternative. From making significant bits of knowledge for related hardware and expanding performance, and restricting the board's expenses with a brilliant resource to motivating astute gracefully chain arrangements, investigation and IoT use continuous system information to open new revenue opportunities and improve customer experience. Tracking and hinting of advantages, hardware, computers, and individuals are important for organizations to be cutting-edge. In the post-COVID-19 timeframe, this would be increasingly relevant [27].

5.4 Cloud/Edge Computing

As IoT gadgets become all the more remarkable and boundless, organizations are liking to bring register and investigation power near where the information is putting forth an unmistakable defense for edge processing. All things considered, choices on whether to decide anxious or distributed computing are not an either/or question and not unrelated. While the touchy development of IoT gadgets and applications keeps on driving edge-registering frameworks and changing how information is taken care of, handled, and conveyed, the cloud offers gigantic advantages to associations that utilization a customary customer/server organize. Both figuring approaches have their upsides and downsides. Be that as it may, by coordinating edge registering with brought together distributed computing (haze figuring), associations can expand the inert characteristics of both while limiting limitations. Furthermore, huge numbers of them will try to do as

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such by co-finding their IT foundation with a server farm [29]. IoT additionally powers edge processing, along these lines information stockpiling and calculation becomes nearer to the organizations, empowering spares in transmission capacity and lack of reaction times. In the coming years, distributed computing would become essential. Organizations that have suffered the most significant hit due to pandemic are those that have not used the cloud for consumer interactions, coordinated efforts by staff, and operational ease. Pioneers have begun to understand the unquestionable attributes that can be powered by the cloud for the continuity of business. There will be a precarious surge in the hybrid and multi-cloud appropriation. The next few years will hardly be the most characteristic time for the cloud. To grow at 20 percent CAGR, cloud advertising is needed. [19].

5.5 Data Analytics

Uncertain occasions and tight, serious markets make it significantly progressively basic for organizations to get to the correct information focuses, break down them completely, and settle on bits of knowledge-driven and educated choices. By utilizing information investigation-based arrangements, organizations have the degree to be progressively proactive and receptive to the advancing circumstance [8]. From improving resource, the executives to guaranteeing exceptionally touchy gracefully chains, investigation assumes a critical job in enhancing activities. Further, prescient support calculations additionally empower undertakings to distinguish dangers and make a therapeutic move before any effect on the framework. All things considered, demonstrative activity dependent on prognostic information requires another mentality, apparatuses, and innovations to help it [19].

5.6 Intelligence Computing

The term Artificial Intelligence (AI) isn't too new for the data innovation circle, it's despite everything expanding its effect. For the most part, AI alludes to the utilization of calculations to fathom explicit assignments by concentrating a lot of information to make speculations as well as some measurement estimations. These calculations empower a PC to "act" simply like a human cerebrum. Man-made intelligence advancements are as of now utilized by 77% of purchasers, day by day show up new

applications. As indicated by PwC investigation, one of the main counseling organizations, By 2030 AI Goods will contribute over US$ 15.7 trillion to the global economy. Various mechanical developments, for example, information preparing, and face and discourse acknowledgment have gotten conceivable because of AI [26]. Simulated intelligence programming is a tremendous region to which one can incorporate AI stages, chatbots, AI (calculation class comprising of different libraries and systems), and profound picking up (utilizing fake neuron systems) and investigation undertakings for money related administrations. It's normal that in 2020 progressively customized applications and administrations for explicit or particular undertakings will be advertised. Acknowledgment of AI chatbots by the administration is developing in such territories as online retail, medicinal services, media communications, banking, money related counsel, protection, vendor, and government. One of the chatbots' particular purposes for business is robotization, which additionally makes occupations less difficult for workers (yet won't cause work shortening as it's occasionally thought of). Inside AI pattern can be laid out implanted AI and Machine learning as help (AIaaS and MLaaS) sub-patterns, which incorporate such sorts as bots and advanced help, subjective registering APIs, AI systems, and completely oversaw AI administrations. As-an administration stages will be utilized for the making of AI applications on account of the significant expense of AI-based frameworks [30]. They will empower taking care of in our information and paying for the calculations or register assets as we use them. Among notable AIaaS are Amazon Web Services (AWS), Microsoft Azure, Google Cloud, and IBM Cloud. Under states of COVID-19 spreading everywhere throughout the world, AI may add to the gauging of buyers' desires, which turned out to be not unsurprising and to assist organizations with sorting out viable coordination. Chatbots may offer customers' help all day, every day, one of the 'must-haves' throughout the lockdown. The prominence of AI may develop because of the need for the improvement of calculation mediators of posts and visual substance in interpersonal organizations (which some of the time square dependable wellsprings of data about coronavirus and don't identify fakes). Computer-based intelligence might be incorporated into dependable patterns because of its productivity, astonishing pace and precision, less slanted to make mistakes in examination with a human, just as the capacity to

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work every minute of every day in perilous and unsafe circumstances. It likewise has a few dangers, for example, cost, the limitation is given as far as possible, and machine reliance. For all clients confronting businesses and organizations, RPA has become even more crucial. RPA is presently at the forefront of client associations, from Chatbots to conversational AIs. A significant portion of business skills are set to obtain RPA rapidly, from HR and Finance Accounting to IT tasks. It is expected that the RPA market will expand by 37 percent CAGR.

5.7 Data Monetization

While information can offer a gigantic incentive to associations on their items, administrations, client desire, and market request, how they can separate substantial advantages that sway the main concern is basic. A McKinsey Survey on information and investigation found that an expanding number of organizations are utilizing information and examination to produce development and considering adapting their information, just as utilizing information in more approaches to make an incentive for clients. Fruitful information adaptation requires a cautious methodology that centers around the most elevated worth open doors steady with an association's general system. Most organizations have found how information can be utilized in everyday activities to decrease costs and develop incomes. However, just one of every twelve is utilizing their information for improved dynamic and income benefits. Organizations can improve their "profit per byte" by not just augmenting esteem creation inside (through cost decrease and income development) yet additionally make a business opportunity for their profoundly important information and bits of knowledge. This two-dimensional methodology will suggest that they are rehashing the game and making sure about market predominance at an opportune time [31].

5.8 Reality Technologies

With a few economies in lockdown and a huge lump of the worldwide workforce working from their homes, advances, for example, expanded reality (AR) and augmented reality (VR) can drive remote joint effort and fabricate flexibility. From giving a compelling option in contrast to workforce preparing necessities to empowering upkeep and fix, item administration, item improvement, creation tasks, field review, investigation, and deals and promoting capacities, AR/VR can empower constant data sharing across associations. This is particularly pertinent for aviation, vitality, and assembling segments. AR/VR is the cornerstone case of how organizations will reclassify their procedures for genuine business benefits going ahead. The developing organization of these innovations has urged designing specialist co-ops to investigate their maximum capacity and bring more AR/VR-helped items, administrations, and plans of action to the market. COVID-19 is anything but a momentary emergency [32]. This pandemic has featured the requirement for creative methods for overseeing business and new methodologies that associatons must convey to guarantee and even location future difficulties. In this season of vulnerability, organizations need to begin utilizing innovation deliberately to have the option to settle on very much educated choices and to deal with their business activities better. COVID-19 circumstance is the opportune time to quickly track the advanced change and influence computerized devices to reevaluate plans of action and remain a stride in front of the opposition.

5.9 Long Live lithium-ion battery

The Lithium-particle (LIB) Battery has been an incredible accomplishment in the previous years and is ready to zap the self-ruling vehicle, IoT, Mechanical Robotics, and the Unmanned Drones. The LIB showcase is required to develop to ~USD 28.7 Bn by 2025. Twelve of the driving players in the vitality segment have reported their arrangements to produce LIBs in India. For example, Exide, Amara Raja, Exicom, Coslight, and Samsung. A spike in joint endeavors and vital coordinated efforts is required to start the creation of Li-Ion Cells and Batteries to diminish the expense and increase the upper hand [11].

5.10 Rule the sky with Drones

Drones have just been effectively tried to disintermediate human intercession in different fields including yet not constrained to last-mile conveyance forms, conveyance of life-sparing medications in laborious territories, investigations in mining businesses, observation, and checking, seeding, and splashing manures in farming, search and salvage activities. The approaches around the commercialization of automatons have been being developed in numerous economies, which, in light of COVID-19, is probably going to take need and put on the road to success. The turn of events and appropriation of new-age rambles i.e., AI, ML,

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Cloud, IoT, and Cloud-fueled automatons, would spike from the current CAGR 56.5% [29][33].

5.11 Presence of Autonomous Vehicles

The auto-driving EVs have already demonstrated their power by shipping logistics from place to place in a most secure and tangible form. The key takeaways are delivery of food, medicines, and testing kits in a contactless form. Nevertheless, once the system matures, automated vehicles can drastically decrease human interactions in transactions and activities, which is also helping to comply with social distance guidelines [10-11].

5.12 Humans to Robots

Specialist robots would broaden its cutoff, from doing basic unremarkable routine occupations to increasingly clever responsive employments. Computer-based intelligence, ML, IoT, and Cloud-supported mechanical robots would accept the position floors and would play out an unremarkable activity of moving an item, stacking a truck to profoundly complex natural work, for example, working a processing plant dependent on the contributions from the reactions from sensors utilized in an associated industrial facility. Human mediation would be constrained to inaccessible observing through cloud reassure and camera [29].

5.13 Cyber Security

Together with the evolution of new advancements and the development of various gadgets, the measure of conceivable digital dangers consistently increments. In general, the primary aim of cyber-attacks is to get delicate data, alter or annihilate it, and coercing cash from clients or interfering with typical business types. These assaults are constant with development in their recurrence and refinement. Insurance of PCs, systems, and mists is generally given by the methods for cutting edge firewalls, DNS separating, malware assurance, antivirus programming, and email security arrangements. Cybersecurity is one of the main trends for organizations, whose business models rely on innovations powered by knowledge. After the General Data Protection Regulations (GDRP) of the European Union have been decided, considerably more attention is given to security and information insurance. The most recent cybersecurity dangers are phishing, ransomware, crypto-jacking, digital-physical assaults, state-supported assaults, and IoT assaults. Information breaks are the greatest cybersecurity concern, and exchanging individual information remains very rewarding at the underground market. Nowadays, when a huge number of individuals are compelled to work remotely, volumes of private information may turn out to be absolutely powerless or possibly not ensured appropriately. This rising issue may give another catalyst to the advancement of this innovation. Cybersecurity may likewise be applied in crowdfunding, administration, flexibly chain examining, record stockpiling, expectation markets, insurance of licensed innovation, IoT, neighborhood microgrids, and stock exchanging [34].

5.14 Extended Reality

Expanded Reality (XR) advancements aren't earth-shattering now, however since as of late they are effectively embraced in the diversion to make progressively vivid computerized encounters (Snapchat channels, Pokemon Go-style games). XR most regularly incorporates virtual, increased, and blended reality. Augmented Reality (VR) is the utilization of PC innovation to make a reproduced situation utilizing headsets that mix out this present reality, rather than viewing on a presentation, drenching an individual in an advanced 3D condition. Dissimilar to VR, Expanded Reality (ER) overlays advanced items onto this present reality through cell phone screens or shows, it doesn't make the entire fake conditions to supplant genuine with a virtual one. Blended reality (MR) is an expansion of AR, which implies clients can cooperate with computerized objects put in reality (think to play a holographic piano that you have set into your room through an AR headset) [35]. The impact of virtual and increased reality will develop in preparing and reproduction, just as offering better approaches to interface with clients, giving new shopping experience [36].

5.15 3D Modelling

One innovation that is contributing proximately to diminishing the hardship made by COVID-19 is 3D-printing. It gives fast prototyping and creation, and its abilities are autonomous of strategic worth chains, making it a well-known choice for crucial clinical guides, for example, veils, respirators, and ventilators. Europe and the U.S.A, the new focal points of COVID-19, are likewise home to numerous 3D-printer Original Equipment Manufacturers (OEMs, for example, EOS, Renishaw, SLM, 3D-Systems, Carbon3D, Envision Tec, Sciaky, Makerbot, and so forth. The 3D-printing biological system in these locales has in this

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way started to lead the pack in quickly turning out advancements for meeting the prompt difficulties presented by the pandemic. For the time being in any event, wariness about the guarantee held out by 3D printing might be alleviated. All-inclusive, COVID-19 is demonstrating that it accomplishes work [12-13].

5.16 Fast 5G Network

5G is recognized as the eventual fate of correspondence and the bleeding edge for the whole portable industry. As per a Huawei Technology vision, the arrangement of 5G systems will develop somewhere in the range of 2020 and 2030, making conceivable zero-separation availability among individuals and associated machines. This kind of versatile web network will give us super-quick download and transfer speeds (multiple times quicker than 4G abilities) just as increasingly stable associations. While 5G portable information systems opened up without precedent for 2019, they were for the most part still costly and restricted to working in kept territories or significant urban areas. 5G will likely have progressively reasonable information plans and significantly improved inclusion. It might turn out to be more useful even than the wired systems running into our homes and organizations. The expanded transmission capacity will give opportunities for development in the zone of the IoT and brilliant apparatus empowering assortment and move immense volumes of information. During the pandemic, when individuals are remaining at home, access to 5G versatile web may turn into an essential need in locales with no web association or low inclusion [29][37].

6. IMPACT OF COVID-19 ON TECHNOLOGY:

Due to COVID-19, the growth of the IT sector is anticipated to slow-down by 3 to 4 percent. There is a downturn in the hardware and software markets. The use of emerging technologies such as cybersecurity, AI, ML, cloud services, IoT, and big data analytics is, however, growing these days. The industry of Information Communication Technology (ICT) has been stronger than ever, and the world has remained closely linked by the use of technology despite the outbreak of the pandemic. E-learning, online education, and e-governance are other fields that would see a

boost. The e-commerce market seems to be the real frontrunner, with digital payments taking over even faster than the physical methods of payment, as shoppers continue to isolate themselves and reduce travelling to congested markets.

With video conference traffic skyrocketing right now, if video conferencing networks are overwhelmed, the dial-in option can be considered as an alternative. With the fixed or limited bandwidth of broadband service, there is a possibility that smartphones will fall back on mobile networks due to the possible congestion, and this will cause a major rise in mobile data traffic. For both consumers and companies, the current recession is an outstanding catalyst for digitalization. Also, the most critical ones will be prepared to align their companies with the digital agenda and will be very much in support of automating their activities. Data-driven automation will be a strategic priority beyond RPA for many technology firms. Businesses, including clients, personnel, and networks, would need to incorporate optimization in several fields.

With video conferencing, congestion skyrocketing right now, if video conferencing networks are overwhelmed, the dial-in option is a substitute. There is a risk that smartphones will fall back on mobile networks due to the potential congestion of fixed broadband networks, and this will cause a major rise in mobile data traffic. For both consumers and companies, the current recession is an outstanding accelerator of digitalization. Also the most critical ones will be prepared to align their companies with the digital agenda and will be very much in support of automating their activities. For several tech firms, data-driven automation is a strategic goal beyond RPA. Businesses, including clients, personnel, and networks, would need to incorporate automation in several fields. Social distancing, lockout, etc. have driven clients to move to online shopping during the pandemic, resulting in e-commerce spikes. Small-scale manufacturers, retailers, and consumers have also started to introduce e-commerce strategies in developed nations to mitigate losses over time. Many measures to promote digital transactions, mobile money transfer, and e-commerce have also been taken by the government. This has highlighted the need for reliable and affordable information and communication technology services and digital instruments for fast money transfer to keep e-commerce on the right track. [38-39].

When patients are hospitalized, chatbots, Robotic

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Process Automation (RPA), etc. are extensively used as the infected ones are to be isolated from the rest. Asymptomatic carriers are instructed to observe home isolation, consult physicians through teleconferencing, and medicines, and essential items are supplied at the doorsteps. Technologies such as geofencing are used for tracking the suspected and infected ones. Processes involved in treating and monitoring of the COVID-19 patients and suspected are executed strictly observing 'contactless' protocol.

The worldwide effect of COVID-19 on the Internet of Things (IoT) showcase size is relied upon to develop from USD 150 billion of every 2019 to USD 243 billion by 2021, at a Compound Annual Growth Rate (CAGR) of 13.7% during the estimate time frame. The main considerations driving the market development remember expanding center for remote observing for the work from home activity, developing reception of keen installment advances to limit human contact engaged with money installments, and rising interest for wearable gadgets [33].

Figure-2 shows the use of technologies in various phases of the disease. Technological advancements are utilized for testing the suspected individuals, tracing the contacts of COVID-19 infected and suspected ones. People with fewer risks are asked to stay home quarantined. Patients with comorbidities are institutional quarantined. They can be monitored using remote patient monitoring, virtual consultation, etc.

Fig. 2 : Digital Technology for Pandemic preparedness and response

The use of IoT is as yet opening new income streams by encouraging constant following of vehicles and giving checking feeds of travelers. The observing feeds of travelers help in the checking of traveler's head out chronicles to distinguish if the traveler should be isolated.

Additionally, organizations are utilizing rambles as another method of transportation to guarantee basic supplies and food conveyances. Shenzhen-based startup Pudu Technology is expected to lessen cross-disease by actualizing home conveyance of medications and suppers through automatons and robots.

IoT in social insurance offers critical life adjusting benefits and has become a significant adopter of innovation. With the rising number of ceaseless sicknesses, IoT has just discovered its way in the social insurance division, with various applications, for example, telemedicine, associated imaging, inpatient checking, prescription administration, associated wellbeing, associated specialist, associated emergency vehicle, alongside numerous others. The ongoing episode of the COVID-19 has driven IoT human services arrangement suppliers to rapidly render answers for combatting the rising interest for excellent administrations for security against the infection. The quick spreading COVID-19 has assumed control over the whole medicinal services environment from pharmaceutical organizations, tranquilize producers, COVID-19 antibody designers, to wellbeing guarantors and

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emergency clinics. Applications, for example, telemedicine incorporate remote patient checking, and intuitive medication, alongside inpatient observing, is relied upon to pick up footing during this time. Given the innovation, the product arrangement section of the market is anticipated to hold a bigger market size during the gauge time frame. With the ascent in the instances of COVID-19, IoT programming arrangements are confronting generous hit. There is a lot of verticals of IoT, for example, producing, transportation, travel neighborliness, and so forth, where all the activities are required to be postponed. In any case, associations have changed their needs, for example, associations need to screen the wellbeing and health of representatives as they are telecommuting. In this COVID-19 pandemic, such use cases are advanced. Alongside the application areas, where interest in IoT programming arrangements has seen a huge increase, some new use cases have been developed. In verticals, for example, transportation, coordination, and assembling, the development of programming arrangements would be greatly affected. Since these are the key contributing regions for obtaining IoT programming arrangements, the disruption due to COVID-19 will have an enormous impact and will drastically reduce the production of the product arrangement showcase [33].

7. IMPACT OF COVID-19 ON HEALTHCARE INDUSTRY:

Technology has given a new shape to the healthcare system. By leveraging technologies, the healthcare system has become safer, reliable, affordable, ubiquitous, and accessible to everyone. The entire healthcare system is experiencing a digital transformation these days. The bricks and mortar "clinic visits" have become obsolete and are being replaced by telehealth. Since the initial stage, the healthcare providers are extending their services to the needy risking their lives. So many inventions and innovations are taking place in the healthcare industry each passing day. The most promising inventions have taken place in testing, surveillance, therapeutics, and vaccine development. IITs and NIT are at the forefront of developing new products. Disinfectant booths were invented to avoid direct contact with patients.

The outbreak of the COVID-9 pandemic has created an immediate need for a collaborative mechanism to contain the disease. To decrease the risk of infection, telemedicine, remote patient care, etc. are extensively adopted. Healthcare service providers have created new COVID-19 management models. The conventional passive healthcare system is being replaced with a ubiquitous patient-centric one. The digital medium is leveraged to a maximum extent during the outbreak of COVID-19. Most of the countries ordered strict lockdown because of which patient-doctor interaction and hospital visits became difficult. Virtual care, virtual consultation, e-prescription, mobile apps, chatbots, etc. have become an integral part of the current healthcare system. Figure-3 illustrates the main stakeholders that are at the forefront of the digital healthcare system. It defines the new healthcare system as the collaboration between people, healthcare institutions, and health technologies. it also indicates that technology has become an integral part of the new healthcare system [40].

- **Virtual consultation**: During the lockdown period there was a lack of reliable and effective healthcare service. Telehealth providers experienced a surge in the traffic during the early days of lockdown. Software like Maya provided genuine information related to any disease. Telehealth consultation was provided to clear doubts of patients related to the disease. Telehealth service providers experienced 2700% traffic during March. They were called virtual doctors who provided ubiquitous healthcare services. There were several service providers for health-tracking, medical counseling, diet-suggestion, etc.

- **'Smart and untiring doctors'**: Robots of different kinds have been developed by IITs and NITs. These robots are extensively used during the outbreak of COVID-19. They can work tirelessly in isolation wards of hospitals without getting infected. They are extensively used to deliver food, consumables, and medicines to the COVID-19 patients thereby reducing face to face contact between healthcare professionals and patients. Some hospitals deployed robots for screening patients and healthcare professionals. Robots were also used to disinfect the used items. They assisted the patients to contact their family members

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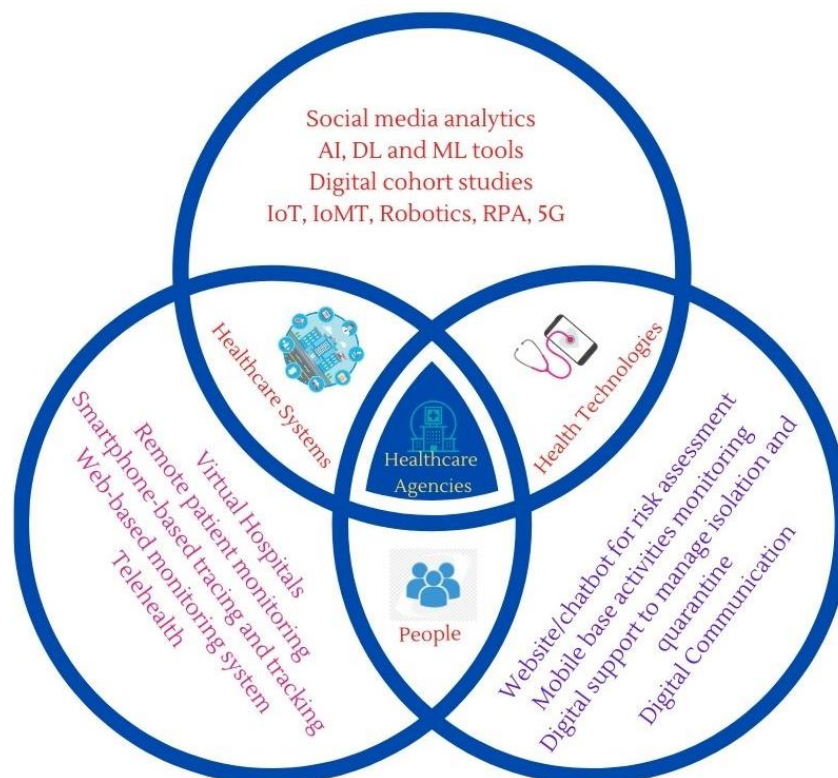and doctors through videoconferencing [41].

Fig. 3 - Technology use in pandemic management

- **3D Printed Medical Equipment**: During the lockdown period there was a surge in demand for PPE kits, N95 masks, and ventilators. May factories stopped production because of travel restrictions to the workforce. 3D printed medical tools were extensively manufactured to overcome the out-of-stock situation.

- **AI in vaccine development and testing**: AI is extensively used to fight against all challenges posed by the virus. With the aid of AI, researchers have identified 29 different DNA sequences of the novel coronavirus. AI is widely used in the virtual screening of both repurposed drug candidates and new chemical compounds. With the aid of AI, the early detection of COVID-19 is possible.

- **Pharmacy at Door-Step**: Several web-portals were developed to deliver medicine to the needy. This helped elderly people who were suffering from chronic diseases such as hypertension, diabetes to stay home, order online, and get the essential medication delivered to their residence [41].

8. POST COVID-19 EMERGING HEALTHCARE TRENDS :

The emphasis given to health and hygiene these days will continue in the same way or even more in the post-COVID-19 phase [19] [42-43]. Prevention and precautions would become the day's critical catalysts. People want to be 'absolutely perfect' these days. In any public place, masks have become a mandate. Good food or good nutrition is becoming the standard. People are almost going crazy regarding the use of sanitizers and hand-wash. 'Contactless Payment' and 'Contactless delivery' would become the norm. Hugs and hand-shakes are replaced by 'Namasthe' of India and 'Ojigi' of Japan. Some of the emerging trends include [44]:

i. **'Digital' Doctor**: The ultimate source of health information will no longer be a doctor. People started to rely on a variety of digital platforms. People started googling health-related information to a large extent. 'immunity boosters', 'Symptoms of COVID-19', 'Covid-19 Vaccine', 'Plasma therapy for COVID-19', 'Loss of smell', 'Weight loss

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treatment', 'Yoga at home' 'Is AC safe during COVID?'. Social networking sites, YouTube, pharma websites, etc. have become sources of information. Doctors will come into the picture only when things are beyond the reach of self-care [45].

ii. **Spike in memberships at gyms and yoga centers**: As health gains more importance, people will depend on gyms and yoga centers to stay fit. Studies reveal that membership to sports clubs and gyms have increased exponentially. A Spike in the demand for gym equipment, fitness tools, fitness bands, etc. is a clear indication of the health-consciousness of people.

iii. **Wearables will gain momentum**: As self-monitoring and self-assessment wearables will be in huge demand in the future. The 'untouchable' band which alarms the wearer when unconscious habits such as touching the face, nail-biting, hair pulling, thumb-sucking are practiced. Some wearables also note down the temperature. Some all-in-one devices with multiple sensors are developed. These devices will record multiple parameters

iv. **Magic of Home-Remedies**: When immunity levels are high it is possible to fight against the diseases. There is a huge demand for items that are rich in Vitamin C, and D. Extensive use of Cinnamon, Garlic, Coriander, Pepper, Turmeric was observed during the lockdown period and is continuing.

v. **Demand for Alternative Medication**: There was a spike in the use of Ayurvedic medicines and homeopathic treatment. Several preventive solutions which were prescribed on different media. These are still being followed in many.

vi. **Mental Health Issues**: The social and economic fissures uncovered by the pandemic would result in mass unemployment, reduced social welfare, malnutrition, increased gender-based violence, homelessness, alcoholism, loan defaults, and millions falling into poverty. This post-COVID-19 setting will be a fertile breeding ground for an increasing prevalence of chronic stress, anxiety, depression, alcohol dependence, and self-harm, leading to an overall uptick in morbidity, suicides, and mental well-being problems.

vii. **A surge in Telehealth**: While it was in use prior to COVID-19, during the time of lockdown it was highly prevalent. Still, people are more dependent on this digital self-care technology. There are secure communication systems available that enable physicians to interact with patients anywhere. There are advanced technologies available for performing remote diagnostics. Cloud services that allow patient records to be stored are in widespread use. Advanced software and technologies are available for remote analysis.

viii. **Implantable devices will become more popular**: The future for implantable devices that can be inserted under the skin and control a patient's vital vitals that track the patient's temperature, blood pressure , heart rate, blood oxygen, and insulin around the clock is not too far away. More importantly, these devices can transmit information to the doctor minute-by-minute remotely. To release medicines into the veins, the machine can also be configured.

ix. **Health-tourisms will subside**: Previously, patients used to travel abroad to avail of sophisticated health care services. Doctors are required to fly for the provision of services in the post-COVID-19 period. travel visas for people with extreme health conditions will become an issue in the future. The new trend would be to fly doctors out, resulting in a reduction in the needless travel of patients and their attendants.

x. **Health Passports become compulsory for travel:** More respect and remuneration for healthcare professionals: The current COVID-19 pandemic crisis has greatly contributed to the urgency of a strong and focused effort to foster public health. The COVID-19 crisis has made it clear that frontline health workers play a critical role in risking their lives. Governments will insist on a health passport for people who wish to travel. This requires collaboration of government and healthcare institutions [46].

xi. **IoT will be transformed to IoMT (Internet of Medical Things):** IoMT, where the patient's vital signs are recorded and stored, will help physicians obtain the health statistics and critical information of a patient over a period. Based on the results of thousands of patients with similar profiles, AI and ML will

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allow the aggregation, assessment, optimization, and rapid deployment of an individual patient's data in circumstances such as the ongoing disease outbreak. emerging technologies such as AI, ML, 5 G networks, and RPA will be maximally helpful in this regard.

xii. **Health-Insurance Schemes will cover-less cost more**: Only obtaining health insurance will not be enough if the amount covered is not sufficient. In the post-COVID-19 scenario, this often-repeated piece of advice by insurers would be particularly valid as the cost of treating the viral infection can run into lakhs of rupees. Because of the COVID-19 outbreak, health care coverage will see a slew of modifications. Reinsurance norms can get harder, and strict terms can be seen in pre-existing conditions. During renewals, insurance rates will see significant hikes of 25-40%.

xiii. **Increased Healthcare Costs**: In the months and years ahead, the cost of healthcare is going to rise very dramatically. For hospital admission and post-care, a COVID-19 patient in the family has to spend a large amount of money. Many hospitals are turning back the infected with COVID-19. For those afflicted, both financially and physically, the disease can be paralyzing.

xiv. **Comorbid conditions generate distress:** They are considered comorbidities when a person has more than one disorder at the same time. Asthma, diabetes, hypertension, and cardiovascular disease tend to have a significant strong correlation with COVID-19 mortality particularly among elderly people. There may also be some cases where people with chronic diseases may suffer due to timely healthcare services being unavailable. In a densely populated country like India, when 1 percent of the population is affected, the situation becomes out of control.

xv. **Parents will not force their children to become doctors:** Many parents would not be pressuring their kids to become doctors. It was always an aspiration of many to become a physician in central India. For future medical careerists, the current pandemic may serve as a dampener.

Suddenly, it's seen as a 'hazardous' frontline career to become a doctor. Only those who dream of becoming physicians will choose to study medicine.

xvi. **Increased prosperity for Pharmaceutical companies**: To better handle potential outbreaks in the future, most organizations should embrace new business models and strategies. To contain the pandemic, the nations have to invest a huge amount of healthcare funds. Companies are speeding up the production of diagnostic tests and therapeutics in the quest to effectively diagnose and treat patients suffering from this highly transmissible respiratory disease.

xvii. **Reduced Hospital Stays**: Hospital-borne infection suspicions are strikingly high during the outbreak of COVID-19. The main demand for post-COVID patients would be to be kept out of hospitals, resulting in a rise in move-in medical examinations and a rise in outpatient surgery. Hospitals have been swift to discharge patients with a higher chance of recovery to home care during COVID-19. This pattern is expected to continue as patients demand to be discharged as soon as possible from hospitals.

xviii. **Increased Homecare**: In the case of decentralized healthcare systems, clinical trials are carried out in the homes of patients. Blood pressure tests and blood tests are likely to be performed at home. The development of a newer trend in senior living called 'elderly daycare' is going to be increased in near future.

The pressure on the hospital system will undoubtedly be immense in the coming days. Non-urgent surgery will decrease, and the demand for associated care and equipment will decrease along with it [42]. The post-COVID-19 period would see healthcare implementing relatively new ideas such as telehealth, remote treatment, and automated healthcare applications of other kinds. Shortly, there will be a rapid surge of groundbreaking digital technologies for improved patient care.

9. DISCUSSION AND RECOMMENDATION:

The healthcare sector is experiencing revolutionary changes and reforms these days. Hospitals not only have adopted advanced tools, equipment, and services but also leveraging advanced analytics for accurate prediction. Devices are transformed into 'smart' and 'contactless'. Predictive analytics is

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extensively used to manage emergencies. Figure-3 describes the main stakeholders of the current healthcare system [2].

Few predictions or recommendations that are much needed during the post-COVID-19 era are

- **Cooperation instead of Competition**: Healthcare institutions are competing with each other for providing better services to their patients. They share data since it is publicly available. In addition to this, if emergency services like ambulance, ventilators, ICU beds, skilled healthcare professionals, and other resources are shared, it would create a more patient-friendly atmosphere. This will be of greater use not only for COVID-19 patients but also for patients who suffer from other chronic diseases. The collaboration initiatives can also prevent stock-out situations to a large extent.
- **Greater Transparency**: Healthcare industry is being accused frequently of lack of transparency. If services, facilities, diagnosis, etc. are made more transparent patients' satisfaction will be doubled. The ultimate goal is to ensure patients' safety [47-48].
- **Digital Divide and Threats to Privacy**: The COVID-19 crisis made everyone realize that digital technology is an effective solution to combat the disease. Whereas technology has its limitations. Extensive use of technology can destroy an individual's privacy and freedom. When the data is publicly available on the digital platform it can be misused. Technology is preferred by youngsters and the ones with adequate literacy. Elderly people and people with poor literacy will not be comfortable with the use of technology [49-50].
- **Need for advanced Communication Technology**: All digital healthcare services can be availed by making use of the Internet, Smartphones, 4G/5G communication technology. In most developing countries there will not be a proper network. Hence lack of adequate communication technology will be a hindrance to digital healthcare [51].

10. CONCLUSION:

Technology has given a new ambit to the healthcare system especially during the situation of a pandemic. All sorts of medical emergencies can be handled easily by making use of suitable technology. Emergencies can be managed more effectively and accurately by making use of connected devices. Smart devices have strengthened the healthcare sector so that better services can be provided to patients cost-effectively. IoT devices are capable of providing real-time data that can be used by the healthcare personnel to determine the current situation of patients. It is also possible to predict the progress of the disease by analyzing the necessary parameters. Statistical techniques can be used to predict the infection rate accurately. The use of technology has integrated several disconnected sectors such as government, patients, health workers, doctors, researchers, academicians, etc. The effective use of technology has created a new atmosphere where every individual is trying his/her best to fight with the disease.

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