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Digital Health During COVID-19 Pandemic: Challenges and opportunities Review

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Abstract – Corona virus pandemic caused an enormous effect on medical care, public activity, and economies on a worldwide scale. Clearly, technology has a vital role to empower omnipresent and available digital health services in pandemic conditions just as against "reappearance" of COVID-19 disease in a post-pandemic period. Likewise, 5G systems and 5G-empowered e-health arrangements are principal. This paper features philosophies to adequately use 5G for e-health use cases and its job to empower significant digital healthcare services. It's anything but a comprehensive conversation of the implementation issues, potential cures and future research bearings for 5G to lighten the health challenges related to COVID-19.

Keywords – Delivery of Health Care, Health Information Systems, Remote Consultation, Telemedicine, Telecommunications.

I. INTRODUCTION

Sometime before the expression "digital health care" was first utilized, a considerable number of tasks utilizing information technology (IT) in giving medical services —under shifted names like mobile health, ubiquitous health, and telemedicine—were dynamic. For twenty years, advanced medical care administrations were successful. The public authority and industry apportioned significant assets to foster devices, software, and administration situations, which appeared to be encouraging and full of potential. Notwithstanding, none of these administrations endure, making discouragement among medical services suppliers endeavor to attempt a new innovation Medical care suppliers are critical to the achievement of advanced medical services. Albeit the articulation "digital health care" infers high-innovation devices and new information, just as patient generated health data (PGHD), just as patient generated health data (PGHD), these components should be incorporated into medication. Medical care suppliers guide patients to perform self-administration in protected and successful manners with the assistance of computerized clinical devices and stages. "Digital health care" alludes to medical services administrations in which information's are gathered, broke down, and used through the assembly of advances, including artificial intelligence (AI), big data, the Internet of Things, and cloud computing. As indicated by this definition, there were instances of digital healthcare services, for example, when a fetal pulse was measured in 1991 [1] and a non-stress test was acted in 1998 [2], distantly. These are instances of distant patient checking executed before the advent of digital health services.

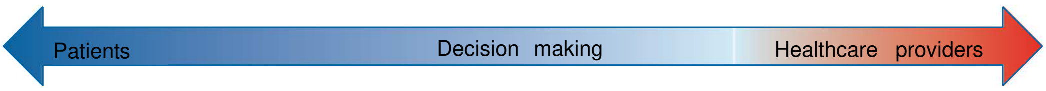
Digital health services require a respective methodology joining medication and digital technology in a synchronized way [3]. As well as expanding the capability of the clinical specialists, government should keep on focusing on further developing individual prosperity. Every device, sensor, and component will eventually essentially affect the medical care industry, and all partners should work together to track down a productive method to give consistent consideration.

II. Grouping of Digital Healthcare Industry

There are various instances of digital health care services; thus, deliberate characterization is needed for an effective review. Since there is no widespread grouping framework for digital healthcare, this review proposes a straightforward order framework for case reviews. The framework, delineated in table1, orders digital health care services as indicated by the service utilization and decision makers (major customers). Considering simply the direct-to-customers (DTC) service, patients' decision to utilize the genome data is situated to one side of the table, while medical services suppliers' choice to utilize clinical picture data is situated at the right-most position. Telemedicine, which assumes patient–medical care supplier correspondence, is situated in the center.

Table1. Computerized medical care administration characterization framework for case survey.

Genome information	(DTC) direct-to customer	*Wearable devices*	*Remote patient care*	Digital therapeutics	Medical image data



1. Instances of Using Image information

Clinical picture data is partitioned into two groups: images that adjust to the Digital Imaging and Communications in Medicine (DICOM) guidelines and clinical images like pathological slides, endoscopic images, and retinographic images.

1.1 Digital Diagnostics

IDx-DR by Digital Diagnostics is a device that diagnoses diabetic retinopathy through retinography. In the wake of checking the nature of retinography images dependent on AI, an oculist decides if an assessment is vital. Albeit most AI frameworks help dynamic by medical services providers, IDx-DR was created to be utilized without the participation of medical care providers, turning into the principal device to gain an endorsement from the US Food and Drug Administration (FDA) [4]. IDx-DR was given the Current Procedure Terminology (CPT) code in the United States, The American Diabetes Association rules likewise notice the expected applicability of the device for screening, showing that the device has been broadly used [5]. Furthermore, a significant outcome from a few significant results from clinical studies (with in more of 1,000 patients) led in many countries have shown that the device has a brilliant future [6,7].

1.2 VUNO

VUNO got medical device licensing for both bone age reading software and pneumonia nodule reading software, both AI-based programming programs. These are delegate instances of "software as a medical device" (SaMD) licensed without hardware [8]. VUNO is putting forth nonstop attempts to get ready prescient models that are fundamental in clinical settings by utilizing essential signs and clinical examination data got from patients [9]. The information utilized by VUNO incorporates general clinical data of Electronic Medical Records (EMRs), emergency clinical benefits, and 12-lead electrocardiogram data. Since acquiring European CE certificate for five significant AI frameworks in July 2020, VUNO has stretched out its business to worldwide business sectors [10,11].

1.3 Lunit

Lunit acquired ubiquity in different nations by clearing different AI contests. It entered the medical device market by securing a permit from the Korean Ministry of Food and Drug Safety in 2018 and the European CE affirmation in 2019. Lunit's agent items are Lunit INSIGHT CXR for recognizing aspiratory illnesses and Lunit INSIGHT MMG for distinguishing breast cancer. Lunit broadens the extent of its business to clinical decision support (CDS) in light of clinical data [12]. The adequacy of Lunit's items has been affirmed by a few clinical studies in different nations, and the precision of its algorithms for predicting clinical cases has been demonstrated by different clinical organizations in South Korea. Moreover, Lunit has reinforced its situation in the clinical field by consistently distributing its outcomes in major journals [13].

2. Digital Therapeutics

Until recently, digital healthcare services were utilized as a significant strategy for checking patients and for the integration, analysis, and prediction of data. Nonetheless, digital healthcare services have as of late been reached out to spaces of therapy dependent on incredible mobile devices with analytic capacities.

Pear Therapeutics, a beginning up in the United States, is starting to lead the pack in digital therapeutics. The application “reSET,” created by the organization, was authorized by the FDA in September 2017 making it the first computerized therapeutic application [14]. The reSET application is usually utilized for 90 days with a doctor's prescription to treat different addictions and dependencies. The reSET-O application, authorized in 2018, is particular for illicit drug use and gives customized treatment to 84 days. The reSET application helps clients with cognitive behavioral therapy: the patients can prepare themselves to recognize triggers connected to drug use without anyone else observing their motivations or changes in thinking. The impact of reSET programming on clients was demonstrated through randomized controlled trials (RCT) in mix with ordinary off-line medicines. Progressing quickly, Pear Therapeutics created Somryst, an application for chronic insomnia authorized by the FDA. In July 2020, when Covid sickness 2019 (COVID-19) was widespread, the organization started an enormous scope clinical examination with real patients [15]. As a market leader, Pear Therapeutics is stretching out its business regions to schizophrenia, epilepsy, and post-traumatic stress disorder [16].

Omada Health gives a product program to prevent and manage diabetes, a far and wide issue in the United States, focusing in on preventing prediabetic patients from advancing to diabetes and assisting them with getting fitter. The product drew a lot of consideration since it was applied in the Diabetes Prevention Program (DPP) advanced by the US Government [17]. Users of the online DPP given by Omada Health showed a higher program completion rate and more weight reduction than clients of another DPP dependent on up close and personal interview [18]. A 3-year longitudinal investigation showed that the group of subjects who had effectively finished the program kept up with their diminished weight and low glycated hemoglobin levels in the long term [19].

Dexcom is an organization that delivers a constant glucose checking system (CGMS), which is intended to quantify and communicate ongoing sugar levels through a device attached to abdomen, not by blood examining with a needle or lancet [20]. Remote persistent observing through such a device works with intensive checking at home, like that in hospitals. Nonetheless, intensive remote observing requires suitable sensors, a mobile system for collecting and sending information, an advanced Electronic Health Record (EHR) system for incorporating the got information into the existing system, and an assistance provision system to give proper checking and intervention [21].

3. Telemedicine

Teladoc is the most established and biggest telemedicine organization in the United States [22]. The normal time that patients hold on to be connected with a doctor after requesting consultation is under 10 minutes [23], and the level of satisfaction of patients is more than 90% [24]. Studies on remote patient monitoring are increasing around the world, and the devices utilized for services, diseases, and patient groups subject to these services are additionally expanding quickly. Several studies highlighted the benefits of remote monitoring; be that as it may, broad changes are essential in the observing techniques for full-scale implementation of services [25].

4. Wearable Device

The classical wearable device measures active work levels. The principal business wearable movement screen was known as Fit bit. Accordingly, the movement following capacity was mounted on most wearable devices, for example, the Apple Watch and Galaxy Watch, as a basic function. Wearable electrocardiogram (ECG) devices are addressed by portable measurements devices created by Alivcor. This device measures the ECG when the user holds it with two hands, Additionally, it can analyze the ECG through a mobile associated by means of Bluetooth and give clinical suggestions dependent on data analysis. The underlying ECG estimation model got a permit from the FDA as right on time as 2014 for the determination of atrial fibrillation [26]. The Apple Watch got a clinical device permit from the FDA in 2018 for the ECG measurement function utilizing the stem of the watch [27].

Notwithstanding these models, a wide assortment of sensor services is being delivered into the standard medical services area to measure and manage body temperature, sleep, pulse inconstancy, glucose level, blood flow, oxygen saturation, electrical skin stimulation, and anatomical positions. In spite of the fact that, as of now, the interest in wearable devices appears to be low, such devices are required to assume a fundamental part in medical care services through detailed service design and technological development.

5. Genome Information Utilization

Hereditary data is particular from different kinds of digital healthcare data, holding the largest volume of data per case, and the most noteworthy potential for development among computerized medical services. Whole genome testing, directed in research facilities for patients with rare diseases, is bringing a massive wave up in medical care services. Albeit the usage of genome data isn't completely included in digital healthcare, a DTC service that empowers patients to see changed outcomes from genome analysis is considered as an area of digital healthcare. In 2017, the FDA authorized the DTC administration for the danger examination of 10 diseases, including Parkinson's and Alzheimer's illness. In 2018, the FDA authorized the administrations for BRCA1 and BRCA2 qualities, which are identified with the onset of breast cancer [28].

Another foundation, Pathway Genomics gives both hospital-based services and DTC services. These services given by Pathway Genomics, unmistakable from 23andMe, are focused around diet and exercise, assisting clients with redoing their well-being the executives through genome investigation. Pathway Genomics focuses around health as rather as diseases.

III. Evidence and Evaluation of Digital Healthcare (GDHP)

The Global Digital Health Partnership (GDHP) [29] is a cooperation between different nations and the World Health Organization to share their arrangements for digital healthcare. The GDHP assesses proof of advantages acknowledgment of digital healthcare services and means to strengthen the standardization of worldwide benefit management. In the proof and assessment, the GDHP guide presents the accompanying seven classifications for estimating the advantages of digital healthcare:

1. Advanced Health Safety

Digital health safety incorporates issues identified with enhancements or safety to patient security related with the utilization of digital healthcare services, including digital healthcare errors, adverse events, and privacy.

2. Digital Healthcare Quality

Digital healthcare services quality incorporates quality of the digital healthcare services related with the utilization of digital healthcare services. This classification incorporates the specialized parts of advanced medical services, just as the improvement of the medical process to improve quality.

3. Digital Healthcare Efficacy

Digital health refers to the improvement of health status indicators related to digital healthcare services, focused on the measurements of clinical items for observing the adequacy of digital healthcare services, including guidelines for clinician's dependent on the outcomes.

4. Digital Healthcare End-User Experience

Digital healthcare end-user experience manages the experiences of end-user utilizing digital healthcare technology or services. Advanced medical care end-user incorporates patients, consumers, digital healthcare services designers, and policymakers.

5. ***Advanced Health Efficiency and Return on Investment***

This class depicts different things that expect speculation to accomplish the best outcomes from digital healthcare services, focusing on the connection between asset inputs, like work, capital, and equipment, and the final health evaluation. This class portrays different techniques to expand the effectiveness of digital healthcare services, diminish unnecessary costs, and improve productivity.

6. Population Trends and Secondary Uses

This classification identifies with the utilization of digital healthcare services for purposes that are helpful to well-being the health management in local communities. The objective is to improve health management for particular disease groups or local community with large populations. The advantages in this class might be assessed as far as different measures, for example, increased life expectancy and further improved emergency systems.

7. Digital Healthcare Equity

This classification is identified with medical care value, which implies that everybody ought to have a reasonable chance, without ridiculous or remediable contrasts, in the appropriation of medical services benefits; All people should be at an equivalent benefit to get to digital healthcare services.

IV. FUTURE DIRECTION OF DIGITAL HEALTHCARE:

1. Digital healthcare Coordinating Center

Executing digital healthcare services is certainly not a simple accomplishment for primary care doctors. A Digital Healthcare Coordinating Center (DHCC) is required as a local center to help digital healthcare services given by primary care doctors [30-32].

At the point when a doctor endorses digital healthcare or digital therapeutics at a clinic, the DHCC can instruct the patient about the right method of utilizing digital healthcare benefits just as playing it safe. Users are known to visit the DHCC just at the first use or at the first session, visiting the primary centers at other times. The patient data extricated and saved through digital healthcare services are communicated not only to patients as well as the DHCC, where clinical staff (or coordinators) can monitor the measured data and give feedback to patients or send outlines in regard to states of individual patients to their primary care doctors. This permits primary care doctors to focus on examining patients in their centers, and utilize the synopses of different estimated information acquired from the medical clinics and communicated by the DHCC. This facility can lessen the burden on primary care doctors as far as time, cost, and work, and reinforce the expertise of DHCC.

2. Policy Suggestions for Digital Healthcare

Currently, since digital healthcare services are given free from cost, the burden on clinical staff and consumers is expanding. In clinical centers, the underlying preparing for digital healthcare users requires a lot of time [33]. In light of everything, inferable from lacking driving forces, automated clinical consideration has not been authorized. It is important to provide clinical staff with motivators for advanced medical care to elevate the main area of clinical benefits. Furthermore, it is important to rearrange the laws on data security and responsibility.

V. THE ROLE OF 5G FOR DIGITAL HEALTHCARE:

1-Financial, and cultural difficulties because of the COVID-19 pandemic

Overpowered healthcare facilities because of rapid growth of new COVID-19 patients, are encountering breaks in arrangement of regular healthcare services. Besides, medical care work force is likewise getting vulnerable against COVID-19 and this is burdening the medical services assets considerably more. To stop the wide spread of the disease, governments force, severe limitations and control on movement inside and between nations, adversely influencing the economies. While the distant work was considered as an option with constraints, certain positions got outdated. The expanded joblessness is a blossoming issue in any event, for solid economies. Aside from that, administration use on jobless labor force, losing pay from areas related with the travel industry like airlines, hotels, local transport, and entertainment were significant difficulties for the economies. Governments needed to present new rules on friendly removing to forestall the spread of the disease. This brought about shutting schools, detaching urban areas and surprisingly confining public connections, influencing the standard way of life of individuals. Such disturbances likewise lead to exceptional results, for example, losing physical and mental prosperity. Keeping up with the cultural prosperity during the COVID-19 pandemic is hence an overwhelming errand.[34]

The technological advancement is one of the vital qualities in the current time to beat the difficult conditions of COVID-19 episode. The ideal utilization of significant innovations will be basic to not exclusively to shield, yet in addition to deal with the post-COVID-19 world. The novel ICT technologies like Internet of Things (IOT) [35], Artificial Intelligence (AI) [36], Big Data, 5G communications, cloud computing and blockchain [37] can assume a crucial part to work with the climate encouraging security and improvement of individuals and economies. The capacities they accommodate unavoidable and available digital healthcare services are significant to ease the pandemic related issues. 5G communications present a change in perspective from the current mobile networks to give widespread high-rate network and a consistent user experience [38].

5G networks target conveying 1000x higher mobile data per area, 100x higher number of connected devices, 100x higher user data rate, 10x longer battery life for low force massive machine communications, and 5x diminished End-to-End (E2E) latency [39]. These targets will be acknowledged by key advances like mmWaves, small cell networks, massive Multiple Input Multiple Output (MIMO) and beam forming [40]. By using these technologies, 5G will basically uphold three service classes for example improved Mobile Broadband (eMBB), Ultra Reliable and Low Latency Communication (URLLC) and massive Machine Type Communication (mMTC). The tale 5G organizations will be worked close by major advances, for example, Software Defined Networking (SDN), Network Function Virtualization (NFV), Multi-access Edge Computing (MEC) and Network Slicing (NS). SDN and NFV empower programmable 5G networks to help the quick arrangement and adaptable administration of 5G services. MEC stretches out the knowledge to the edge of the radio network alongside higher preparing and capacity abilities. NS makes legitimate networks on a common infrastructure to empower various kinds of services with 5G networks.

These 5G technologies will empower universal digital healthcare services fighting COVID-19, depicted in the accompanying segment as 5G based healthcare use cases. Nonetheless, there are likewise execution challenges which need to relieved for efficient and high-performance solutions with wide accessibility and client acknowledgment.

2. 5G Based Medical Services Use cases for COVID-19

Abilities of 5G technologies can be viably used to address the difficulties related with COVID-19 presently and in the post COVID-19 time. Existing health care services ought to be custom fitted to fit the necessities of COVID-19 period while creating novel answers for address the particular issues began with the pandemic.

2-1 Telehealth for Patients

Telehealth is the arrangement of health care services in a remote manner with the utilization of telecommunication technologies [41]. These services incorporate remote clinical health care, health related training, public health and health administration, characterizing more extensive extent of services. Telemedicine [42] refers to remote clinical services like healthcare delivery, diagnosis, consultation, therapy where a medical care proficienals correspondence foundation to convey care to a patient at a remote site. Telenursing alludes to the utilization of media transmission innovations to convey nursing care and direct nursing practice. Tele pharmacy is characterized as a help which conveys distant drug care through broadcast communications to patients who don't have direct contact with a pharmacist. (For example, remote conveyance of doctor prescribed medications). Telesurgery [43] permits specialists to perform surgeries over a remote distance. Every one of these medical care related teleservices are exceptionally empowered in post-COVID-19 period because of various reasons. Absence of assets (i.e., hospital capacity, human resources, protective equipment) in health care facilities due to existing COVID-19 patients, social distances guidelines forced by authorities, necessities of keeping up with the ordinary medical services administrations clinging to the new guidelines imposed by the healthcare administrations and the need to limit the risk of medical services professionals getting exposed to COVID-19 are factors inspiring teleservices related with health care.

Table 2 Technical requirements of digital healthcare [44–50]

Use case	Application	Expected capacity	Expected latency	Number of devices	Other requirements
Telehealth	Telemedicine	>500 million visits per year	<1–100 MS	1–10 per appointment	Real-time backhaul connectivity Streaming data type

	Telenursing	<50 Mbps	<1–100 ms	1–10 per appointment	Real-time backhaul connectivity Streaming data type
	Telesurgery	30–50 Mbps >1 Gbps for holographic rendering	<1 ms	10–100 per surgery	Real-time backhaul connectivity Streaming data type >99.999% availability required >99.999% reliability required
	Telepharmacy	<50 Mbps	<1000 ms	1–10 per appointment	Real-time backhaul connectivity Streaming data type
Supply chain	Connected goods	Small-data (<1 kbps) per device, >1–10 Gbps of data per supply chain	<10000 ms	Up to millions per supply chain	Intermittent backhaul connectivity Streaming/historical data >95% availability required
	Manufacturing	>1–10 Gbps of data per plant	wide range: <1 ms for time-critical (e.g., robotics), <10000 ms for non-time-critical optimizations (e.g., asset localization)	1000–one million per plant	Real-time backhaul connectivity Streaming data Indoor connectivity and high availability
Contact tracing	Using sensor data for contact tracing	>10–100 GB of data per city per day	<1 ms	1000–one million per city	Real-time backhaul connectivity Streaming data type Low power consumption
	Self-isolation	<1 GB of data per isolated person per day	<1000 ms	1–10 per isolated person	Real-time/intermittent backhaul connectivity Streaming data type

These teleservices once in a while have strict prerequisites and call for refined fundamental advancements for appropriate usefulness.

For instance, a telemedicine follow-up visit between the patient and the specialist would require 4K/8K video web based with low-latency and low jitter. Telehealth based remote health education projects ought to be open to the understudies from any place through an Internet connection having an appropriate transfer speed. Observing the patients by means of telenursing the patient and the medical attendant.

Distant conveyance of medications requires continuous HD/4K video web based through Unmanned Aeriel Vehicles (UAV), which requires guaranteed availability with base station to send/get control directions without delays. Extreme use cases like telesurgery requires super low latency correspondence (under 20 ms E2E inertness) between the surgeon and the patient, network between an enormous number of devices like cameras, sensors, robots, Augmented Reality (AR) devices, wearable, and haptic feedback devices [51].

2.2 Role of 5G

The future 5G networks will utilize the mmWave range, which prompts the sending of ultra-dense small cell networks, including the network connectivity for indoor conditions. Technology like massive MIMO joined with beam forming will contribute for giving very high data rates to enormous number of served users.

These technologies together give a superior confinement to indoor conditions [52], they understand the eMBB service class which works with the transmission of 4K/8K recordings between the health care proficienals and the patient, regardless of the area of access. The new radio access innovation produced for 5G network, otherwise called 5G New Radio (NR) supports URLLC. The URLLC service class assists with understanding the ultra-low latency requirements of telesurgery applications. A Local 5G Operator (L5GO) has its core and access network conveyed locally on premises and serves the healthcare facility with different base stations sent both outside and inside to give availability to case specific needs. This sending is useful for telesurgery use case to accomplish ultra-low latency, given that there is a necessity of surgeon and patient to be in separate rooms because of the pandemic circumstance. MEC workers conveyed at the 5G base stations can be used to send the control capacities for UAVs for legitimate medical payload deliveries. The major plan changes in 5G networks will empower the communication of enormous number of IOT devices, which for the most part move less information contrasted with human activities like streaming. These mMTC services offer help to 5G empowered Medical IoTs (MIoTs) that can be utilized to monitor and treat remote patients. mMTC will associate and empower communication between heterogeneous devices into the 5G network with the goal that they can work in synchronicity. A sensor in a wearable device of the patient can promptly convey a message to the distant attendant by means of 5G network with the goal that the medical care taker can actuate an exceptional gear in the patient's room utilizing the cell phone.

3. Rapid Development of New Medical care Applications and Services

The spread of COVID-19 disease requests the rapid launching of new medical care services/applications, changes the manner in which present medical services are given [53], incorporates current devices like AI and Machine Learning (ML) in the data analysis process [54]. Anew application can collect the information's of COVID-19 patients from various medical care centers, transfer the data to a cloud server and make the data accessible to public with the goal that others can depend on the data for various purposes. Live video conferencing based intelligent applications empower medical care professionals to talk about with patients and help them [55]. Different applications would perform health checking of patients, for example, follow-up visits, give instructions on medical services, and spread information on present COVID-19 circumstance and exceptional safety measures. The trouble during the pandemic was that there was a need to automate the majority of the customary work to limit the interaction among individuals and new application improvement needs were likewise sudden. This requires a flexible network infrastructure which upholds the improvement of such applications inside a short period of time.

3.1 Role of 5G

As opposed to the present 4G network, 5G supports the production of new network benefits as soft warized Network Functions (NFs) by using SDN and NFV technologies. These NFs can be facilitated at the cloud servers, operator premises, or in the edge of the network dependent on the application requests. MEC servers equipped with storage and computing power and dwell at the edge of the radio network, will be a reasonable stage to have these applications. The sending of such applications will be more adaptable in 5G network in view of the SDN and NFV. Bringing the NFs towards the edge eliminates of the reliance of the infrastructure beyond the edge, making the applications more dependable. Expanding the limit of the 5G network is much easier in light of the fact that the network itself is programmable. 5G networks are fit for conveying network slices which make sensible networks to feed the services with comparable sort of prerequisites, for example, IoT slice and low latency slice, consequently serving applications with guaranteed service levels.

4.SupplyChainManagementforHealthcare

A surge in demand for Personal Protective Equipment (PPE), ventilators and certain drugs was observed toward the start of the COVID-19 spread, causing an implance of the regular supply chains [56]. Manufacturing plants couldn't keep up with the regular production because of deficiency of crude materials and workforce, in this way they were not equipped for reacting to the expanded interest in the products. The supplies of completed items were additionally deferred because of transport limitations and there could have been no appropriate elective transport systems with the goal that individuals who are truly in need would get them.

N95masks, hand sanitizers, and regular medicine are a portion of the products where this imbalance of supply was regularly seen. The individuals who responded rapidly could stock things in excess while other people who are in need didn't get them. Gifts to the casualties were not generally circulated in a reasonable way due to the shortfall of centralized management systems.

What's more, the limitations forced by the authorities to restrict the actual contact. It is difficult for the government, healthcare authorities, and distributors to carry out proper mechanisms to deal with the supply chains of healthcare items in the COVID-19 period. To resolve the issues in health care related supply chains, industries can receive smart manufacturing techniques outfitted with IOT sensor network, robotized creation lines which progressively adjust to the varieties sought after, and refined observing networks. IOT based supply chains could be utilized to appropriately follow the items from the manufacturing plant to the end consumer. UAV based automated delivery mechanisms are particularly fit in the COVID-19 circumstance to deliver medicine, vaccines, masks to the end consumer limiting the physical contact.

4.1 Role of 5G

5G supports direct connectivity for mMTCand IOT between IOT devices. This will fuel the likelihood to utilize enormous amount of IOT devices to expand the efficiency of supply chains. Deployment L5GOs to serve the requirements of industries is a superior method to coordinate IOT sensors, actuators, and robots straightforwardly into 5G network empowering a 5G based smart manufacturing system. The proper network availability for the sensors, actuators, robots in the manufacturing plants will be empowered by the mmWave 5G small cells sent inside. Massive MIMO will give availability to countless devices and beam forming technique guarantees a better quality of the network connection. The immediate availability of goods into the 5G network makes the supply chains more straightforward. MEC coordinated with 5G, can be utilized to handle the data locally to work on the scalability of the systems just as security and protection of collected data. Also, MEC incorporated with 5G can without much of a stretch be utilized to execute decentralized solutions by means of blockchain [57,58]. The delivery of items to the last destination can be performed by means of Beyond Line-Of-Sight (BLOS) UAV directed by the 5G network. This could limit unnecessary connections in COVID-19 period and lessen human effects. Real-time data is accessible for the authorized users for monitoring and tracing, which expands the transparency of the operation.

4.2 Self-isolation and contact tracing

Corona virus positive patients with mild conditions are generally prompted for self-isolation to forestall additionally spread. While self-isolation is a good alternative to deal with the capacity of healthcare services, the self-isolated individuals to be appropriately observed to ensure that they follow the self-isolation rules. The challenge is to follow each development of the patient, which is currently impossible. In an occasion of a violation of self-isolation rules, control guidelines ought to be sent. Cell phone based self-separation checking is conceivable through an application which sends GPS information of patient's cell phone to a cloud worker. Wearable devices appended to the patient's body utilize their sensors to measure the conditions of the patient and transfer the information by means of the cell phone. UAV based solutions can monitor the conditions of the patients from distant. UAVs can monitor body heat level by means of infrared thermography and recognize the individual through face recognition algorithms. Besides, contact tracing of distinguished positive cases is critical [59]. Nonetheless, present contact tracing mechanisms include significant human engagement and comprise lot of manual work. This prevents the recognizable proof of the multitude of conceivable close contacts and blocks close contacts are identified.

Manual following doesn't ensure that every one of the conceivable close contacts are distinguished. Bluetooth Low Energy (BLE) based contact following applications use BLE wearable devices, which promote its ID periodically so other compatible devices in closeness can catch the ID and store with the significant details, for example, timestamp, GPS location data. Once an infected COVID-19 patient is distinguished, the BLE arrangement gives the IDs of the nearby contacts over a characterized period. BLE based arrangements distinguish the contacts in the scope of few meters, while pure GPS based solutions don't have that accuracy.

4.3 Role of 5G

mMTC in 5G is responsible for good connectivity of heterogeneous IOT devices like sensors, wearable, and robots. The small cell networks equipped with MIMO and beam forming in 5G will guarantee better availability and positioning including indoor conditions. Thus, IOT devices straightforwardly associated with 5G network can be successfully used to monitor the compliance of self-isolation. Rather than utilizing general cell phone data, the patients can be connected with low power wearable devices which move data by means of BLE technology. Those sensory data can be refreshed to the cloud by means of the 5G network can be approved effectively and can monitor the conduct of the patient. A comparable idea can be used to contact following where the wearable BLE devices collect data of close by devices and transfer to the cloud by means of 5G network. When a patient is positive, all the nearby contact details are now in the cloud, and they are advised for appropriate safety measures like self-isolation. MEC servers sent to the 5G base stations are valuable to expand the scability of the operation as the resource request increments. Allocating a separate network slice for contact tracing data transfer is a superior way to deal with guarantee the Quality of Service (QoS) and reinforce the privacy and security of the data.

5. Execution challenges

In spite of the use cases for 5G concerning healthcare and the fight against COVID-19, there are additionally impending difficulties ranging from technical ones, for example, scability to financial ones including technology acceptance.

5.1. Privacy protection issues.

A video recording of a telemedicine session may contain personal data which the patient might want to reveal just to the doctor. Furthermore, automated contact tracing applications aggregate sensitive location data without the owner's knowledge. Imparting such sensitive user data to unauthorized parties [60]. Furthermore, security assurance is a legal prerequisite, which is presented by different lawful structures, for example, GDPR [61] and Health Insurance Portability and Accountability Act (HIPAA) [62].

5.2 Potential Solutions

To address the privacy challenge, solutions like Privacy by-Design [63], software defined privacy [31] must be sent with 5G health applications already at the design phase. Privacy by-Design depends on the thought that data controllers and processors ought to be proactive in tending to the privacy implications of any new or upgraded system, procedure, policy or data sharing initiative, not at the later phases of its life-cycle, however beginning from its arranging stage [65]. The created e-health solutions in 5G ought to consider the whole life-pattern of health data while ensuring them. To ensure protection, access control techniques overseeing how various parties access data are essential. Edge computing is helpful to limit data transmissions through various network elements and empower nearby handling, further improving privacy aspects [66]. Moreover, users of e-health innovation ought to be made completely mindful of what they are consenting to in regard to data sharing and handling when they are utilizing such digital solutions. Also, straightforwardness through advising users about potential protection chances is compelling to work on the reception of e-health solutions [67].

6. Security challenges

Attempts by adversaries to attack the data sets containing sensitive data present security risks. The significance of e-health systems worsens the effect of assaults on the accessibility prerequisite. The mix of MIoT builds security risks of healthcare systems. Such low-end devices are similarly simple to hack and powerless against Denial-of Service (DoS) attacks. Massive number of associated devices increases the number of entry points for attackers to perform unauthorized operations, for example builds the assault surface, on the health care network [68].

6.1 Potential Solutions

Lightweight and scalable security mechanisms should be intended to get MIoTs. Satisfactory security mechanisms are essential to address the restricted capacities of constrained sensors, as well as vulnerabilities if a part of the security capacities is offloaded to the cloud. For the digital health services, wide spread automation, data analysis and smart control requires ML and AI methods in 5G systems. Scrambled data transmission and distributed security solutions, for example, blockchain can keep attackers from accessing the network and subsequently ensure to protect user data of various premises. The utilized security mechanisms and algorithms should uphold ceaseless updates with negligible exertion to adjust to found weaknesses and arising security threats.

7. Scalability and QoS provisioning in massive network system

A fast deployment of new health care applications will add additional traffic just as increment the number of 5G users who access such services. This will prompt expanded network congestion. For instance, AR based applications utilized in telemedicine require high band width and low latency. Be that as it may, a congested network fails to fulfill the assistance levels for such applications. Besides, it is trying to oversee billions of MIoTs. At the point when an enormous number of IOT devices produce ad hoc data transfer, the network ought to be scalable to adapt to the expanded number of traffic events. The small data characteristics and intermittent connectivity of IOT burden the medium access and physical layers of access networks serving e-health applications.

7.1 Potential Solutions

NS in 5G with dynamic scalability is a potential solution for address this issue. The slices serve comparative kind of services, and they can be made adaptive dependent on the different parameters such as the priority, present network traffic, available network resources, QoS prerequisite, number of IoT devices presently connected [69]. Deployment of virtual NF dependent on request at the MEC workers will give an answer for the congestion brought about by unexpected increment of localized demands. For further developing adaptability, edge computing networks and appropriated mists can perform visual handling on huge computational abilities like GPUs and send the varying media yields enhanced with examination results to portable e-health devices. Thus, the effect from device limitations is flexibly minimized while congestion towards core network is additionally relieved. Concerning physical layer, for example, full beam forming technologies utilizing countless antenna elements increment scalability, high-frequency usage efficiency and fast corresponding speed communication.

8. 5G Organization and Restricted Network Difficulties

Network operators need to send these 5G based solutions at the earliest opportunity. The limited deployment of 5G networks and restricted accessibility of 5G devices will be an immediate problem for some nations. Without a doubt, the 5G expansion is required to be steady as far as network connectivity and capacity. The complexity and implementation issues of 5G devices including power utilization because of high frequency transmissions just as multi-band support of upper and lower frequency bands entangle the device cost and creation challenges.

8.1 Potential Solutions

Governments and networks operators should push forward their arrangement plans, also, limited scope 5G arrangements, for example, L5GO networks [70] ought to be urged to use in hospitals, manufacturing plants [71]. Reason constructed IOT devices with a more modest however designated capacities for e-health use-cases can lighten the complexity and cost issues in regard to the deployment and commissioning of 5G systems. According to the business point of view, offering a rebate to mobile operators offering in range barters in return for a further developed inclusion responsibility can speed up the 5G sending. For further developing inclusion in ineffectively served regions, some range groups can be shared by various network suppliers. From the expense minimization viewpoint, RAN sharing permits various operators to utilize a similar radio access infrastructure and empowers a simpler c overage development for 5G.

8.2 Cultural Issues and The Human Factor

Occurrences, for example, destroying the cell base stations [72,73] because of conspiracy theories connecting new 5G mobile network and the COVID-19 pandemic [74], Notwithstanding, network availability and service continuity are basic for associated e-health solutions. 5G solutions may require the user to have complex degree of specialized proficiency. In any case, numerous individuals need such degree of specialized education. The provided ease of use is an important factor that supports or inhibits the execution of e-health systems. Health personnel are discouraged from or impervious to utilizing such new frameworks with complexity to their workflows, or requiring additional effort/time [75]. Besides, 5G devices are essentially more costly, prompting an expense trouble on user.

8.3 Potential Solutions

Experts and media have obligation to get out these incorrect social convictions with the help of civil society and governments. The applications can be made simpler to utilize and to execute on average hardware and devices so everybody can bear the cost of it and utilize the services. For e-health solutions supporting doctor patient interaction, an effective clinical decision supportive network should limit the exertion needed by clinicians to receive and act on system suggestions. This prerequisite is stretched out to incorporate usability for patients and their relatives and other service users, or even health experts be-sides clinicians, for example, nurses [74].

8.4 Legal and Regulatory Dimension

Solutions for remote monitoring and contact tracing will bring about legal issues except if the sensitive personal data isn't as expected took care of. Models are contact following after the patient has recovered from COVID-19, collecting and putting away pointless data from the personal devices. Since access to healthcare is a right, if the technical solutions preventing people from obtaing timely healthcare or cause wrong conclusion/therapy, that is an issue concerning fundamental rights. 5G-enabled devices for e-health will affect manufacturers, service companies, insurers and consumers. Such a circumstance could likewise prompt legally issues.

8.5 Potential Solutions

Sticking to the approaches characterized by standardization and strategy bodies, for example, EU proclamation on contact tracing [76] legal issue issues. Standardization and guidelines should cover the entire scope of medical device technologies chain from clinical device technologies to software technologies, including sensors. Getting legal counsel before the development of various applications would likewise forestall future legal issues. The traditional item responsibility restricted to tangible individual property ought to be reached out to the right functioning network and services in e-health solutions. This is more difficult because of the complex environment of 5G. Thus, root-cause analysis strategies and pervasive checking are important [68].

VI. Conclusion

Healthcare services of the nations were quick to get influenced because of the spread of COVID-19 disease, confronting various difficulties. As the nations currently have control components set up to limit the spread of COVID19, they are returning the economies so people in general can continue their ordinary way of life. To forestall any "reappearance" of the disease, healthcare sectors of every nation should be outfitted with novel answers for address any arising difficulties successfully. To this end, 5G technologies are significant. 5G uses mmWave frequencies of the radio range with small cell base stations which will give better network including indoor conditions by means of its NR. Massive MIMO joined with beam forming will serve countless 5G devices/users

With ensured data information rates. These advances convey eMBB, URLLC and mMTC services classes which empower the improvement of various kinds of services utilizing 5G networks like AR, UAV communication, and collaborative robots. Along with 5G, MEC and NS will further develop flexibility, scalability, ensured service levels and security for the applications. Thus, solutions created utilizing 5G technologies serve different health related use cases, for example, telehealth, technologies network, supply chain management, self-isolation and contact tracing, and rapid health service deployment. Nonetheless, a wide scope of implementation challenges like privacy/security, scability, and societal issues ought to be tended to prior to conveying such applications with full functionality.

Abbreviations

(IT): information technology

AI: artificial intelligence

DTC: direct-to-customers

PGHD: patient generated health data (PGHD)

DICOM: Digital Imaging and Communications in Medicine

CPT: Current Procedure Terminology

EMRs: Electronic Medical Records

DHCC: Digital healthcare Coordinating Center

ICT: Information and communications technology

CPT: Current Procedure Terminology

IOT: *Internet of Things*

MIMO: Multiple Input Multiple Output

(*e MBB*): enhanced mobile broadband

(URLLC): ultra-Low Latency Communication

(m MTC): massive Machine Type Communication

(NFV): Network Function Virtualization

SDN: Software-Defined Networking

(NFV): Network functions virtualization

(UAV): Unmanned Aeriel Vehicles

(MEC): Multi-access Edge Computing

(LG5O): Local 5G Operator

QOS: Quality of Service

(RAN): Radio Access Network

(DOS): Denial-of Service

CONFLICT OF INTEREST

All authors declare no conflicts of interest.

AUTHORS CONTRIBUTION

Authors have equally participated and shared every item of the work.

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