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5G APPLICATIONS IN HEALTHCARE SYSTEM

Dr. Priti Subramanium[1], Dr. Dinesh D. Patil [2,] Dr. Sudhir B.Ojha[3]

Shri Sant Gadge Baba College of Engineering and Technology, Bhusawal, India.

Abstract*: 5G is the fifth generation mobile network. 5G is a novel global wireless standard after 1G, 2G, 3G, and 4G networks. 5G enables a novel type of system that is planned to connect approximately everyone and everything together including machines, objects, and devices. Fifth generation network is competent to fetch higher multi-Gbps peak data speeds, ultra low latency, more reliability, massive network capacity, increased availability, and a more uniform user experience to more users. Advanced performance and enhanced efficiency give power to new user experiences and connects new industries. Fifth generation is used crosswise three main types of associated services, including enhanced mobile broadband, mission-critical communications, and the immense IoT. An important capability of fifth generation is that it is designed for forward compatibility—the ability to flexibly maintain future services that is unidentified today. 5G healthcare use cases which, as healthcare providers look to the future of their digital strategies will support the enduring conversion of the industry and the move towards digital health. Although independently some of these use cases can be delivered without fifth generation, once fifth generation standards are set and coverage is broad enough, 5G will act as a means for receiving at scale by improving end user knowledge and diminishing existing barriers with current connectivity solution.*

Keywords: LTE, CAD, AVL, AI, IOT, HD, NR.

1. INTRODUCTION

Fifth generation, which is intended to give more connectivity than was increasingly accessible before 5G is a united, more competent air interface. It has been intended with an extensive capacity to facilitate next generation user experiences, empower new deployment models and deliver new services. With high speeds, advanced consistency and negligible latency, 5G will get bigger the mobile ecosystem into new realms. Fifth generation will brunt each industry, making safer transportation, remote healthcare, precision agriculture, digitized logistics and more a reality. 5G is intended to deliver peak data rates up to twenty giga bits per second based on IMT-2020 necessities. Qual-comm technologies' flagship fifth generation solutions, the Qualcomm® Snapdragon™ X65 is intended to achieve up to 10 Gbps in downlink peak data rates. However fifth generation is concerning more than just how fast it is. In accumulation to higher peak data rates, 5G is intended to provide much more network capacity by expanding into new spectrum, such as mmWave. 5G can also convey much lesser latency for a more instant response and can afford an overall more uniform user experience so that the data rates stay consistently high, even when users are moving around. And the novel 5G NR (New Radio) mobile network is backed up by a Gigabit LTE coverage foundation, which can provide ubiquitous Gigabit-class connectivity. 5G is previously here at present, and global operators started launching new 5G networks in early 2019. Also, all main mobile manufacturers are commercializing 5G phones. And soon, even more public may be able to access 5G. 5G has been deployed in 60 countries and continent. We are considering much quicker rollout and adoption compared with 4G. Consumers are very thrilled about the high speeds and low latencies. But fifth generation goes more than these profit by also provided that the capability for mission-critical services enhanced mobile broadband and massive IoT. While it is hard to predict when everyone will have access to 5G, we are considering great momentum of 5G launches in its first year and we expect more countries to commence their fifth generation networks in 2020 and beyond. Novel smartphone that supports 5G if you want to be able to use the network. For example, smartphones power-driven by the Snapdragon 5G Mobile Platforms are 5G compatible. Currently there are more than a diminutive number of novel mobile phones accessible that are considered to support 5G, and multiple carriers across the world support the 5G wireless network. Although the fifth generation reduce timeline progresses, additional smartphones and carrier subscriptions will turn out to be available, as 5G technology and 5G compatible devices becoming more mainstream[1]

2. Literature Review

One central barrier stands in the way of trustworthy, instantaneous telecommunication, according to Dr. Shafiq Rab, chief information officer at Rush University System for Health: internet bandwidth. The same restriction that makes an internet connection suffer slower when difficult to download data-heavy files or when manifold users are working on the same network presents a obstacle for growing medical practices like physician-to-physician consultations, at-home monitoring and video-based telemedicine. "When you go away into a swarming place, there are 20 people with everyone going, 'I can't download this, I can't download this,'" Rab said as an example. "All individuals' equipment is restricted by bandwidth." That's why Rush, an academic health system in Chicago, plans to be the first U.S. healthcare organization to officially try using 5G—the latest generation of wireless internet—in a hospital setting. 5G internet connectivity is predictable to revolutionize nearly every industry. President Donald Trump have been one of its pinnacle

advocates, calling 5G deployment a "race America must win" during a briefing last month. As fraction of his remarks, Trump pledged to take steps to encourage local governments and telecom companies to invest in 5G. "5G determination is as much as 100 times faster than the present 4G cellular networks," Trump said, according to a White House transcript. "It will renovate the method our citizen work, study, communicate and travel. It will formulate American farms more productive, American developed more competitive, and American healthcare better and more accessible." On a 5G network, a user could load a webpage or download a file anywhere between 10 and 100 times faster than today. Most foremost smartphone developers plan to discharge devices that support 5G connectivity this year—in fact, a handful already have—making it possible 5G service will be broadly available in the U.S. by 2020.

That makes Rush individual of the "pioneers" of 5G, according to Rab. "But I assume by the end of this year, it will turn out to be popular everywhere," he added. The academy of Healthcare Information Management Executives has been touting the technology's benefits, as well. The assembly made its voice heard former this year, submitting a statement to a Senate subcommittee ahead of a hearing it convened with telecom providers and government officials to discuss the importance of deploying 5G nationwide. In its declaration, CHIME—which is chaired by Rab—said there's "no question that the combination of 5G into healthcare will enhance access to care."

"We need more speedily, improved capabilities to be able to influence the kinds of technologies that are both in the marketplace and entering the marketplace," Leslie Krigstein, CHIME's vice president of congressional interaction, said in an interview after the hearing. Dominant troupe in the healthcare industry have perverted their attention to internet infrastructure in recent years, arguing that connectivity has become integral to healthcare access. The American Medical Association in November adopted a strategy to advocate for extended broadband and wireless internet access across underserved areas of the U.S. Lack of internet access or deprived examine in these regions has hindered the accessibility of emerging digital health services, such as telemedicine, according to the AMA. "With no broadband and wireless, patients in underserved areas will face constant superior health challenges," Dr. Gerald Harmon, preceding chairman of the AMA board of trustees, believed in a statement announcing the new policy last year. There's absolutely a disparity amid those with and without internet. As evidence of a digital divide, the Federal Communications Commission in a 2018 report establish that in rural America 31% of people lacked access to wired broadband that met the FCC's speed benchmark. A fifth invention network strength be a benefit for rural areas looking for access to internet-connected healthcare services, appreciation to 5G's use of "small cells," or radio equipment placed on existing structures, such as buildings. "There is the latent to assist several of those that broadband has left behind," Krigstein said. "Since 5G have covered at a local level and has a varied infrastructure, we have the hope that we will be able to avoid some of those alike access challenges, particularly in low-income or rural areas."

Off course, that depends upon telecom giants such as AT&T, Sprint and Verizon setting up diminutive cells and antennas in areas that need them. AT&T's mobile 5G rollout encompass parts of 19 cities as of last month, and Verizon has started in Chicago and Minneapolis. AT&T plans to launch 5G in Chicago, together with at Rush, later this year.

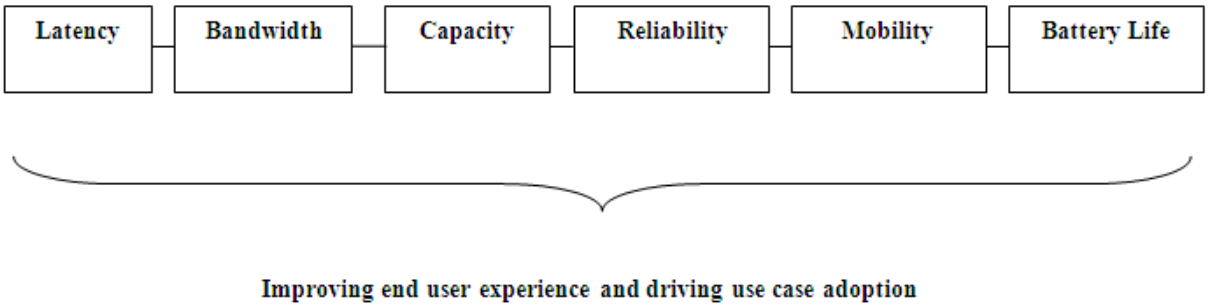
Healthcare analysts speak much of the technology's potential revolves approximately cutting down latency, which is the time lag between when a user requests an action—such as by clicking on a webpage—and when the network responds. 5G will allegedly get that response time down to just milliseconds. That sets the phase for quicker data transmission between remote monitoring devices and near real-time telemedicine visits. "A lot of the building blocks of change are already in motion," said Brian Kalis, Accenture's managing director of digital health. "The benefits of fifth generation are bringing behind barriers to broader scale and development of things that exist in the market today." One of the most thrilling possibilities for 5G is making robot-assisted telesurgery extensive. That's an action where any insulate between a physician's motion and a network's reaction would be undesirable, according to Spandan Mahapatra, global head of the business solutions unit at Tata Consultancy Services, an IT services and consulting firm.

"If there is any network latency—could you imagine the impact that would occur because of even a minor gap there?" he said. "It would be a major problem."[1]

3. 5G Health Care uses case transforming digital Health

5G health care use cases which, as health care providers look to the future prospect of their digital strategies will maintain the long-term transformation of the industry and the shift towards digital health. Although individually a little of these use cases can be delivered without fifth generation, once fifth generation standards are set and coverage is broad enough, 5G will act as a means for approval at scale by improving end user experience and diminishing existing barriers with current connectivity solutions.

In our existing article exploring it has survey that how Corona is changing global health condition, we wrote about the explosion in telehealth use cases as healthcare providers, insurers, and governments look to meet the extraordinary demand and strain on medical services. Almost overnight, healthcare systems had to transform to manage both the intense needs of COVID-19 patients, while also running the normal needs of existing patients. At the instant, in the wake of the pandemic, healthcare providers need to review which parts of their rapid digital transformation to continue to build and scale, as the responsibility shifts from severe care back to the management of chronic diseases and the backlog of patients who have gone without the treatments they require.



Healthcare monitoring will produce huge amounts of data from a huge amount of devices. Use case need to be on cellular for mobility, but 4G doesn't provide the reliability of connection.

Figure 1: 5G's Health Care uses case transforming digital Health [1]

5G healthcare use cases

5G enabled remote healthcare

1. Remote patient monitoring.
2. Connected ambulance.
3. HD virtual consultations.
4. Video-enabled prescription management Augmented reality/virtual reality healthcare use cases.
5. AR/VR assistance for the blind.
6. Distraction and rehabilitation therapy.
7. Remote expert for collaboration in surgery.
8. AR/VR training and education.
9. Real-time, high-throughput computational processing.
10. Video analytics for behavioral recognition.

4. 5G-enabled remote healthcare

1. Connected ambulance

Some propose that "connected ambulances" could help emergency services meet gradually more stringent targets and generally progress patient outcomes. A connected ambulance and its team act as a means to accumulate and transfer information of the patient, either through wearables, sensors, or streaming of HD video/body cameras, back to hospital Accident and Emergency (A&E) departments whereas the patient is being transported. This way hospital staff has a better understanding of a patient before they arrive to hospital. In some situations, specialists can be busy to help guide paramedics during certain procedures or diagnostic assessments without the need to travel to the hospital, creating efficiencies across the emergency services.

Unlike other use cases, connected ambulances could not be implemented without 5G's capabilities. This is due to the:

- Lower latency 5G can bring data and video have to be sent in real-time to the hospital/clinicians as in emergency situations, split second decisions can have significant impact.
- High B.W of 5G will enabled video to be streamed live from emergency respondent body cams in the field without loss of quality or buffering.
- Increased reliability and security of 5G.
- Emergency services may also have their individual private "slice" of the network due to 5G's network slicing.

2. High definition (HD) virtual consultations

Two-way High Definition video is used between the patient and a primary/secondary care professional to conduct, initial screening assessments, routine check-ups (which do not require physical procedures), therapy/rehabilitation sessions, and

increasingly visual diagnoses (e.g. identifying dermatological conditions and symptoms). By conducting these appointments over the air, patients do not require to travel to see healthcare professionals and vice versa, reducing the burden on the patient and decreasing the cost of each appointment.

5G will enable two way HD virtual consultations to happen at scale when compared to other connectivity solutions through the promise of:

- Mobility vs. in home connectivity solutions such as Wi-Fi.
- Higher B.W versus existing cellular connectivity bringing the necessary consistent quality of service in the field.
- Increased reliability and security of 5G.

3. Remote patient monitoring

Remote patient monitoring is seen as a key in driver for more efficient and proactive delivery of health care services and chronic disease management. By using sensors, wearable's and e-health devices, patient attributes can be collected and analysed without the need for patients to travel to primary care facilities and have a face to face appointment with a medical professional.

5G will facilitate remote patient monitoring to happen at scale when compared to other connectivity solutions through the promise of:

- Greater security and reliability of the service.
- Increased capacity for number of connected devices per square kilometer.
- Mobility vs. in-home connectivity solutions such as Wi-Fi.

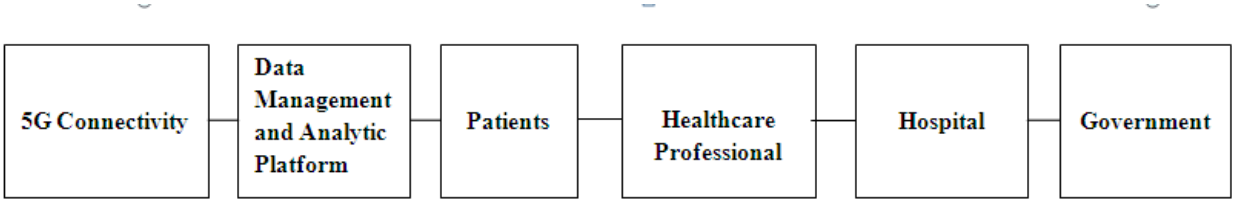


Figure 2: **5G-enabled remote healthcare [1]**

4. Video-enabled medication adherence

Adherence to prescription regimes is a key challenge in the healthcare industry, particularly with some elderly or mentally ill patients forgetting if and when they have taken their prescription medication. 5G can help take on this difficulty through the use of video enabled medication adherence, connecting qualified pharmacists and carers directly to the patient via video to ensure the right precipitation and dosage is taken at the right time. An instance of this use case in PAMAN (Pioneering Approach to Medication Administration), a video-enabled "Medihub" presently in engaged in a proof of concept in a UK 5G test bed. 5G will permit video enabled medication adherence at scale through: Increased bandwidth enabling video to be streamed at high quality in real time Ease of installation of SIM based technology versus other solutions (e.g. Bluetooth/Wi-Fi).Increased security and reliability of 5G versus 4G Augmented reality & virtual reality use cases in health care.

5. Augmented reality and virtual reality assistance for the blind

Individuals with low, impaired, or still no vision can often be deferred in doing tasks that able bodied individuals may take for granted, such as crossing the road, reading a website, entering a building etc. through assets of a 5G enabled AR/VR headset or set of video streaming glasses, visually impaired individuals can be linked in real time to a live advisor who can show the patient during certain activities in their daily life. Aira is a company looking to distribute such a service to its customer base. 5G will allow AR/VR support for the blind to occur at scale through Higher B.W enabling advanced quality video to be streamed to the guide.

Low latency means the video be able to be streamed in real time to the guide which, in situations similar to crossing the path, would be significant. Furthermore, lag and jitter while using by means of AR/VR headsets can effect the user to feel sea sick, and so low latency is essential for user experience. 5G's Wi-Fi mobility though meets the performance necessities, many of the activities for AR/VR assistance will happen on the move.

6. Distraction and rehabilitative therapy

Augmented reality and virtual reality can be used inside a hospital or clinical setting to improve the experience of patients. An example of this is by means of AR/VR for distraction and rehabilitative therapy. In the case of distraction therapy, a child that is about the receive an injection can take the headset (which through 5G could stream cloud based videos/applications of the child's

choosing in real time) to be transported to a novel environment and distracted from the potential fear of receiving the jab. In the case of rehabilitative therapy, the headset may possibly be used, for example, on an amputee to virtually overlay relaxation of the lost limb in order to relieve phantom limb pain. This use case will require 5G's capabilities because: Low latency and high bandwidth enable cloud-based streaming of applications and videos – this means information does not need to be downloaded and held on the device (reducing cost and bulkiness of the headset). It also provides the user with increased choice of application.

Low latency also improves user experience by falling lag and jitter, which can make patients feel nauseated (latency should be below ~20ms to reduce sea sickness for VR applications).

7. Remote expert for collaboration in surgery

In the context of 5G, a use case that is frequently mentioned for healthcare is "telesurgery", where a specialist can execute an operation from a remote location. Though this use case would obviously require 5G's capabilities, we consider it is over hyped and, at least for the foreseeable future, unrealistic for mainstream use (few doctors would be keen to execute surgery on someone using a remote controlled robotic device that they had not set up and checked in person).

A more sensible short-term chance is using a 5G-enabled AR/VR headset to permit a specialist to examine in on a surgery taking place in real time, guiding the in-person surgeon and commenting on what they see based on their individual information. This might also be wide to include haptics such that for example the in-person surgeon could obtain vibratory cues for where and when to move from the remote guide, or the point receives haptic information on the texture patients body in order to better assess the situation.

This use case will need 5G's capabilities to be delivered:

- Low latency across an extensive area – to facilitate real time communications and video streaming between the surgeons.
- Diminish jitter to reduce nausea as well as for consistent haptic response.
- High bandwidth to send tremendously high definition video as would be required for remote surgery.
- Reliability and security – plunge in QoS could lead to loss of life.

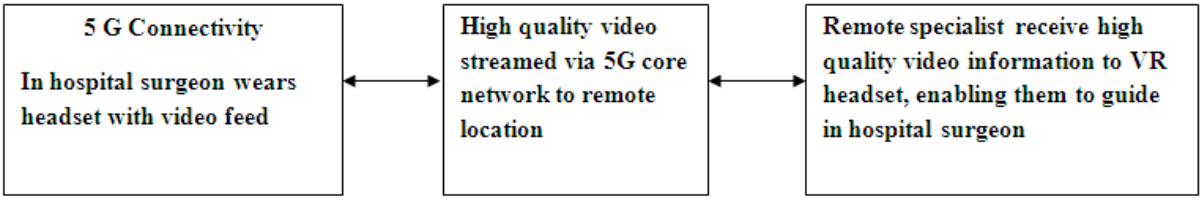


Figure 3 : 5G connectivity [1]

8. Augmented reality and virtual reality for training and education

Especially at the moment in the wake up of COVID-19, organisations across all verticals (including healthcare), are searching for new virtual ways to train and educate new staff and students. Using an AR/VR headset, both in the hospital, classroom, or even at home, could facilitate medical students and trainee specialists to perform practice procedures in a virtual environment (on virtual/non-real patients) and even cooperate with each other on these virtual procedures in real time.

This use case will require 5G's capability for:

- Low latency –to make easy real time communications and video streaming among participants in the class.
- Diminish jitter to reduce nausea of users.
- High bandwidth to launch tremendously high definition video as would be required for the level of detail in a surgical process.
- Consistency to provide a consistent quality of service, otherwise adoption for the use case would be prohibitively low.

9. Real time high-throughput computational processing

In healthcare, there are a lot of high-resolution images and files which may necessitate high-throughput computational processing for diagnostics and design. By means of 5G, for example, after getting an MRI or CT-scan, images can be sent in real time to where they need to be analysed to provide a diagnosis. In addition, there is an rising use of in-silico high-throughput screening for additional effective drug design in the pharmaceuticals industry. 5G can make easy transfer and analysis of molecular models and

structures to the cloud to leverage the higher compute/graphic processing power and cheaper resource compared to a local high-end desktop. Workspot, Netgain, and Fordway are organisations leveraging Virtual Desktop Infrastructure to facilitate low latency, cloud-based calculation in healthcare and life science.

- High bandwidth to launch high resolution files in real time without buffering/delay.
- Mobility vs. fixed connectivity resources machinery and equipment does not need to be tethered to a specific location.
- Low latency for by means of cloud based processing means images/models can be rendered and iterated in real time.

10. Video analytics for behavioral recognition

In hospitals, care homes, psychiatric centres etc. video analytics can be used in the hallways to recognize patients who are behaving out of the ordinary, have had an incident such as diminishing, or are becoming a danger to themselves or others. Hosting the analytics on device using smart cameras can guide to prohibitively exclusive hardware and so the analytics should happen in the cloud (or more likely using an edge compute to maintain data localisation and security).

5G can be used to facilitate this use case owing to:

- Enhance in bandwidth allowing high definition video to be sent for processing and analytics.
- Low latency enabling analytics to happen in real time and improving patient outcomes.
- Security and reliability protecting patient data (e.g. through 5G slicing).
- Improved flexibility of the solution vs fixed connectivity – easier to add/remove cameras as SIM based-solution.

This is the second installments in a sequence looking at healthcare use cases for rising technology. We have formerly looked at edge computing healthcare use cases and will be explore IoT, AI, and block chain healthcare use cases in our future articles. For additional information on the impact of 5G on the healthcare industry, appreciate our report quantfying the benefit of 5G use cases for free [1]

5. 5G-Powered Medical Robot Performs Remote Brain Surgery

Doctors have performed the first fifth generation remote brain surgery. The patient was more than 1,500 miles away and moreover suffered from Parkinson's disease. The patient received a deep brain stimulation implant all through a three hour procedure. Dr. Ling Zhipei performed the innovative surgery by means of manipulating instruments in Beijing from his location in Sanya City using a computer powered by China Mobile and Huawei's 5G network.

It wasn't simply a trial to see if it could be done, Dr. Zhipei splits his functioning time between Beijing and Hainan. The Beijing-located patient requisite surgical treatment while the doctor was in Hainan, and neither could fly to the other. The doctor resolute to challenge the medical robot-assisted surgery from his remote location and use of the 5G network eliminated issues like lag and remote-control delay typical on 4G networks.

Figure 4: 5G-Powered Medical Robot Performs Remote Brain Surgery [2]

5.1 Increased Data Speeds Enable the First 5G Surgery on a Lab Animal

The first 5G-powered surgery on a human, operating over the new wireless network was tested on a laboratory animal in January 2019. The first 5G remote surgery involved removing a laboratory animal's liver successfully. Doctor used a surgery instrument

which was controlled by a medical robot that was 30 miles away. In that analysis, lag on the fifth generation system was only 0.1 seconds, 4G networks at that distance could experience as much as two seconds of lag, hardly sufficient in an operation scenario.

5G networks diminish latency, resultant in near-instantaneous data transfer. The technology is competent of delivering a mere 2 millisecond lag between devices. Lower latency opens up new potential for technologies like augmented and virtual reality. Surgeons separated by thousands of miles be able to work as if they were present in the same room Doctor Zhipei said that he could barely tell his patient was 3,000 kilometers away. [2]

5.2 5G Networks Can Improve Level of Care during Robotic Surgery

Customers can't wait for fifth generation networks to progress video calls, gaming, and download speeds. But dedicated surgeons expect to see an development of global, robotically enabled long-distance surgery. The profit offered by the 5G connection applies to telepresence as well as telesurgery. But fifth generations promise is not just improving the speed of today's technologies. The enhanced volume of data that can be processed at great speed will allow surgeons to connect medical devices together and collect data in ways that haven't even been thought of yet. Different specialists, from all across the globe, could work together for the first time. In the long time, it could cut the expenditure of surgery while increasing the level of care to patients in remote areas [2]

5.3 Robotic Surgery: The Role of AI and Collaborative Robots

In the operating room, surgeons must always be accurate when making incisions or performing other surgical tasks. The recurring responsibilities are challenging, to assist surgeons; the medical field is by means of the advancements of AI and collaborative robots in the OR.

5.3.1 Surgical Robots Bring Skills to the OR

Surgical robots are able to control the route, intensity, and speed of their dealings with great accuracy. They are particularly well-suited for measures that require the same, repetitive movements as they are able to work with no weariness. Robots can also remain completely stationary for as extended as needed and can go where traditional tools cannot. Experience is invaluable in the OR. The longer surgeons can keep performing surgical treatment, the enhanced, but surgical events can be physically challenging. The skills and knowledge that surgeons accumulate over their careers can be impeded by a loss of motor skills. Collaborative robots can ease reduce the effects of hand tremors and keep away from unintended or accidental actions. [2]

5.3.2 Robotic Surgery and AI

Artificial intelligence is being applied to surgical robotics. Manufacturers see the necessitate to use deep learning data to computerize rather than behavior programmed by an engineer that does not identify all the scenarios. This deep machine learning data is composed from surveillance surgeons perform. Appreciation to this data and complex algorithms, AI can establish patterns within surgical measures to improve best practices and to improve a surgical robots' control accuracy to submillimeter precision. AI is also being used with machine vision to examine scans and detect cancerous cases. Laparoscopic video analysis of surgeries, like sleeve gastrectomy procedures, helps to recognize missing or unexpected steps in real time [2]

5.3.3 Robotic Surgery Applications

Robots have a superhuman facility to replicate exact motions. This is tremendously useful in hair transplant surgeries, for example. The robot harvests hair follicles and then implants the follicular units interested in targeted areas on the scalp. Integrated power sensing ensures that the robot maintains the special force during harvesting and implantation. Abdominal surgical robots can move about by way of an eye-tracking camera control. Surgeons are able to move the camera merely by moving their eyes. The device also provides haptic feedback so they can feel the services that the robotics arms encounter. Surgeons require immensely steady hands when working in delicate areas, such as the eyes. Tests of a system to remove membranes from patients' eyes or blood beneath the retina due to age-related macular deterioration have been successful. And in some belongings, the surgery via the robotic system was more effectual than doing the procedures manually. Surgery is done by means of robotic surgery platforms that use micro instrumentation, bendable robotics, and additional technologies for bronchoscopic procedures. Robotics gets enhanced outcomes for patients by accessing and treating disease throughout the body's natural openings. The platforms integrate endoscopes, instruments, and navigation into a distinct platform, allowing physicians to better conduct endoscopic interventions. Collaborative robots are rapidly attractive part of everyday life. To learn more about applications of mutual robots [2]

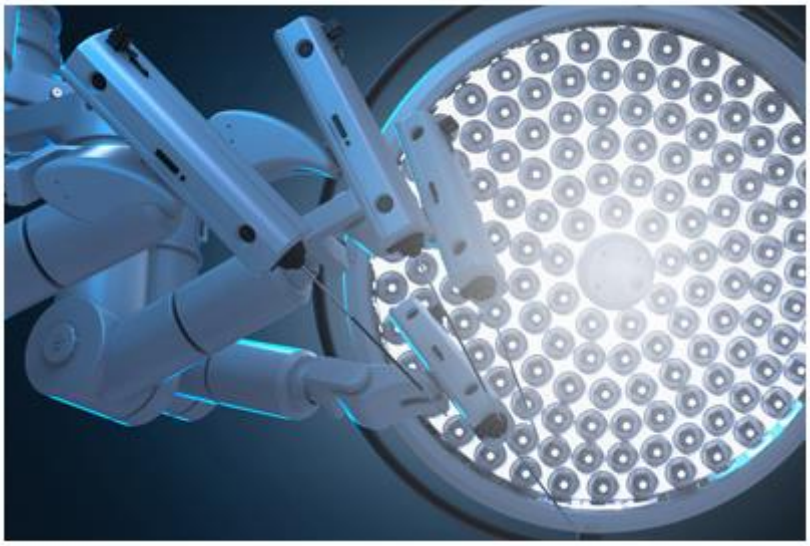


Figure 5: Robotic Surgery [2]

5.4 5G Changing Healthcare Delivery

The technology shows promise for telehealth, robotic surgery and more, but questions and challenges stay behind. The emergence of 5G technology has the prospective to transform healthcare release by boosting velocity and capacity while rising latency. Although still in its infancy, this influential network has big prospective for healthcare. Among the possibilities: transmitting huge medical images, facilitating telehealth initiatives and sustaining remote patient monitoring tools — as well as enabling more composite uses of artificial intelligence and increased and virtual reality. 5G also will make possible faster downloads and communication on mobile devices and tablets used in healthcare settings, and it's likely to be a fitting complement to Wi-Fi.

"We necessitate an original network that can power the speed of link with the breadth of data," Robin Braun, Global Storage CIO for Healthcare at Dell EMC, recently told HealthTech. "5G promises to make available that communications and push smart devices and decisions from the core to the edge, creating secure, smarter data streams and enabling greater personalization."

Still, many questions stay behind, which is why healthcare leaders must appreciate the developing 5G setting and related challenges of the transition.

5.4.1 How 5G Could Help Improve Healthcare Delivery

Most organizations launch or expand their telehealth offerings, the high quality video fueled by 5G could help patients and providers achieve a quick, clear connection. However, this will require that 5G coverage 10 to 100 times faster than a typical 4G cellular connection be available both in remote areas and at the site of care delivery.

5G is also balanced to profit an expanding network of Internet of Medical Things devices and other wearables used to perform remote patient monitoring. Such efforts permit clinicians to maintain tabs on vital signs, medication adherence and other data from afar to personalize care.

5G will be critical for sending large images and it could pave the way for imaging tools such as X-rays and MRI's to maneuver wirelessly. And it can also play a role in sustaining augmented and virtual reality tools for training in complex medical scenarios. Looking further, there's enthusiasm regarding 5G's potential to power robotic surgery tools that reduce distance (and technical lag time) among doctors and patients. The primary such challenge took position in China last year: 5G aided a surgeon's robotic placement of a brain stimulation device in a patient with Parkinson's disease located 1,900 miles away.

6. Challenges of Implementing 5G in Healthcare

To entirely control the power and advantages of 5G, it's helpful for healthcare leaders and clinicians to appreciate some misconceptions and roadblocks that must be addressed in the years ahead. Initial, accessible fourth generation smartphones aren't compatible with 5G (Gartner forecasts 221 million 5G smartphones will be sold this year; the tally will more than double in 2021). Current coverage, likewise, is only available in a limited quantity of metro areas, and not always in a consumer-facing capacity. Besides, there has been misleading 5G branding, and there are concerns about 5G towers' shorter range, which has required many more towers to be installed. Meanwhile, healthcare organizations will also need to assess their infrastructures and device stables. Transitioning to 5G is "not a light switch," as Craig Richardville, senior vice president in addition to CIO of SCL Health in Denver, recently told TechTarget. That includes novelty expertise and applications to either speak 5G or disabling the [legacy]

technology piece by piece." There's no question that much is left to address before 5G becomes a mainstream component in healthcare. The scheduling and problem-solving must start now. [6]

7. 5G and the Future of Telemedicine and Remote Surgery

Currently we are at a turning point for telemedicine (also known as telehealth). In past hundreds of years, communications between doctors and patients have been frequently face-to-face in medical offices, hospitals, homes and care amenities. These days, medical technology and faster networks like fourth generation LTE and fifth generation are changing the face of healthcare. Telemedicine technologies have been affecting ahead gradually. Most observable has been the rise of wearable health devices to monitor vital signs. The idea of doctors seeing patients over the Internet has been attractive yet not widely put into practice. However, the COVID-19 endemic has changed that. In order to keep patients and medical staff safe, health organizations are increasingly using telehealth technology to serve patients. Consequently, growth in the telemedicine market is accelerating worldwide. These days' Medical device companies are racing to meet demand. Moreover, today's fourth generation LTE and evolving fifth generation wireless technologies is fueling the growth of telehealth and other healthcare functions as never before. A few of the contributing technology factors comprise widespread cellular network availability**,** ease and speed of deployment and greatly improved bandwidth. Fifth generation new radio (NR) technology is a major improvement over the current fourth generation LTE technology. In fifth generation millimeter wave spectrum is used and it can bring a theoretical download speed of twenty gigabits per second compared with less than two gigabits per second for LTE. This 10x performance improvement means more and better information in near real-time Fifth generation mm. Wave uses tremendously high frequencies between 24 GHz & 100 GHz, competent of delivering high data rates, but at a much shorter distance than LTE. Therefore, more Fifth generation antenna towers are needed. Now a days, mobile communications vendors like Nokia or Ericsson are already able to demonstrate Fifth generation download speeds of up to 10 gigabits per second. Because of its super speed and robustness, Fifth generation will accelerate telehealth's development. Fifth generation can also support massive Internet of Things (IoT) and smart city infrastructure. As a result, it will progress the growth of home healthcare, distant patient monitoring, remote and robotic surgery assistance, and smart city infrastructure. Patients and healthy persons alike will see direct impact to their well-being and available resources for health management. [2]

7.1 5G-Enabled Remote Surgery Support

Figure 6 : 5G-Enabled Remote Surgery Support [2]

Most of the hospitals have experienced surgeons; they typically do not have every surgical area of expertise staff. Often, they will discuss with physicians with specialized knowledge. Expert's in particular surgical fields have been using video and audio to support the surgical team during the operation. With medical development, more and more surgeries are depending on technology. For example, a small surgical microscope can be inserted inside the body, and, using a high definition 4K display such as that of the Olympus Visera, clearly expose the information of the area to be operated on a 5G connection will mean that the same information viewed by the surgical team can be live streamed in real-time to the supporting expert team, and in the future in even advanced 8K resolution. This real-time link will enable the experts to advise the team as the surgery takes place. [2]

8. Better Emergency Support in a 5G Smart City

During the epidemic, a lot of hospitals became overwhelmed due to Covid-19. In some cases, hospitals had to turn away patients for lack of ICU room. Being incapable to admit a patient to an ICU rapidly endangers patients and disrupts normal hospital routines.

Some cities have in progress to experiment with smart cities technologies to sustain better healthcare. In smart cities, after an ambulance picks up a patient who needs emergence medical care, a nearby hospital would be informed automatically about the

patient's condition and the estimated arrival time. The patient information would enable the hospital's emergency team to speedily get ready. If there is no Intensive Care Unit bed available, the ambulance would have been warned, and the system would automatically route the ambulance to the next available hospital without stopping. If electronic health records are installed, the hospital would know the patient's condition before arrival and have the right medical setup ready. By knowing information in advance about any allergies to medicines or materials, the medical team can organize with less last-minute crambling. Moreover, in a smart city the ambulance is guided through traffic by means of Computer Aided Dispatch & Advanced Vehicle Location. Smart traffic lights these days controlled with 4G LTE adaptive traffic control and ultimately controlled by 5G will automatically be synchronized to allow the ambulance to go through while stopping all other traffic, economy time and increasing safety. [5]

Figure 7: Emergency Support in a 5G Smart City [2]

9. The Future of 5G and Medical Technology

Figure 8: The Future of 5G and Medical Technology [5]

5G will get better home healthcare and remote patient monitoring and surgeries. In smart cities 5G will move further on the way emergencies are handled. Critical information, easy to get to in near real time, will let teams act in response much more quickly to deliver better care. Looking further on, it is predictable that many of these decisions and functions can be performed with Artificial Intelligence. Machine learning, Artificial Intelligence and robotics will play a greater role in events to improve precision. Emergency teams will have more time and be better prepared to deal with unpredicted situations caused by sickness or accidents as well as natural disasters. [5]

9. Conculsion

Fifth generation standards are set and coverage is broad enough, 5G will act as a means for receiving at scale by improving end user knowledge and diminishing existing barriers with current connectivity solution. Fifth generation network is competent to fetch higher multi-Gbps peak data speeds, ultra low latency, more reliability, massive network capacity, increased availability, and a more uniform user experience to more users. Advanced performance and enhanced efficiency give power to new user experiences and connects new industries. Fifth generation is used crosswise three main types of associated services, including enhanced mobile broadband, mission-critical communications, and the immense IoT.

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