THE NEED FOR A DIGITIZED SMART HEALTH CARE SYSTEM IN A POST-PANDEMIC WORLD

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INTRODUCTION: THE STATE OF THE HEALTHCARE MARKET

Since the beginning of 2020, the global outbreak of COVID-19 has put incredible pressure on the majority of every national healthcare system in the world, highlighting the imminent need for modernization and digitization of the sector.

At present, the healthcare sector is characterized by a high degree of technology fragmentation that prevents different units from communicating efficiently with each other.

The prevalent communication technology in hospitals is fixed line connectivity due to straightforward motivating reasons. Given the condition of the cable, network availability and reliability are almost 100%, which is important because this communication can be vitally important for the health of thousands of patients. Relying on fixed line connectivity, however, imposes significant limitations on the usability of automated communication in a real-life hospital environment. Despite most patients being bedridden, a hospital is still characterized by a high degree of mobility. Patients are frequently moved for different diagnostic procedures, to and from surgery theaters, or even between hospitals and wards.

Connectivity in the healthcare sector today is characterized by a high degree of proprietary profiles and interfaces that are developed specifically for different healthcare areas, standardized by the Healthcare Level 7 (HL7) initiative, referred to as the Fast Healthcare Interoperability Resources (FHIR). In addition to the HL7 initiative, Integrating the Healthcare Enterprise (IHE) is working toward a standards-based communication protocol, particularly for the radiology vertical. While these initiatives foster data transmission and communication within each vertical, they complicate inter-vertical communication, because these proprietary profilers of the same protocol do not automatically interoperate with each other.

To enable seamless communication between different medical verticals, wireless connectivity in the healthcare sector has recently started to gain some traction, with every major hospital being equipped with Wi-Fi connectivity. However, the use of wireless connectivity in the healthcare sector, at the moment, is largely limited to Information Technology (IT) applications in the healthcare environment and not for medical use cases, as the application of wireless Wi-Fi communication technology still uses frequencies on the Industrial, Scientific, Medical (ISM) bands and, therefore, has to employ "listen before transmitting", making it susceptible to network disturbances from outside jamming. While the use of proprietary profiles can help mitigate this, it would introduce an additional degree of proprietary fragmentation, therefore complicating the communication between different healthcare entities (e.g., hospitals) with each other.

DIGITIZATION AND ICT EFFORTS IN HEALTHCARE

As traditionally, the telecommunications industry and healthcare domain have been very isolated from each other, health care workflows and processes have never been digitised at large. Because of this lack of action, the true potential of ICT supported smart health care could never properly unfold. In the wake of the outbreak of the Covid-19 disease, however, considerations about how to modernize healthcare systems have intensified. In order to strengthen remote services has led public authorities to realize of the importance of modernizing the healthcare system, therefore creating more favourable conditions to modernize communication infrastructure within the healthcare domain: In China, the regulator on unified national standards for 5G networks in healthcare environments and in the United States the Federal Communications Commission (FCC) approved US$200 million of funding for telehealth initiatives in April 2020 as part of the Coronavirus Aid, Relief, and Economic Security (CARES) Act. The COVID-19 Telehealth Program provides immediate support to eligible health care providers responding to the COVID-19 pandemic by fully funding their telecommunications services, information services, and devices necessary to provide critical connected care services.

CARRIER ACTIVITIES

Efforts from the telecom industry are at the heart of this modernization. The French network operator Orange, for example, is partnering with Sanofi, Capgemini, and insurance companies to create a digital ecosystem for e-health applications, which is in operation from June 2021. Realizing the growing importance of digital innovations and data, the joint initiative will consist of a virtual platform as well as physical campus, located in France. To provide the necessary financial means, the partners have announced to jointly invest US$29 million (€ 25 million) into building the physical campus, including all necessary infrastructure.

Similarly, other carriers have dedicated offerings in place to address the growing demand from hospitals and other health & social care facilities.

Deutsche Telekom founded the division Telekom Healthcare Solutions in 2010 as part of the T-Systems subsidiary. While most of the most of the operator's healthcare business now considers providing connectivity for IT applications within the healthcare environment, the network operator is currently developing service-based business models to bring cellular connectivity to medical use cases as well. Key pillars in developing e-health solutions is the strengthening of the surrounding software developer ecosystem by creating incubators to invest into new start-ups.

South Korean network operator KT launched extensive 5G services for the medical domain in January 2020, at the Samsung Medical Centre in Seoul, South Korea. Most prominently, these include digital diagnostic pathology, access to proton therapy information, teaching surgery, and AI-enabled care for in-patients, as well as an autonomous robot for operating rooms.

China Mobile collaborated with infrastructure vendor ZTE to present China's first 5G medical edge platform, integrating 5G slicing edge computing capabilities to bring them to hospital campuses. In November 2019, China Mobile deployed 5G network in the West China Second University hospital in the Chinese province of Sichuan, presenting the world's first 5G medical private network. In May 2020 China Mobile deployed a 5G cellular network in the First Affiliated Hospital of Kunming Medical University in Yunnan province to enhance the hospital's remote diagnostics and treatment capabilities in response to the outbreak of COVID-19.

INFRASTRUCTURE VENDOR ACTIVITIES

Infrastructure vendors are focusing their efforts on providing the necessary equipment for smart health care platforms. In line with their cellular technology, most of established infrastructure activities are connectivity-driven and therefore focus on bringing enhanced connectivity into a healthcare environment. As section 3 will lay out, however, healthcare digitization requires more than just bringing connectivity into a hospital or doctor's office.

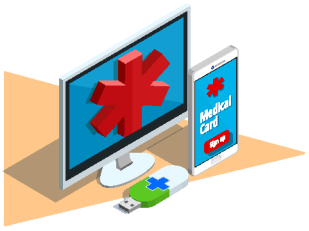
As a leading example, Huawei has launched its initiative for a fully connected digital healthcare platform as part of the broader TECH4ALL initiative (which will be discussed in section 6). In a lighthouse deployment project, Huawei partnered with doctors in New Zealand to provide a full end-to-end digital health platform (called MaiHealth), uniting artificial intelligence, cloud capabilities, sensors, and connectivity (both cellular and Wi-Fi) to provide a truly smart health care experience. As such, the platform offers frictionless access to patient healthcare records and enhanced capabilities for remote consultation of specialist across the entire country.

Finish infrastructure vendor Nokia offers its Future X architecture for healthcare. Nokia worked together with the University of Pittsburgh Medical Centre (UPMC) to design a resilient networking solution for healthcare IT applications, with latencies of less than 1 ms, to provide seamless service to end-users. To enable transmission of data-intensive video files, Nokia managed to boost the optical core from 1 GB to 10 GB/s. Furthermore, Nokia offers extensive SD-WAN solutions for use in different hospital departments, like radiology. To showcase the potential of 5G for the healthcare sector, Nokia engaged with network operators China Mobile

and China Telecom in 2017 to demonstrate how 5G can enhance the communication between ambulances and hospitals.

To contribute towards a smart healthcare system, the Swedish infrastructure vendor Ericsson is partnering with the British King's College University in London in providing the relevant network infrastructure. Most prominently, the research lab explores utilizing 5G technology to increase the reach of a high-quality healthcare system by enabling and enhancing remote access to healthcare specialists.

In China, the Ericsson worked together with China Mobile and China Telecom to deploy 5G networks at three hospitals in China (Ezhou Third Hospital, Qianjiang New Maternal and Child Health Hospital and the Xiaogan Xiaonan Disease Control Center) to enhance remote diagnostics operations, as well as at the Xiaogan Xiaonan Disease Control Center



The telecom industry should look at these efforts and consider them as guiding examples, as more industry wide initiatives are needed to drive smart healthcare deployments.

DIGITAL TRENDS FOR THE HEALTH CARE DOMAIN

To enable and support these digitization initiatives, a range of digital trends emerge, ranging from Artificial Intelligence to smart wearables and 5G connectivity, and to extended reality applications, that shall be discussed in the remainder of this section.

ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelligence (AI) refers to the intelligence demonstrated by machines, acquired through specific machine learning algorithms. In the healthcare environment, AI enables a device or software program to interpret complex data, including images, video, text, and speech or other sounds, and act on that interpretation to achieve a goal.

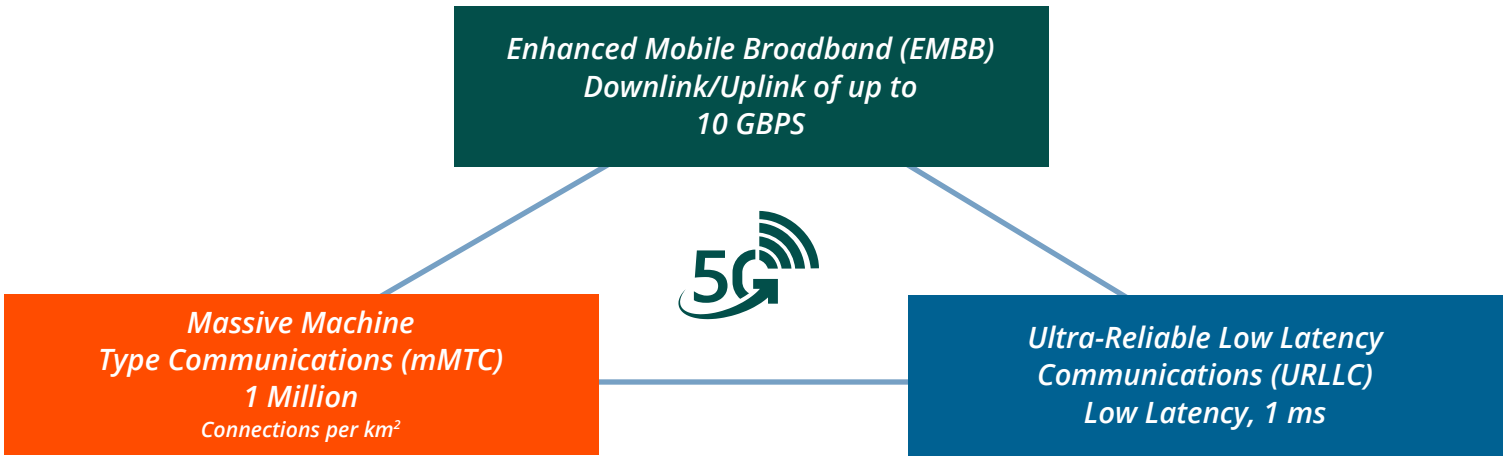
The large-scale adoption of machine learning and artificial intelligence for example allows for efficiency and quality enhancements in diagnostics procedures. For example, image recognition could be used to analyze patients' MRI or radiography scans to automatically detect any kind of anomaly. Artificial intelligence could also be used to suggest a potential diagnosis to healthcare specialists based on different patient healthcare input data from different tests or examinations. Thereby, AI applications can contribute to shortening the time it takes to determine a patient's diagnosis. In a similar vein, it can help to reduce the workload on healthcare professionals by suggesting the most likely diagnosis for validation.

5G

5G will have the potential to fundamentally change communication technology in the healthcare sector both when it comes to in-house applications (hospitals or care homes, for example) and for increasing the reach of a healthcare system to people without easy access to healthcare infrastructure, as it standardizes three key capabilities, illustrated in Figure 1.

Figure 1: ITU-2020 5G Capabilities

(Source: ABI Research)



While access to healthcare is a lesser problem in developed countries (in the United States, there is 1 hospital bed for every 361 inhabitants[1]), this becomes increasingly important for developing nations like India, where, statistically speaking, there is 1 hospital bed for 1,810 inhabitants. Guaranteeing peak bandwidths of 10 Gbps in the downlink and 20 Gbps in the uplink, as well as sub-10 ms latencies will allow the transmission of data-intensive video files, will enable a range of remote operations, such as diagnostics, patient monitoring or care, and remote surgeries, that rely on particularly low latencies to transmit any haptic feedback to the remotely operating surgeon.

By guaranteeing enhanced mobile broadband (eMBB) capabilities, 5G will also be a critical enabler of other technologies in the healthcare sector, such as AR and VR, which involve transferring large amounts of video data. AR and VR applications in the healthcare sector can range from training courses for doctors and nurses in a virtual patient environment to applications in real-life hospital situations, in which doctors or nurses could use AR-enabled glasses to pull up additional statistics about health status during treatment and could model the potential effects of a treatment method before actually applying it in real life.

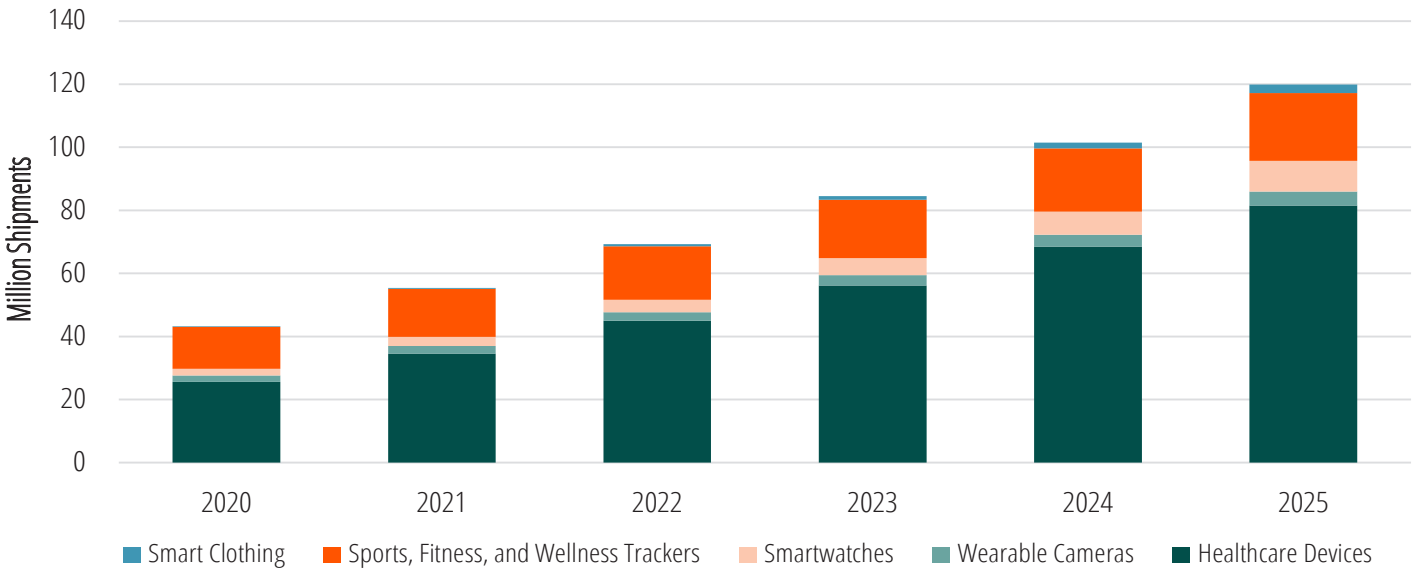
SMART WEARABLES

The trend for digitization does not stop at the boundaries of enterprise premises, but rather extends into the more consumer-oriented domain as well: More and more individuals are counting their steps, tracking their fitness activities with specific trackers or measure their heart rate either through smart watches or breast straps. All of this is enabled by technology components becoming more affordable and smaller in size, which makes them fit into conveniently sized devices. Health care and physical activity data is then uploaded into cloud solutions provided by either smart wearable manufacturers (smart watch manufacturer Garmin with

[1]*Calculated by using Organization for Economic Co-operation and Development (OECD) data on the number of hospital beds per 1,000 inhabitants: https://data.oecd.org/healthreqt/hospital-beds.htm*

their Garmin Connect platform, for example) or third-party application providers, like Strava. The capabilities of these smart wearable devices, however, does not stop at tracking physical activities or counting the daily number of steps, but also extends to more sophisticated measures like blood pressure or (long-term) electrocardiograms (ECG). As smart wearables are becoming much more than consumer gadgets, they will reduce the burden on health care systems, since they can take over routine medical check-ups. In combination with Artificial Intelligence, these smart wearables could even take over preliminary diagnostic capabilities of routine measurements to free up more resources. In line with this, ABI Research expects the market for wearables in the healthcare domain to expand to 120 million shipments by 2025, with CAGR of 22.6% from 2020-2025.

Chart 1:
Healthcare Wearable Device Shipments by Device Type, World Markets Forecast: 2020-2025
(Source: ABI Research)



OTHERS

In addition to these key transformative technologies, there are adjacent developments that will play an important role for digital healthcare. Most importantly, augmented and virtual reality applications (AR and VR) will play an important role in digitizing different aspects of the health care environment. While augmented reality can enhance medical workflows in direct contact with patients, one of the main use cases for VR applications lies in enhancing training opportunities for nurses and doctors. The use of VR can allow medical students to increase their hands-on experience by being allowed to test their abilities directly with virtual "patients". This early hands-on experience would be impossible in a traditional health care education setting, as it would potentially put a patient's life at risk.

Augmented Reality technology on the other hand, can be applied to direct patient-facing contact. While visiting different patients, for example, doctors wearing augmented reality glasses can use these to pull up additional health condition data for each patient to determine optimal treatment. Furthermore, augmented reality could be used in a surgery setting to determine a patient's general condition more accurately, and therefore reduce the instances of critical complications during a surgery.

As augmented and virtual reality technology involves transmitting particularly data-intensive image and video files, the large-scale adoption requires particularly high network bandwidth. By bringing about enhanced mobile broadband capabilities (eMBB), 5G can be an important enabler for the large-scale deployment of these technologies.

USE CASES FOR DIGITIZED HEALTHCARE OPERATIONS

Digitization in the healthcare domain can enhance quality and efficiency of the sector in different environments. Either they can be used to enhance the quality of processes and workflows for health care providers (i.e., hospitals, or inpatient services in other healthcare environments) or, alternatively, they can be used to improve medical and diagnostic operations.

HOSPITALS AND INPATIENT SERVICES

Firstly, like 5G connectivity, AI or extended reality applications can be used to digitize processes and workflows within hospitals or other healthcare provider facilities. Not only does this increase the efficiency of for example a hospital, but it also raises the quality by equipping doctors with AI-based diagnostic capabilities that will enable them to diagnose even rare diseases and determine the best possible treatment for each patient.

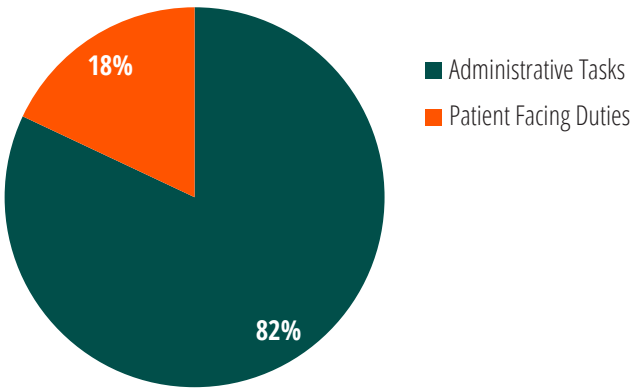
PERSONNEL AND ASSET MANAGEMENT

New technologies like cellular connectivity (5G) or even identification technologies like RFID (Radio Frequency Identification Technology) can be implemented to enhance management of hospital staff and used for asset tracking.

Different studies suggest that each nurse spends up to 82% of their day performing administrative tasks (translating to an average of 6 and a half hours, assuming an 8-hour working day), such as walking to/from different patients, retrieving medication & supplies, and recording information into the EHR system, while only 18% of their day (1 and a half hours) is spent with patients. Extrapolating these numbers over a typical working year, this means that a single nurse spends a total of 1,560 hours in an average working year (assuming 240 working days per year and a typical working day of 8 hours) performing administrative tasks. By providing automated personnel and asset management, a 5G enabled smart healthcare system would minimize this proportion and therefore allow nurses to spend more of their day with patients.

Chart 2: Typical composition of nursing duties

(Source: Zebra Healthcare)



With the proposed centimeter-level accuracy (that will come with Release 17), 5G connectivity will be perfect fit for asset localization. The main asset for 5G in this case, however, is the ability to address more use-cases that stretch well beyond tracking applications (extending to more demanding medical use cases). Therefore, deploying 5G connectivity is rather expensive in comparison to pure localization technologies like RFID, which can provide tracking applications for hospital a staff, patients, or medical assets using active tags, operating mostly in ultra-high frequency RFID bands (300 MHz-900 MHz).

PATIENT DATA MANAGEMENT

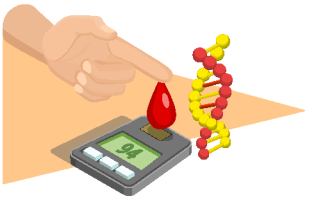
In addition to tracking of hospital staff and assets, a 5G based health care communication system will also be able to manage patient data more efficiently.

In order to do this, the network needs to be deployed as a platform, so that specialist healthcare software developers can build their applications on top of that network infrastructure to ensure seamless interoperability with existing healthcare communication standards (such as FHIR or IHE).

ENHANCED DIAGNOSTICS

By guaranteeing high enough bandwidth and low latencies, 5G will enable the large-scale application of Artificial Intelligence (AI) technologies in the healthcare sector. While AI will certainly help with managing patients and hospital staff, from a medical point of view, AI technologies will also assist hospital staff with medical diagnoses.

By providing edge capabilities and decentralizing medical processing, 5G will enable AI to decentralize toward the network edge. Algorithms, for example, could be trained to automatically detect anomalies in medical imaging procedures (e.g., X-rays or Magnetic Resonance Imaging (MRI)) and automatically transmit the findings to the respective medical consultant immediately. A preliminary diagnosis could reach the respective consultant before the patient has even exited the diagnostic environment. In a traditional healthcare environment, it might take several hours or even days just for the imaging data to reach the respective consultant.



While in a traditional setting it would take at least took at least 20 minutes for patient tissue to even be transported to and from the pathology department (therefore making it difficult for pathologists to conduct on-site group analyses), by enabling remote diagnostic capabilities, 5G services have contributed towards valuable time savings and faster diagnosis.

CONNECTED AMBULANCE

There are two important ways in which connectivity technologies can enhance the workflows within ambulances. Firstly, cellular connectivity can allow the ambulance car to communicate with other road users, road infrastructure (such as traffic lights), or pedestrians. Therefore, ambulances could communicate emergencies to cars within their vicinity and automatically adjust traffic lights to get critically ill patients to hospitals as fast as possible, without having to waste valuable time fighting their way through busy traffic situations.

Secondly, ambulances can use cellular connectivity to connect their onboard medical devices with hospitals. Transmitting important patient data to the hospital well before the arrival of a patient allows staff to prepare in the best possible way for the newly arriving patient: for example, by preparing diagnostic cabinets, specific medical diagnostic devices, or calling relevant specialist consultants. Transmitting ultrasonic medical image data could also enable hospital staff to help emergency response personnel with initial diagnoses.

REMOTE SURGERY

By combining the high bandwidth guaranteed by eMBB, as well as the low latencies and high reliability guaranteed by URLLC, 5G will enable carrying out remote surgeries, where the operating surgeon does not have to be in the same cabinet as the patient, but operates a robot conducting the surgery on the surgeon's behalf.

While the vision of a completely remotely operated surgery using robots is a very long-term vision, an intermediary step could be a remotely located specialist advising or instructing a junior surgeon on how to conduct the surgery. This would ensure a human surgeon being present during the surgery and would therefore increase the subjective feeling of safety for the patient.

HOMECARE FACILITIES AND OUTPATIENT SERVICES

In addition to inpatient services (that by and large focus on creating efficiency and quality enhancements for healthcare providers), digital healthcare and eHealth initiatives also benefit healthcare payers directly in that they allow remote monitoring of patients at home to stabilize and monitor their medical condition. Not only can this improve the efficiency of health and social care provisions, but it can also help to prevent healthcare provider facilities from coming in physical contact with infectious diseases. Finally, enabling remote monitoring and home care increases the geographical reach of healthcare provision, as allows patients to access health and social care services even from remote areas. In this context cellular connectivity plays an important role, as it can augment and extend existing WIFI connectivity.

PATIENT MONITORING FOR PREVENTATIVE MEDICINE AND PRESCRIPTIVE CARE

Since 5G allows the transmission of large data sizes, as well as the connection of a large enough number of devices, this allows measuring of healthcare data to transform from one or more individual, isolated measurements during the day into one continuous measurement. While this is already possible for in-hospital patients, 5G connectivity allows this enhanced monitoring to be extended to patients that are well enough to stay at home. Not only does this increase the efficiency of health and social care work, but also it can ensure continuous levels of care irrespectively of surrounding circumstances. During an outbreak of a pandemic, e.g., the Coronavirus disease (COVID-19), the subsequent social distancing measures and "stay at home" guidelines underlined illustrated the importance of remote patient monitoring, as it allowed vulnerable individuals to continue receiving medical support without being exposed to an increased risk of infection.

Several studies have looked at the value of continuously monitoring patients with heart conditions. Their findings suggest that **continuously monitoring patients' heart data could identify anomalies 11 days before the patients would normally be admitted to hospital.** In the case of problematic heart conditions, for which the application of the right treatment is extremely time-critical (several minutes or even seconds in the case of a stroke), gaining insight about anomalies several days before the patient would have been admitted to hospital is absolutely critical to maximizing the likelihood of the patient fully recovering from the condition.

REMOTE CARE AND DIAGNOSTICS

Apart from remotely operating patients through smart wearables, or their medication intake, digital healthcare technologies can also be used to extend the reach of social care and diagnostics capabilities.

First, smart healthcare technologies can be used to reorganize care for elderly or particularly vulnerable people in that it allows some duties of care to be carried out via video connectivity.

Second, they enable video consultation between patients and doctors for a first diagnosis. The benefits of such a solution are clear since this prevents diseases from spreading easily in the population by decentralizing opportunities for an accurate diagnosis. This decentralization is important for two reasons: sick people bring new disease to a hospital / a doctor's practice and therefore increase the risk infecting other, and secondly, since most people visiting a doctor suffer from a weakened immune system, they are more susceptible catching a new illness by visiting an area highly concentrated with bacteria and viruses.

Especially in the wake of the global COVID-19 pandemic, the demand for video consultation has risen sharply. In the United Kingdom of Great Britain and Northern Ireland, for example, data from the Royal College of General Practitioners (GPs) suggest that **during the COVID-19 pandemic, 71% of routine GP consultations took place remotely, compared to around 26% face-to-face (a reversal of the figures in pre-pandemic conditions).** The trend for remote consultation is expected to last well beyond the current COVID-19 pandemic. In the UK, for example, the Royal College of GPs envisages a 50-50 split between remote consultations and face-to face meetings.

Figure 2 summarizes and illustrates these use cases for digitization technologies in the healthcare domain.

Figure 2: Use cases for ICT Technologies in health care environments
(Source: ABI Research)

MARKET PAIN POINTS AND SPHERES OF INFLUENCE

Having discussed the immense potential that the widespread adoption of ICT technologies, like 5G connectivity, artificial intelligence, smart wearables, extended reality technologies, and carriers for improving healthcare operations, the question to ask is why these technologies are not yet adopted on the large scale. To understand this, it is important to discuss current technology gaps as well as the role that external parties (such as regulators and public bodies) play in modernizing the healthcare communication infrastructure.

TECHNOLOGY GAPS

At present, the healthcare domain is characterized by a high degree of technology fragmentation, which prevents different domains from communicating efficiently with each other. The prevalent communication technology in hospital is using fixed line connectivity.

Relying on fixed line connectivity, however, imposes important limitations on the usability of automated communication in the real-life hospital environment. Despite the majority of patients being bedridden, a hospital still is characterized by a high degree of mobility; patients are frequently moved to different diagnostic procedures, to and from surgery theatres, or even between hospitals and wards.

Furthermore, connectivity in the healthcare domain as of today is characterized by a high degree of proprietary profiles and interfaces that are developed specifically for different healthcare domains. Figure 3 gives an impression of the different connectivity technologies present in a health care environment.

Figure 3: Connectivity Technologies in the Health Care Environment

(Source: ABI Research)

While there are initiatives to standardize communication technologies within healthcare domains, a common technology interface and cross-domain standards are currently missing. Furthermore, up until 5G, there has been no connectivity that could fulfill the stringent performance indicators required to address particularly life-critical use cases.

As patient healthcare data is highly sensitive, any solution addressing these technology gaps also needs to ensure full network integrity and data protection. Among everything else, this means that patient health care data should never have to leave hospital premises but should always be processed locally. This can be achieved by deploying a private cellular network, where communication is completely independent (and therefore protected) from any public network. It should be at the forefront of the industry, public bodies, and regulators to educate patients about these opportunities for secured data protection to increase the degree of trust in smart health care systems.

INFLUENCE OF GOVERNMENTS & POLICY MAKERS

One of the main challenges in modernizing healthcare infrastructure stems from the fact that benefits of a smart healthcare system are not directly monetizable (or easily translatable into cost savings), as the sector heavily influenced by public health insurance. Although the healthcare system of the United States is much less reliant on public funding than health care systems in other parts of the world, still 45% of health care spending is accounted for by public funding (representing 8% of the U.S. American GDP). As a result, the intrinsic motivation to advance towards a smarter, more standards-based health and social care system is limited.

Therefore, regulators and public bodies have a pivotal role in accelerating the adoption of ICT technologies towards a smarter, more efficient health care system. As the outbreak of the COVID-19 pandemic has painfully illustrated, health care systems across the globe are in desperate need for modernization to enhance the quality of medical care and increase the efficiency of delivery.

The support from public bodies for a smarter health care system can take different forms. Firstly, public bodies can release additional funding for investments into smart health care initiatives. The FCC's telehealth funding program can serve as prime example here: as of June 2021, the COVID-19 telehealth program awarded funding to more 539 applicants. It, therefore, has accelerated health care digitization initiatives in more than 500 instances. As the benefits of a digitized health care system (better quality healthcare, translating to lower number of preventable deaths) will over time reduce public health care expenditure (and therefore benefit the overall society), it is in the public body's interest to keep providing the funding opportunities to accelerate healthcare digitization.

Similarly, the French government supports healthcare modernization through the recently established "Pari-Santé Campus" project.

Providing financial means for investment, however, is only one channel through which public bodies can create external incentives for health care modernization. As the sector is tightly regulated, governments or regional public authorities can use their legislative power to instigate modernization. In Germany, for example, public authorities passed what is commonly referred to as "E health law", in 2016 to create an electronic health record for every patient that will collect and store all health care related files. While this will increase quality as well efficiency of individual consultation, a desire for such as system was never clearly voiced from within the healthcare professionals.

To address technology fragmentation, the Chinese government released universal standards for its 5G hospital networks, based on requirements defined through industry partnerships between the ICT industry and medical professionals. This standard outlines the guiding principles for a 5G radio access network (RAN construction between different hospitals to ensure seamless communication across the entire network). As a result, the deployment of 5G private networks in Chinese hospitals has noticeably picked up the pace.

WHAT NEEDS TO BE DONE

To modernize communication infrastructure for smart health and social care, a few aspects need to be addressed to maximize the potential benefits:

1. **Healthcare providers need to prepare their workflows and processes, so that they can digitize them easily and make optimal use of the efficiency gains. Not only does this entail streamlining different workflows to fit into a digital infrastructure, but also to solve the deeply rooted technology fragmentation between different health care domains and prepare each of them to converge to a universal technology.**

2. **Healthcare providers need to develop a common understanding needs to emerge from within the healthcare environment on the scope of a smart health care system. Specifically, this requires a common understanding of what data should be gathered, what they should be used for, where they should be stored and how they should be processed.**

3. **In line with observations discussed in section 5.2 regulators and public bodies need to provide favourable conditions for healthcare digitization and innovation to happen. Not only does this imply providing necessary financial means, but also (and arguably more important) providing a forum or platform for initiatives to emerge.**

IMPORTANT ROLE OF INDUSTRY COLLABORATIONS AND PARTNERSHIPS

To create applications and the necessary infrastructure for digital innovation initiatives, a thorough understanding of requirements and existing conditions in the healthcare domain is imperative. To acquire this understanding, industry collaborations are important, as these present the telecom industry as well as healthcare professionals or insurance companies with a fast and agile way to extend their knowledge base and design solutions. As such, collaborations and partnerships should be carefully orchestrated to ensure that these do not duplicate existing capabilities but create additional value for all partners involved.

To account for the specific role of public bodies and regulators as a motivator for health care digitization (as discussed in section 5.2), these partnerships should also extend to the public sector.

The joint venture between Orange, Capgemini, Sanofi, and Generali is prime example of how these collaborations can propel innovation in the healthcare domain, as it combines telecommunications expertise with system integrator capabilities (Capgemini) as well specific requirements from healthcare professionals (Sanofi) and insurance companies (Generali). By attaching this initiative to the "PariSanté Campus" project, it furthermore extends to the public sector.

In addition, broader industry-wide initiatives are needed to foster the exchange between public sector and private companies to create favorable conditions and provide the necessary infrastructure for innovation.

One successful example in this context is the 5G Infrastructure Public Private Partnership (5G PPP). Initiated by the European Commission as part of the Horizon 2020 program, it serves as the central interface for 5G related research initiatives between the public sector and private enterprises in Europe. To translate its research findings into actionable advice, the initiative is a catalyst for important early deployment projects for 5G enhanced public infrastructure. One of the most important 5G PPP projects in the health care environment is the 5G-Heart Project, which looks at innovative use cases for 5G in healthcare, transport, and food production industries and operates 5G testbeds in Finland, Greece, Norway, and the Netherlands.

While a lot of these initiatives are focused on a specific technology (e.g., 5G connectivity), this does not necessarily have to be the case, as industry collaborations can also adopt a wider, technology-agnostic approach. The TECH4ALL initiative, for example, was founded by Chinese infrastructure vendor Huawei to identify how different emerging technologies can be used to derive tangible benefits for everyone in support to achieve the United Nation's Sustainable Development goals (SDGs). As such, the initiative brings together key players from public bodies, non-governmental organizations (NGOs) with private enterprises from the technology industry and different vertical sectors to drive technology adoption. For health care enhancements, the initiative focuses their efforts on three main use cases: increasing access to healthcare (by increasing affordability and availability of health care services), telemedicine applications, and utilizing technology to improve medical research.

RECOMMENDATIONS & CONCLUSIONS

As this Whitepaper has laid out, emerging technologies carry an immense potential for enhancements within the health care environment. However, the degree of technology fragmentation, as well as a missing intrinsic motivation for modernization, are currently in the way of realizing this potential. However, even the smartest health care system is worth nothing if it is not used by its patients. Therefore, it should be at the heart of technology suppliers, healthcare providers, and public authorities to educate patients about the benefits of smart health care technologies and the underlying measures to ensure data and privacy protection to maximize their degree of trust. In addition, external parties need to accept their responsibility to ignite the necessary appetite for digitization initiatives in healthcare environments to happen:

To drive technology adoption in hospitals, doctors offices or care facilities, healthcare providers need to refine their understanding of the variety of enhancements that 5G connectivity, artificial intelligence, smart wearables and other technologies will bring to the healthcare system to be able to assess how these efficiency improvements translate into monetizable benefits.

Prior to deploying a specific on their premises, healthcare providers need to decide on the specific deployment option, using either shared spectrum or licensed spectrum directly from the regulator (where possible) or side with an MNO for network operation. Furthermore, healthcare providers need to be fully aware of the implications of each of these deployment options.

In order to accelerate the trend towards a smart and connected healthcare system, public authorities need to understand their responsibility in formulating unified regulations to provide the necessary unified framework that pushes healthcare provider (especially in the public sector) to deploy cellular connectivity for healthcare applications.

Public authorities need to understand, that the benefits of a smart healthcare system (better quality healthcare, translating to lower number of preventable deaths) will ultimately benefit the overall society. Therefore, to foster the adoption of smart and automated healthcare system, public authorities need to accept their responsibility to provide the necessary investment.

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Published July 2021

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