Making 5G Pay in Healthcare

How will 5G transform the future of healthcare?

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Can 5G provide healthcare with the digital boost needed to relieve the strain on practitioners and improve patient outcomes?

Similar to other developed economies of Europe and the US, the UK is experiencing severe strains on its health resources. Despite a growing economy, in the healthcare system the demand for medical services is growing year-on-year while budgets remain flat and there is constant shortage of skilled medical staff.

The environment is made more challenging by having to deal with an ageing population increasingly living with multiple chronic conditions that require repeated usage of the system. Efforts to apply technology to drive efficiency and improve services in the health sector are continually being deployed, but large scale technology transformations are made more complex by the diversity and scale of the system.

So, what relevance does 5G have for health in improving the quality of the outcomes, managing the demand for medical services and the tension between the demand and the available budgets? How can 5G be used to address some of these challenges? And what guidance should the key players in the health ecosystem follow to enable 5G to make a tangible impact in the medium term?

Recognising the profound challenges facing the sector, the National Health Service has set out its priorities in the Long Term Plan, released in January 2019. This plan puts technology transformation and widespread adoption of emerging technologies at the core of the reinvention of healthcare services delivery.

In the home:
People will be given control of their own health through increased availability of online tools. It's planned that over the next five years, every patient in England will have the right to choose telephone or online consultations either with their GP or a new digital GP provider.

In the community:
Integrated Care Systems (ICS) will take the lead – delivering the 'triple integration' of primary and specialist care, physical and mental health services, and social care – with an increasing focus on population health and local partnerships with local authority-funded services.

In the hospital:
Pressure on Emergency Departments and the flow of patients through wards and outpatient clinics will be reduced through better collaboration within the ICS, increased spending on social care and improved primary care through video or remote consultations. Care outside of hospitals will be boosted by delivering an expanding range of health and care services remotely or in social care settings. Also, by prioritising coordination between different healthcare organisations within a locality to ensure that people either get home or into community beds when ready to leave hospital.

5G is likely to play a pivotal role in helping realise a number of these objectives at scale, as it will enable the 'internet-ification' of the health system by making every aspect data-enabled. This is the next step to reap the potential of emerging technology advances, such as the internet of medical things (IoMT), massive internet of things (mIoT), artificial intelligence (AI), augmented reality (AR), virtual reality (VR), drones and robotics. This potential is already being recognised in the UK health sector as 5G trials are underway for connected ambulances and IoMT, and 5G skills are being added to the NHS team. This is the tip of the iceberg as 5G use cases will grow in relevance and application in all settings from the hospital to the home to the community.

25%
of the UK population will be aged 65+ by 2050, compared to 20% in 2018[1]

68%
of people in the 65+ age group are expected to be living with multiple chronic conditions in 2035, compared to 54% in 2015[1]

7%
average annual increase in the number of ambulance calls and 111 transfers between 2011-2016[1]

21%
of attendances at major A&E departments in 2019/20 (April to December 2019) missed the four-hour target from arrival to admission, transfer or discharge[1]

[1] National Health Service England statistics, National Audit Office, Office of national statistics, World Health Organisation statistics, PwC analysis, Grand View Research and National Institute of Health Research.

Connected-health technologies are already having an impact – but not yet at scale

Advances in connected-health technologies have already enabled healthcare providers to improve collaboration and communication, while also empowering new care delivery models that make access to care more convenient, such as remote patient monitoring, virtual care, robotics and telepresence.

With an estimated digital health market of over US$350bn[1] globally in 2025 and an estimated average annual growth of 22%[1], this has attracted a lot of attention from investors. However, the adoption at scale of the new solutions is difficult, because they are challenged by the complex demands posed by the volume, variety, and velocity of health information on today's communications networks. To improve the functioning of mission-critical applications and devices, and the simultaneous connection of large number of devices or simultaneous operation of multiple use cases, more sophisticated connectivity capabilities are required. This is where 5G can be an essential enabler, as it provides:

- ultra-reliable low-latency communications (URLLC), delivering faster response times to facilitate remote monitoring and control of medical machinery and ambulances for local and wide area connectivity;

- network slicing, enabling dedicated virtual instances of 5G connectivity with higher levels of reliability and availability in hospital settings;

- higher bandwidths using enhanced mobile broadband (eMBB), permitting real-time data gathering and analysis of 'heavy data' (such as 3D visualisations, VR and AR scenarios, and HD video-based analytics);

- massive machine type communications (mMTC), offering higher connection densities for IoT sensors and devices and offering greater security and reliability than a low-power/ wide area network; and

- enhanced energy efficiency, through reductions in the amount of power consumed by the base station antennae and connected devices.

These capabilities mean 5G enables a vast suite of new technologies that will unlock a wide array of new digital use cases in the health sector. Together, these use cases will help to improve patient outcomes, reduce the strains on the health practitioners, and transform the delivery of services to cope with ongoing increases in demand.

[1] Global Telehealth market 2018-2022, Global Digital Health Market 2019-2023, Technavio

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> **5G will unlock a large number of use case opportunities in healthcare from AI and AR/VR. What we are seeing now is just the beginning.**
>
> Rolf Meakin
> PwC Global Telecommunications Consulting Leader

5G connectivity features and what they enable

Enhanced mobile broadband

eMBB

Emerging technologies enabled by 5G

- Connectivity coverage, speed and number of connected devices
- Virtual reality
- Augmented reality

Massive machine-type communications

mMTC

- Industrial internet of things
- Advanced analytics powered by artificial intelligence and machine learning – ML

Ultra-reliable and low latency communications

URLLC

- Autonomous monitoring & robotics
- Critical mission data transmission
- Drone delivery
- Vehicle-to-everything communication

5G key features – comparison to existing connectivity over Fibre and 4G

	Speed	Throughput	Connection density	Latency	Reliability
5G	Up to 1 Gbps	1-20 Gbps	100 per part	1-10 ms	99.999%
4G	20-50 Mbps	300 Mbps – 1Gbps	12 per part	30-50 ms	99.99%
Wi-fi	1 Gbps	9.6 Gbps	8 per part	20 ms	99.99%

Definitions

- Speed: Expected practical speeds per user/device
- Throughput (bits per second): Theoretical maximum amount of data moved successfully from one place to another in a given time period
- Connection density: Number of connected devices per unit area
- Latency (milli-seconds): Delay between the sender and receiver of the data – the lower the latency the more 'real time' the experience of the event
- Reliability: How efficient the network is in transporting data between the source and destination without packet loss

5G-enabled use case families vary by setting

In the home

The home is at the beginning of patient care, and the most challenging setting in which to provide personalised care at scale. With virtually every citizen today having either smartphone or fixed broadband connectivity to the internet, they are increasingly demanding better access, monitoring and self-care.

The 5G differentiator?

5G will enable better connection of rural areas that are currently poorly connected to allow more treatment options, while also helping to accelerate innovation in telehealth to provide real-time monitoring and management of citizens in remote settings by carers, friends and family. The eMBB features of 5G are going to enable an expansion of access to care for people who would otherwise have to travel great distances to receive it. Patients with chronic or complex issues will gain the freedom to access their doctor remotely for advice. 5G connectivity will help address the potential impact of isolation or loneliness by enabling High Definition ('HD') video calls with other non-medical service providers as a realistic alternative to phone or video calls consultations with the GP only.

Digital health providers such as Babylon are already looking at the benefits of 5G for remote care. Separately innovation centres such as Livernerds Lab are testing a variety of digital technologies over 5G for example using sensors and VR to enable remote monitoring of important changes to a patient's health.

At the same time, the ability to use 5G for large data transmission to help monitor heartbeat, blood sugar and activity levels multiple times throughout the day will unlock more insights into the day-to-day health of patients. Continuous monitoring will be instrumental in transforming a largely re-active system to a pro-active one. This will help to ensure that more care can be delivered outside the hospital, and help to reduce the number of patients who turn up to Emergency Services and the number of hospital admissions. Recent examples of tele show the potential to significantly reduce the demand for A&E services and hospital admissions. Airedale NHS Foundation Trust, for example, has implemented a tele-medicine solution with a 24 hour video link between clinicians and patients/residents in 500+ nursing and residential care homes and thousands of residents with long-term conditions living in their own homes, indicated demand for A&E services and hospital admissions could decrease by up to 30%.

In the community

As most national health systems aim to decrease the burden on the emergency services and hospitals without negatively affecting patient outcomes, health and care organisations are exploring opportunities to implement population health management using advanced analytics and increase the role of the citizen/patient and community in managing personal health and re-balance the focus from reactive to preventive care.

The 5G differentiator?

5G's ultra-reliable, low-latency communication capabilities will drive a step-change in the effectiveness of medical responses in many ways. These advances will include, enabling connected ambulances that can provide on-site treatment via a video link to experts; ensuring better co-ordination between hospitals by sending patients to where they can be seen fastest and sending critical information about a patient's vital signs to prep the operating rooms well before the patient's arrival. In the UK, BT, the University Hospitals Birmingham NHS Foundation Trust and the South Central Ambulance NHS Foundation Trust have worked together to demonstrate a remote diagnostic procedure with paramedics linked in real time with surgeons and consultants using a 5G-connected ambulance. Similarly, as part of the Autoair 5G project, O2 and Samsung are working with the East of England Ambulance Trust on a trial of connected ambulances that will enable the paramedics to collect data and communicate remotely with consultants using on-board equipment.

The mMTC capability of 5G will open up more opportunities for population health management using analysis of massive volumes of historic patient data correlated with other external data sets to pinpoint trends across demographics and locations, and help national and regional bodies to make interventions quicker to prevent large disease breakouts or avoid the need for costly treatments. In Australia, Telstra, the national mobile operator, has initiated a National Cancer Register that is being combined with other data to help manage bowel and cervical cancer screening for the population.

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> **In the short term, 5G will make possible transfer and analysis of massive amounts of data and can truly change the ways primary care and population health management are delivered.**
>
> Oliver Bernath
> Partner, Consulting Health Analytics, Strategy&, PwC UK

In the hospital

As the population ages, the demands on hospital services will increase. This means the competing objectives of reducing treatment costs and improving patient outcomes are not sustainable without rethinking how medical services are delivered in the hospital, to enable higher throughput and better results and experiences for patients.

The 5G differentiator?

With its ultra-reliable, low-latency eMBB and mMTC capabilities, 5G will enable management of a massive number of devices and data simultaneously, opening the way to the use of IoMT, VR/AR and robotic applications at scale. This will help to improve treatment care outcomes, increase the efficiency of patient flows and enhance access to care, including:

- In-person – 3D anatomical rendering: holographic renderings can be used for training or studied by doctors prior to surgery/consultations to define precise treatment strategies to improve patient care.

- Via tele-presence – Assisted surgery: a surgeon can follow an operation on a high-definition video stream and offer live expert support, enabling more specialist treatment in smaller centres which may be constrained by recruitment issues.

- Via tele-treatment – Remote surgery: a specialised procedure is performed with the help of robotic-assisted surgical tools controlled from a remote location.

- Via tele-treatment – Remote therapy: a care professional can deliver therapy sessions such as rehabilitation exercises using VR for patients unable to attend in person.

- Via intelligent asset management – Bed allocation: the hospital bed occupancy status is transmitted in real time to the appropriate teams, including porters, cleaning teams, A&E and ward nurses, and also perform more regular checks of patient compliance with treatment plans.

Pilots are in progress for many of the 5G enabled use cases and some of the enabling technologies are already available. Robotic technology, for example, is already in use in hospitals to improve medicine delivery or to treat special case patients. One notable recent example is the treatment of one patient diagnosed with coronavirus by a robot doctor at the Providence Regional Medical Centre Everett in the US. Another example is the UK's first robotic hysterectomy performed in 2016 on a patient who had previously undergone a heart transplant.

Similarly, the Hospital Clinic de Barcelona is collaborating with Vodafone Spain, the online education portal called Advances in Surgery (AIS) Channel, 5G Barcelona and Mobile World Capital on pilots for real time remote surgery with the first assisted surgery delivered in 2019.

Digital healthcare - a dynamic multi-player ecosystem enabled by 5G

Healthcare ecosystem key players

Policy makers

- ✓ NHSE&I
- ✓ NHS Digital
- ✓ NHSX
- ✓ Other independent bodies

Commissioners

- ✓ Integrated care systems
- ✓ Clinical commissioning Groups

Medical services – Hospital

- ✓ Acute hospitals
- ✓ Community hospitals
- ✓ Mental health hospitals

	Use case family	Definition
1	Health and wellbeing self-management	Apps and wearables to allow citizens to manage their own health and achieve their personal wellbeing goals
2	Remote chronic diseases monitoringw	A service that provides real-time monitoring and management of citizens in a remote setting by carers, friends and family
3	Digital front door	Digital platform that enables access to end-to-end healthcare services, from initial contact to diagnosis and treatment, by providing services such as digital consultations, managed prescriptions and a personal health record
4	Streaming patient vitals High resolution diagnostic Remote diagnostic	Real-time data transfer of images, video, and healthcare-related large amount of information from clinical-grade devices, providing clinicians information for faster and more accurate remote diagnosis and advice or for the preparation of the operating theatre before the patient arrival
5	Remote treatment	Tele-healthcare enabling remote consultation, remote patient monitoring and remote management of patient's equipment
6	Intelligent asset management	Digital management and tracking of hospital assets, staff and patients using Industrial IOT technology making it easier to control capacity, automate operations and take patient-centric decisions
7	Technology assisted treatment such as assisted surgery, remote surgery	5G-enabled AR/VR and robotic applications, helping to improve treatment care outcomes, and the precision and reliability of procedures, including surgical ones
8	Technology assisted diagnostics	Exploiting the possibilities of AI, AR/VR and advanced devices will transform diagnostics to enable more accurate and quicker diagnoses and deliver better outcomes
9	AR/VR enabled training	Skills building in the medical arena can be enhanced through 5G by providing greater access to simulation activities.
10	Population health management advanced analytics	Use of massive amount of data to support improvement of population health management

Use cases require 5G capabilities that cannot be delivered with current technologies

Use cases can be delivered using current technologies with 5G like capabilities, but might impact other connectivity services, 5G will enable roll-out at scale

Use cases can be delivered using current technologies, 5G could act as substitute where required connectivity services not available

6 7 Operating theatre

10 Advanced analytics centre

9 Training unit

Smart Community hospital

2 6 Ward

3 Pharmacy

Smart Acute hospital

8 X-ray room

Medical services – home and community

✓	Primary care networks
✓	Ambulance trusts
✓	Care homes
✓	Other providers

Device manufacturers

✓	Wearables
✓	Medical equipment
✓	IoT
✓	VR/AR

ICT Providers

✓	IT
✓	Edge
✓	Telcos
✓	OEMs

Value of 5G	Latency	Reliability/availability	Bandwidth/through put	Mobility
⌒	◔	◔	◔	◑
⌒	◑	◑	◔	◑
⌒	◔	◔	◔	◔
📶	◑	◑	●	●
📶	◔	◔	●	●
📶	◑	◑	●	●
📶	●	●	●	◔
📶	●	●	●	◔
📶	●	●	●	◔
📶	◔	◔	●	◑

● High demand for this performance feature of 5G ◀——— ◑ ———▶ ○ No demand for this performance feature of 5G

Smart hospitals – 5G will enable the digitalised hospital

What is the healthcare challenge being addressed?

Today, UK hospitals are challenged by poor interoperability between systems, analogue processes and inefficient management of assets. In combination, these issues disrupt patient flows and create pressure points in A&E and operating theatres. For example, 21% of patients spent over four hours in A&E in 2019/20 (April – December), and one million patients are estimated to receive delayed transfer of care each year in UK hospitals.

Furthermore, the existing communication technologies such as Wi-Fi are not well equipped for handling activities, such as large data transfers and multiple connected devices transmitting clinical information. Given the critical need to improve medical response times, it is vital for hospitals to rethink connectivity as a key enabler of improved patient outcomes.

What does 5G enable?

5G in the hospital will be the 'amplifier' for bringing to life use cases with high requirements in terms of devices, network availability, data and processing. Examples include using AR/VR for holographic renderings or doctor training simulations; AI/ML for deep analysis of medical imagery; and IoT for widespread tracking of connected hospital assets. It will also significantly speed up the transfer of medical data within the hospital setting, freeing up valuable face time between patients and medical staff.

What outcomes are expected?

The results will include improved healthcare outcome, an improved patient experience through reduced waiting times, and a reduction in medical staff bottlenecks through access to the right information on patients and assets at the right time. This will also release staff to perform more value adding activities and attain a greater work experience and work-life balance.

What implementation challenges need to be overcome?

Adoption of these technologies will be challenging, due to competing investment demands and hospitals' varying levels of maturity in their technology transformations. Furthermore, aside from the constraints imposed by the maturity of the technology platforms, medical machinery and the regulatory requirements, applications such as remote surgery will only truly take off with widespread investment in surgical robots and upskilling of surgical staff.

Connected ambulances, using 5G, will enhance emergency care outside the hospital

What is the healthcare challenge being addressed?

The NHS is facing a continuing increase in demand for ambulance services and significant shortages of staff. Between 2011 and 2016 ambulance calls and 111 transfers rose by an average of 7% a year. Furthermore, more than two thirds of calls could not be solved on site and the patients needed to be conveyed elsewhere.

What does 5G enable?

5G's high reliability and low latency will make high-resolution, real-time video conferencing and data transfer between ambulance and hospital a reality. The improved communications will extend diagnostic and treatment capabilities from the hospital to the emergency site, redirecting response types towards more cost-effective models. 5G's capabilities will also enable better data exchange between the emergency services and hospitals during conveyance, as well as better fleet management. These impacts will reduce inefficiencies in patient transfer, freeing up ambulance resource to respond to more patients through faster turnaround.

What outcomes are expected?

The results will include improved patient outcome and experience, improved medical staff experience and more capacity in the ambulance service.

What implementation challenges need to be overcome?

Practical and widespread use of 5G across the NHS will be hindered by factors including high capital barriers in upgrading or replacing the existing fleet, the need for more widespread 5G coverage to achieve national scale, reduced capabilities until the emerging enabling technologies and required devices reach a more advanced stage of development and the skills gaps of paramedics to operate advance diagnostic equipment. Use cases such as high-resolution data transmission, remote diagnostic and surgery will be critical to the potential value that can be generated.

Challenges to overcome to realise the full potential of 5G in healthcare

The 5G-enabled digitisation of the healthcare system is a highly complex and multifaceted transformation – one that realistically will take many years to truly revolutionise service delivery when launched at scale. It could take even longer without careful navigation of the top five challenges that may stall the implementation of 5G, hindering the sector's long-term goals. In health, now more than ever, collaboration is key.

1. **5G should be at the heart of the digitisation roadmap to help the NHS achieve its long-term priorities**

There are a number of key digitisation opportunities that can be delivered over existing connectivity solutions such as 4G and Wi-Fi. A combination of competing investment demands, the relatively low maturity of many healthcare providers in their technology transformation journey and the fact that many 5G solutions have not yet been tested at scale could lead to the NHS taking a short-term view of its technology roadmap. This could place further strains on existing connectivity solution as multiple digital use cases are run at the same time. The NHS should focus on the short-term digitisation agenda but invest in 5G functionalities to avoid rework and delays later, by working with the 5G ecosystem players in test beds to explore and test each use case.

2. **Workforce upskilling and culture shift are needed to boost digital adoption and overcome emerging innovation fatigue**

Medical professionals and staff are said to be experiencing innovation fatigue, with some technology initiatives failing to prove their value. Strong leadership that drives the digital agenda and is aligned between all NHS systems is fundamental to improving the adoption rate of new technologies and digital processes within healthcare organisations. It is important for leaders to sponsor repeated efforts to digitally upskill staff and patients, using human-centred design principles to get them involved in early stage trials to help change the culture and effect higher rates of adoption for medical staff and patients.

3. **True collaboration is required between the NHS, connectivity players and other key emerging players**

The diverse nature of the technologies that must be brought together to create a workable solution in healthcare means that no single organisation has all the required capabilities. This means drawing on specialist knowledge from across the rich ecosystem of partners including hospitals, device manufacturers, sensor developers, connectivity providers – patients/citizens and more.

Robust, trusted partnerships are essential and require new ways of thinking about partnerships, and a more hyper-connected, dynamic form of ecosystem engagement.

To facilitate the degree of required collaboration, the NHS may need to revise its procurement and partnership policies. History suggests that the unwieldy scale and structure of the NHS has contributed to many business models failing to capitalise on this market and deliver the promised outcomes. Let's not allow history to repeat itself when it comes to 5G.

Separately, the key emerging players in healthcare from the private sector need to define the role they want to play within the new value chain. They must base this decision on realistic business cases, and have the courage to propose innovative models for sharing risk and reward, and clear responsibility for delivery and commercial risks.

4. **Impact of the new 5G enabled business models on the end-to-end healthcare eco-system**

New business models to deliver the use cases that 5G enables are already emerging and will transform the way medical services are delivered. Babylon Health, for example, provides digitally enabled GP services over existing connectivity to patients opting in to their services and leaving their current surgeries. They are also exploring the potential benefits of 5G for remote care. Innovative businesses like these bring clear benefits for patients but their broader impact on the healthcare eco-system needs to be carefully evaluated to prevent unintended consequences around funding, adoption rates and longer term care outcomes.

5. **Additional regulation, standards, frameworks and solutions are needed to enable interoperability, end-to-end security and data privacy**

Emerging business models enabled by 5G will require new regulatory standards and frameworks to govern a complex environment with:

- changing interoperability requirements between legacy and 5G technologies and devices, and between existing and new data platforms and providers;

- end-to-end security needs for prioritised critical or vertical segment use cases, examples of leading security-by-design practice, and defined parameters for tests and trials; and

- technologies that are nascent in their development such as cloud, AI, sensors, IoMT require testing, acceptance and promotion by the relevant healthcare bodies; periodic revision of the testing and acceptance regime is required to take account of the complexities of new platforms and devices.

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