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eHealth takes off

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Dear Readers,

In this tenth edition of “u” we delve into a particularly timely topic: the global healthcare sector and the potential that wireless technologies and the Internet of Things have to give it a facelift that is both vitally important and long overdue.

Despite the vast and varied challenges that the global COVID-19 pandemic has brought upon us, there is ample ground for optimism. Repeatedly, we have seen how in times of crisis innovation and technological adoption go into overdrive. And we are seeing it again, across industries. We are living through a societal, technological, and economic inflection point that is unlikely to be undone, even once the pandemic subsides.

In these pages, we peer into the future of healthcare and explore the many ways it will be transformed by digital technologies. In our expert interview, we dissect the wireless technologies that will make the transition possible and take stock of the barriers that are holding it back. We investigate how smart, reliable, and secure wireless communication and services will become indispensable as data takes on a growing role in diagnosing disease, streamlining healthcare delivery, cutting costs, and keeping medical supply chains running smoothly. And we look at how increasingly sophisticated consumer and medical devices will improve our health and wellbeing.

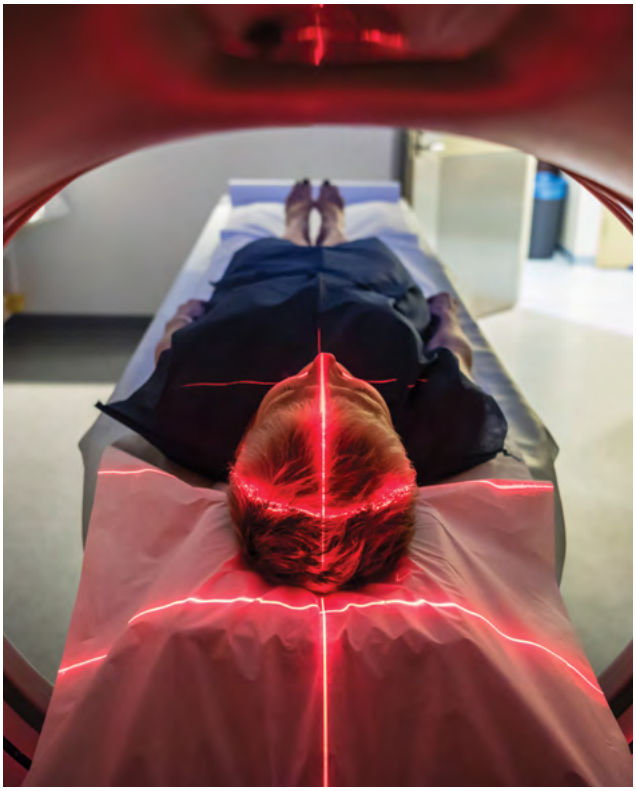
In these extraordinary times, we would like to thank you, our loyal customers across all sectors. Not only for your continued trust, but also for the ingenious ways in which you deploy our technological solutions to make the world a better and more sustainable place.

We wish you good health, and a smart and enjoyable read!

Sincerely,

Thomas Seiler, CEO

Content



7 The eHealth revolution: Vitally important, long overdue

14 Flattening the curve

The eHealth revolution: Vitally important, long overdue

Without extensively digitizing our healthcare systems, meeting growing demand – sustainably - will remain out of reach.

In a perfect world, COVID-19 would not have caught us off guard. Instead, we would have detected the first cases using artificial intelligence, sounded the alarm, and triggered a carefully orchestrated cascade of events: Data on patients and the virus would have been made available to stakeholders across the healthcare sector, driving a globally coordinated response. Those infected, and everyone else, would have been instructed on how to protect themselves and to contribute to slowing the spread of the disease. Healthcare facilities would have seamlessly transitioned patient flows to isolate those infected from the rest, and replaced human workers with robots wherever possible. And like hospitals, social life, commerce, work, and the industry would have been prepared to adapt to the new normal.

In that perfect world, we'd already be at the tail-end of a full digital overhaul of the healthcare system. Not with sci-fi technologies such as 3D printing of live organs, the full reversal of paralysis, or gene-editing babies, but simply with technologies that are already available today: dedicated smartphone applications, telecon-sultations, electronic patient records, widespread adoption of wearable medical sensors and connected medical devices, hospital robots, highly secure Big Medical Data, and perhaps even transport drones. Thanks to their data-driven response and open and transparent communication, governments, guided by science, not politics, would have gained the trust of their citizens, who would be eager to contribute to halting the spread of the virus to keep it from morphing into a full-blown pandemic.

An obvious question remains: would such a technocratic utopia be desirable? Compare it to where we stand today. After initial attempts to contain the virus in Wuhan, China, the virus spread to all four corners of the globe. Some countries, in particular those affected by the SARS outbreak in 2002-2003, responded on cue, successfully quashing the virus through aggressive testing, quarantining, and contact tracing. Others failed catastrophically, causing infection rates to surge for months to come. At the time of writing, almost 40 million cases have been diagnosed, close to 30 million have recovered, and over one million have died from the disease as its hotspots have traveled from Asia to Europe to North and later South America. These numbers are likely dwarfed by undiagnosed cases of the disease.

"Digital technologies can address many of the weaknesses of today's healthcare system."

A stress test for the global healthcare system

While it is far from over, COVID-19 has been a harsh stress test for the global healthcare system. And, let's face it, it came out humbled. Not that that should have been a surprise. Despite tremendous victories over the past decades – eradicating smallpox, reducing child mortality, including in the developing world, making AIDS a largely manageable disease, and improving the survival rates for cancer to name a few – healthcare services are, by and large, seldom described as a paragon of high quality, efficiency, equity, affordability, and accessibility. Yet, according to an assessment of the impact of the digital transformation of health services by the European Commission (EC), these five points describe the goals they should aspire to.

According to the World Economic Forum, the pandemic revealed a number of gaps in global healthcare systems, in terms of funding, access, a shortage of healthcare workers, and insufficient research capacity to develop a coronavirus vaccine without hampering ongoing research into other pressing health challenges. In an article published in the Journal of Public Health, researchers have lamented that the pandemic exposed the "hollowness" of the notion of equity and collaboration between the Global North and South. And fissures opened by the pandemic left scars outside of the healthcare sector as well, contributing to the rise of the Black Lives Matter movement in the US, fueling social movements in South America, and uniting an eclectic mix of activists in anti-mask and anti-lockdown protests in the world's capitals. When the healthcare system coughs, society catches a cold.

Digital technologies can address many of the weaknesses of today's healthcare system at every step along the patient journey, with an estimated global economic impact of $1.6 trillion by 2025 according to McKinsey. They offer new ways to connect patients with their caregivers, to improve acute care by directing patients' immediate needs away from overfilled emergency rooms to online consultations, and even to move care away from hospitals and clinics to people's own homes. They can help patients with special needs reclaim lost autonomy, and encourage patients to play a more active role in their own health and wellbeing.

Why technology has failed to stick

What, then, has kept the healthcare sector from adapting to the digital age? In a podcast by McKinsey recorded before the pandemic, two of the firm's senior partners took stock of the challenges facing global healthcare systems. From one side, they argue, healthcare systems are confronted with societal and demographic challenges of an aging population and the shift from infectious diseases to long-term chronic conditions often caused by a poor lifestyle – diabetes, cardiovascular and neurological diseases, cancers, and obesity. From the other, they are under pressure due to the constantly rising cost of care, partly explained by the shift in prevailing pathologies, but also by the rising costs of treatments and personnel.

In the healthcare setting, they argue, the competitive pressures that forced other industries to modernize and adopt technologies to increase their efficiency have failed to act, be it for

emotional or pragmatic reasons. Consequently, more affordable and efficacious treatments often failed to replace well established yet more expensive ones, effectively disrupting the technological disruption that leads to efficiency increases in other industries.

Scaling up local successes

Accelerating the pace of technological adoption in healthcare is critical. But because of the way we are wired, it's also a hard sell. As Matthew Herper, a columnist at STAT News, put it: "We tend to overreact to problems that are facing us right now but underreact to long-term threats that build slowly. [...] We panic, but we don't prepare." Face masks are a case in point. Toilet paper is another.

But prepare we should, and not just for the next pandemic. With the abundance of technological solutions that are already available to alleviate pressure on the healthcare system, improve the quality of care, realign it with today's needs, and bring down costs, the sector's digital transformation is vitally important and long overdue. Not only in developed countries, but in the developing world as well. A collection of isolated pilot studies and full-scale deployments scattered around the globe show how locally applied technology has already improved healthcare in both expected and unlikely places.

On our roads, for example. The EU has mandated that all new types of cars produced after 2018 feature an emergency call system, eCall, that automatically sends vital information such as location, the direction of driving, and the number of passengers to emergency services in the event of an accident. It is expected to save thousands of lives each year by speeding up emergency response. Or on our wrists. In Scandinavia, it is increasingly becoming expected for people with dementia to wear GPS trackers to keep family members and caregivers informed on their whereabouts when they leave their homes. These trackers, like those worn by lone workers, are typically equipped with inertial fall-detection sensors that can send out alerts in the event of an accident.

Around the world, the COVID-19 pandemic saw the adoption of teleconsultations and other forms of virtual care surge, as people seeking medical help stayed clear of medical facilities for fear of contracting the disease. In India, there was a 500 percent increase in teleconsultations in the early months of the pandemic, 80 percent of which were first time users. As a result of

positive experiences, support for telehealth and mobile health has increased throughout this initial phase of the pandemic, to where it has become palatable to a majority of those surveyed, if not their preferred channel.

Ground-based and airborne robots have proven themselves in a variety of medical use cases. Today, drones are regularly relied on to fly blood to remote sites in Rwanda and India, AIDS tests to clinics in Malawi, and quarantine-related supplies in China. Hospital robots disinfect rooms, replenish supplies, and lug clean linens to patient rooms. And care robots can support disabled or elderly patients at home or in the clinic, while robotic avatars can let bedridden patients, old and young, partake in social activities and school classes.

In any other sector, solutions that demonstrably improve the quality of service while cutting costs would flourish. For reasons we've already outlined, this hasn't been so in healthcare. But if the COVID-19 pandemic has shown us anything, it is that, when pressed, we are able to find the societal willingness and the financial means to overcome our resistance to change and adopt new solutions.

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With new technologies come new opportunities

Ever since the advent of information technology, analog and then digital sensing, wired and then wireless technology, the healthcare sector has, at least at the margins, sought to leverage these to its benefit. But the current confluence of innovations, their affordable cost, and their increasing ubiquity across society have changed expectations. Whereas in the past, they would have been seen as futuristic enhancements to a well-established system, today, it's the absence of digital initiatives to improve the sector's efficiency and performance that can seem difficult to wrap one's head around.

How is it, for instance, that in this day and age many medical professionals still take notes on paper, which they later have to transcribe in digital form, before storing them on closed servers? Instead, they could directly take notes using smart devices, from where they would be aggregated with all other relevant clinical information in electronic health records (EHR), also referred to as electronic medical records (EMR). These could be securely shared between medical professionals within and across clinics to facilitate collaboration, allowing easy access to up-to-date, complete information on patients, and assisting in the delivery of faster diagnosis and safer care with fewer medical errors. Efficiency gains could further let medical staff spend more time treating patients and less time taking care of administrative tasks, in the best case leading to overall cost reductions.

Then there are distributed ledger technologies (DLTs), which offer a means of securely managing databases of interoperable electronic health records while ensuring the privacy and confidentiality of sensitive data. Additionally, by formalizing the governance of personal health records, DLTs could act as a framework to manage consent and permissions for data use, making patients the ultimate owners of their own health records. Most implementations do not store the healthcare data in the ledger, but rather metadata regarding ownership of and access rights to that data, be it for care or for medical research. The need for such technology will only continue to grow as users capture and eventually hope to mine an increasingly rich and diverse health dataset for insights.

As artificial intelligence algorithms become increasingly capable, they too will find broad application across the healthcare industry, with the main benefits falling on robot-assisted surgery, virtual nursing assistance, and administrative workflow assistance by 2026, with a total savings potential estimated at US$ 269.4 billion, according to an article published in Forbes.

Rather than replacing human caregivers with AI, it's far more likely that AI will augment the current medical workforce by supporting diagnosis, decision making, and medical interventions.

And just as artificial intelligence augments practicing medical professionals, mixed reality could transform medical education, allowing students to explore human anatomy through the practice of virtual dissection. Doctors could use it as a powerful communication tool to explain surgical procedures to patients. And in the operating theater, surgeons could rely on mixed reality to guide them through complicated interventions. Researchers from the German university of Duisburg-Essen have also evaluated the potential of augmented reality to help employees correctly deliver first aid in the event of workplace accidents – a concept that could easily grow out of the workplace and into a more diverse set of scenarios.

The road to the future is rocky

The opportunities digital technologies present to improve the delivery of primary care are huge. Still, the obstacles that need to be overcome are considerable. Some of the pushback is coming from within the establishment. Doctors are often reluctant to accept the increased transparency in terms of cost, quality, and performance that a more digital healthcare system would bring. And because of the opaque pricing schemes used today, those well versed in long-established procedures have little incentive to switch to more modern ones, even if they are cheaper. Ultimately, as a report on promoting a digital transformation in healthcare by McKinsey points out, going digital would require leaders in the pharmaceutical and medical technology industry to reassess their culture and mindset, their organizational structures, and their governance.

There's resistance coming from outside the establishment as well. Often, it's customers who, not always without reason, lack trust in national health authorities or feel uncomfortable with having their entire medical history stored on a database, where it could become the subject of the next big data leak to make the front pages. The security, privacy, and confidentiality of their data is not something they take lightly. And resistance comes in other forms as well. One point discussed in the McKinsey podcast referenced earlier on is that the recipients of healthcare are often uninterested in studying available options and appear at the clinic willing to follow the first course of action that they are presented with.

Systemic issues are at play as well. For all the benefits they may bring in increasing the transparency, availability, and the quality of healthcare, the financial return on investment that they deliver is not yet clear. With healthcare budgets constantly under pressure, finding ways to get a positive ROI will be essential to boosting the adoption of digital healthcare technologies, in particular in less wealthy countries. As a result, the digitization of healthcare could deepen the digital divide between developed and developing countries. According to an OECD report, development finance could play a critical role in strengthening health systems that have been weakened by the ongoing pandemic.

"The ongoing transition from volume-based to value-based healthcare is demonstrating how digital technologies and new healthcare models can achieve a positive ROI."

The ongoing transition from volume-based to value-based healthcare, seen, for example, in the US, is demonstrating how digital technologies and new healthcare models can achieve a positive ROI. Rather than compensating doctors for the treatments they prescribe in a fee-for-service model, value-based healthcare ties fees to measured patient outcomes, with the objective of improving performance metrics and reducing healthcare cost. Data sensing and analytics are the key enablers of the assessment of clinical outcomes that these approaches build on, as are well defined, standardized quality metrics that outcomes are measured against.

Without good governance, good digital healthcare will remain elusive. Building trust in national authorities is always difficult. With poor governance, it's all but impossible. The same is true for tasks such as aligning demands and requirements from relevant stakeholders to build and run a secure and interoperable nationwide electronic health record database. Or for bringing down the costs of medical procedures and essential, life-saving drugs, and for managing available medical resources, be it personal protective equipment, hospital beds, intensive care units, or medical specialists nationally or internationally. It's encouraging that the World Health Organization reports that 58 percent of its member states have an eHealth strategy and that 87 percent of them have already implemented at least one national mHealth initiative. How much countries are ultimately able to benefit from the digital revolution of their healthcare systems will likely be predicted by how well they are governed.

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Hard-earned achievements will likely pay off

In a world that is more connected, volatile, uncertain, complex, and ambiguous than ever, being able to adapt nimbly to changing circumstances, be it a slow-moving demographic change or a fast-moving crisis, will only become more essential. For all the suffering it has caused, the current pandemic may turn out to be a shot across the bow, a warning call that will force us to get serious about putting health on the global agenda and preparing for potentially worse calamities that lie ahead. If, as a result, we move boldly, not blindly, closer to the perfect world described in the opening, with a public health system that is eager to innovate and integrate new ideas to improve service while bringing down costs, we may not have to wait for future generations to thank us. We'll thank ourselves. ■

Flattening the curve

How secure and reliable wireless technology can bring relief in this and future pandemics.

The current pandemic is a battle of technologies. On the one side is a complex, non-living biomolecular compound – a virus – capable of the archaic yet highly sophisticated genetic technology of data storage, host infection, and parasitic replication. On the other side, there's us, who, too, have a vast technological arsenal at our disposal that builds on age-old societal strategies, such as refraining from physical greetings, physical distancing, and quarantining. Our medical technologies, including drugs, genetic testing, and artificial respirators continue to improve year on year. And since the dawn of the digital era, we've had a new category of technologies: digital technologies and, subsequently, data. These, we're rolling out and testing for the first time against a global pandemic.

What the post-pandemic world ends up looking like will depend to a large degree on how successfully we wield this newest arrow in our quiver. To understand its importance, simply imagine the pandemic without the internet and the myriad innovations it spawned: smartphones, the cloud, the Internet of Things (IoT). Without instant messaging, video calls, and social media, lockdown would have been more socially isolating, and home office far less productive, perhaps even pointless. And on the medical front, we would have had to make do without our growing knowledge base and our ability to tease out insights in real-time from statistics that health authorities put out. Our ability to manage scarce resources, develop treatments, and bring a viable vaccine to market would be handicapped.

One thing is certain: for all the benefits they've so far brought to our fight against COVID-19, we're still far from using digital technologies to their full potential. For one, the gains they

can deliver are tied to their levels of adoption. And while they are sufficiently widespread to enable many applications, such as digital contact tracing, adoption is still too low for these applications to play any more than a supporting role. At the same time, scaling up adoption to sufficient levels will quickly use up available wireless bandwidth. And because the data that the digital technologies capture and process are stored in separate systems that interface poorly with each other, much of the insights they hold remain out of reach. Connecting datasets would, however, increase their value to hackers, raising the demands on data security and privacy.

"For all the benefits they've brought to our fight against COVID-19, we're still far from using digital technologies to their full potential."

Still, the promise digital technologies have shown so far is clear, as is their potential for helping us combat the pandemic and adapt to the new reality that awaits us once we're over the hump. From optimizing detection, diagnosis, and follow-up to enforcing social distancing and enabling contact tracing, all the way to helping us keep the economy and our social lives going, digital technologies could become a saving grace in this pandemic. And, if we play our cards well, lessons learned this time around could prove invaluable in future calamities that befall us.

Detection, diagnosis, and monitoring

It's a little-known fact that artificial intelligence was the first to send out an alert that something was brewing in the Chinese Wuhan region, and that it could spread from there. As reported in WIRED, a Canadian health monitoring platform, BlueDot, beat both the World Health Organization and the US Centers for Disease Control and Prevention to the punch by about a week. Fast-forward almost a year, and dozens of technological applications to detect, diagnose, and monitor the disease have emerged.

At the first sign of symptoms, patients have multiple communication channels at their disposal to seek advice on next steps. While the precise mix of channels depends on their location, they typically include standard

telephone helplines, virtual video consultations, and AI-powered chatbots. National health authorities and local healthcare providers, media outlets, and tech giants have also set up online information portals presenting official recommendations and up-to-date information on the outbreak. In short, thanks to the abundance of communication channels, those seeking information can find what they are looking for.

Countries that had been exposed to highly contagious and lethal viruses in the recent past were quick to respond by setting up countrywide detection, diagnosis, and monitoring infrastructure. A number of Asian countries that had set up contingency plans in the wake of the SARS outbreak in 2003, the H1N1 influenza outbreak of 2009, or the MERS outbreak in 2015, mounted a fast response. In Korea, for instance, drive-thru COVID-19 testing centers were quickly set up across the country, delivering results only hours after the nose swab was conducted. Transparent communication and an online tracking system of those infected helped contain the virus. The successful responses in Singapore, Hong Kong, and Taiwan are rife with lessons for Western countries.

"Countries that had been exposed to highly contagious and lethal viruses in the recent past were quick to respond by setting up countrywide detection, diagnosis, and monitoring infrastructure."

To assess the virus's impact at the city-level, researchers have turned to a foul-smelling proxy. Sewage, which has previously been analyzed to estimate such things as recreational and medicinal drug consumption, contains genetic sequences stemming from the coronavirus. The concentration detected can then be used to estimate the actual infection rate of the local population. These data can be fed into epidemiological models to make predictions of where the next hotspots might be and help to efficiently allocate medical resources.

But now that millions of people have contracted and largely recovered from the disease, an alarming trend is coming to light: a significant percentage of recoverees continue to show symptoms long after the peak of the infection has passed, from fatigue to headaches to shortage of breath. Mobile health applications present a valuable tool to follow the progression of the disease once the initial acute phase of the virus is over. And in August, the MIT Technology Review reported on a group of "COVID long haulers," people with lingering health problems stemming from COVID-19 infection, who got together using electronic messaging platforms to collect data and study their condition themselves.

Social distancing and contact tracing

Viruses have a host of strategies to spread from one human to another. In the case of COVID-19, the main pathway of contagion is via airborne transmission, for instance via droplets that are sprayed out with a cough. What makes it uniquely complicated to rein in, however, is its capacity to spread pre-symptomatically. Research shows that among the most effective means of slowing the spread of the disease is wearing a face mask in public. It might disappoint tech enthusiasts to learn that the combination of physical distancing, quarantining, and contact tracing using analog solutions were already relied on in some form half a millennium ago, when syphilis, the bubonic plague, and other pests ravaged continental Europe. But today's wireless technology is making their effective implementation simpler and more efficient.

Enforcing physical distancing is up to each of us. But for employers that don't want to take risks, technological tools can help ensure that their employees are following the rules. Polte, operating out of the US, has, for instance, developed a 4G LTE or 5G lanyard that sends out an alert when employees come too close to each other, while also giving them the possibility to report unsafe working conditions to their employers with the push of a button. According to a report by CNBC, Amazon has tested a device featuring

a LED light and an audio system that signals an alert when workers are too close to each other. And companies eager to limit liabilities are using AI-powered image analytics to show that rules are being followed.

“What most contact tracing apps have in common is that they use Bluetooth technology to monitor and record the proximity and (anonymized) identity of nearby users.”

But if there is one area where IoT technology has been in the limelight, it is contact tracing. While analog contract tracing becomes impractical when too many people are affected, digital contact tracing, typically using a smartphone app, actually improves as the population size grows. In countries such as Singapore, where the use of contact tracing apps was strongly encouraged by the government, and in Korea, where private developers enhanced the functionality of the government’s official contact tracing app, adoption levels were high, potentially contributing to the more successful pandemic response when compared to many European and American countries.

What most contact tracing apps have in common is that they use Bluetooth technology to monitor and record the proximity and (anonymized) identity of nearby users. If one user is diagnosed with COVID-19, all app users having spent too much time in their proximity are informed that they are at risk of being infected, asked to self-quarantine, and requested to have themselves tested. Where the apps differ is in how the data is stored, and who has access to it. Some countries have favored a centralized

approach with more control, while others have adopted a decentralized approach that gives up some control in exchange for increased privacy and confidentiality.

Keeping society and the economy going

Should we focus on stopping the virus or on saving the economy? It's a question that cities, states, and countries have been asking themselves since the early days of the pandemic. But what if that's the wrong question? According to a Bloomberg article published in June, countries like Sweden, and US states including Arizona, Arkansas, and South Carolina, which loosened their lockdowns in a bid to save the economy, actually fared worse than those that kept restrictive measures in place for longer. Rather than it making it a choice between one or the other, the focus should be on finding ways to rein in the pandemic while minimizing long-term harm to the economy and, ultimately, adapting to a new normal, which just might involve finding ways for the economy to thrive despite it. Here, technology will, no doubt, play an important role.

In fact, it already has. If you are reading this, it's likely that you, too, spent several weeks or months working from home earlier this year. It turns out that, at least for white-collar workers, being physically present at the workplace is much less essential than previously assumed. By harnessing virtual meetings, online access to corporate servers, and collaborative work tools, productivity-losses have been minimized. Not only that, in many cases, remote work has led to savings, with lower occupancy in the office, less travel, and almost no conferences or other events. According to the World Economic Forum, many of us may never return to our pre-pandemic habit of driving to and from the office for our daily nine-to-fives. The office won't fade into oblivion; its role, however, will not be the same as before.

But the situation was different for white-collar workers and medical professionals – the "essential" workers who were regularly applauded by the rest of us during the lockdown. In hospitals, factories, warehouses, supermarkets, work continued, with more or less stringent measures in place to protect workers. Anticipating the new normal, industries are moving to automate more and more of their processes to better deal with worker shortages caused by the pandemic and future crises. In a survey by McKinsey, nine out of ten questioned were planning to grow their in-house digitization talent, outlining planning challenges (e.g. in sourcing, supply chain management), operational challenges (e.g. in enabling remote work, protecting the workforce, increasing efficiencies, improving quality), and delivery challenges (e.g. in logistics, warehousing) as their main target areas. And, while the growth of IoT device shipments has slowed, unsurprisingly, shipments of IoT devices for the healthcare sector have not.

"While the growth of IoT devices shipments has slowed, unsurprisingly, shipments of IoT devices for the healthcare sector have not."

A dress rehearsal for the next crisis

The result is a dramatic acceleration in preparedness, on all fronts, for the next waves of this pandemic – or for new pandemics that are still in store. At the time of writing, we are still fighting fires, responding to increases in cases by tightening restrictions, from limiting crowd sizes to extending the use of face masks to ever more scenarios, and then loosening them again when numbers subside. Rinse and repeat until enough people have gained immunity to stop the spread of the virus, either by having been infected or thanks to a vaccine. But moving forward, governments, healthcare workers, and businesses, who have been focused on responding to the pandemic, will be forced to direct efforts at adapting to it.

Judging based on the successful responses to the current pandemic on the part of countries that were most traumatized by past ones – SARS, MERS, H1N1 influenza, etc. – lessons learned the hard way have a good chance of sticking. ■

eHealth

When logistics saves lives

In the healthcare and medical sectors, the quality of logistics can spell the difference between life and death.

The right product, delivered to the right person at the right time, unblemished. Tick all four boxes and you have a successful logistics operation. Get one wrong, and you're likely to hear complaints. But it's one thing when an online delivery gets sent to the wrong doorstep. If a blood transfusion, a beating heart, or vial of vital vaccine gets switched up, lost, damaged, or delayed, the consequences can be dire. Valuable, life-saving resources are wasted and patients left waiting. When the stakes are so high, simply trusting the logistics chain is sometimes not enough. Harnessing wireless sensing, reliable and secure data communication, and satellite-based positioning, the IoT can help ensure that logistics saves lives.

Tracking blood from donor to patient

Blood transfusions are a poignant example. According to a World Health Organization (WHO) factsheet on blood safety and availability, 118.5 million blood donations are collected globally each year. Once carefully labeled with the patient's ABO blood group and Rhesus factor, this blood is typically either stored and then transfused to a patient unaltered, or it is broken down into its constituent components, including red blood cells, platelets, and plasma, before being delivered to patients in need.

Whole blood needs to be stored between two and six degrees Celsius. Any colder, and it can cause fatal bleeding or renal failure once delivered. Warmer and it can become a viable home for harmful bacteria. To avoid losing their blood clotting availability, platelets, on the other hand, have to be stored at a warm 20 to 24 °C, while plasma, the fluid that carries the blood cells, has to be stored frozen at -25 °C or less until it is thawed. These temperatures need to be guaranteed not only at the blood bank, but also during transport from the blood drive to the analytics lab, or from the blood bank to the patient, during which the blood bag can rack up hundreds if not thousands of kilometers.

A complex, far-reaching supply chain

In such a complex supply chain, many things can go wrong. Every step of the process is prone to temperature exceptions caused, for instance, by power outages or errors in handling. With every minute that the blood products spend outside their ideal storage temperatures, their quality deteriorates and the risk they present to patients goes up. And while receiving the wrong blood type is rare, with around four cases per million units of blood transfused, it can have potentially life-threatening consequences.

Solutions that leverage the Internet of Things aim to track blood and create a continuous data trail of its journey from the donor to the patient. EY Canada and the Canadian Blood Services have, for instance, put out a proposal to combine the strengths of the IoT with the Blockchain to this effect. The approach banks on the proven strengths of IoT sensors in asset tracking and condition monitoring to gather relevant timestamped data, and uses the Blockchain as a decentralized and virtually immutable platform to manage the visibility and security of the collected records. Other initiatives, such as one developed by Swedish-based Tridentify, include smart blood bags that automatically log data in real-time.

Not challenging enough? Try organs!

If transfusing blood sounds tricky, try transplanting a live kidney, spleen, or even a beating heart! In what has been described as one of the most complex procedures in medicine, all of the challenges of getting blood from a donor to a patient are compounded. In addition to matching the blood type between donor and patient, the donor and the recipient need to be about the same size. Because organs can only survive for about four to 48 hours outside the body, depending on the organ, donors (often deceased) and recipients need to be in the same geographical area, in particular for hearts and lungs. And because such a match is so rare, doctors are unlikely to get a second chance at a transplant. The replacement organ has to be in perfect condition prior to the surgery.

As with blood, IoT-based solutions are being relied on to ensure that organ transplants are delivered on time and intact. According to an investigation by Kaiser Health News and Reveal from the Center for Investigative Reporting, between 2014 and 2019 there were around 170 transplant-ready organs that had to be discarded. More than twice as many were classified as near misses due to delays in transport.

According to the report, kidneys and livers, which are less time-sensitive than hearts and lungs, often travel as standard cargo in the belly of commercial airliners, with no way to follow them in real-time.

As in the case of transporting blood, wireless connectivity and satellite-based positioning have the potential to bring transparency in these situations. Solutions such as TransMedics's Organ Care System offer a means to track the location of critical organs and monitor their condition while *en route*. This is in addition to other tasks, such as controlling the biomimetic properties of smart transport boxes that are used to keep hearts, lungs, livers, and other organs alive via a user-friendly interface hosted on wireless smart devices.

"Harnessing wireless sensing, reliable and secure data communication, and satellite-based positioning, the IoT can help ensure that logistics save lives."

Straight as the crow flies

Whenever blood, organs, or biological tissues are being shuttled from a donor to a recipient, they are racing against time. In places with poor transport infrastructure, such as rural Rwanda, drones can already look back at a four-year history of delivering blood to hospitals, unhindered by potholes, traffic, and, for that matter, curves. The drones, which are guided to their destination using a GPS-assisted autopilot, fly to the delivery point, drop off the cargo by parachute, and return to their home base, saving precious minutes, and lives.

More recently, there has been increasing interest in using autonomous flying vehicles – drones – for organ transport, with the potential of making these critical operations safer, faster, and more reliable. An article published on the website of the United Network for Organ Sharing (UNOS) shows not just what this would look like, but how it is already playing out in practice. The first drone-delivered live organ landed at the University of Maryland Medical Center in 2019. Now the approach has been proven to work, and drones are finding use in a growing number of medical use cases. It's safe to say that we should expect big things to come!

Immunizing the world

Of the many challenges that will face us in the coming months, developing and then distributing a COVID-19 vaccine will be among the most formidable – and the most pressing. Over 170 teams of researchers working towards a safe and effective vaccine, eleven of which, at the time of writing, are in phase 3 clinical trials. Supply chains are being strengthened to be able to swiftly ramp up the production of those that prove their value. And, to save time, production facilities are being erected ahead of time to produce a so far unknown product.

The objective: 7 billion vials of vaccine. 14 billion if it requires two doses. Add another 20 to 30 percent to make up for losses during transit and storage, and you end up with a mind-blowing 19 billion vials, as estimated by the World Economic Forum (WEF). Swiftly addressing COVID-19 would take five times the number of vaccines produced in 2018, and that in addition to the 3.5 billion vaccines needed to prevent non-COVID-19-related diseases.

The logistics required to deliver them will be unprecedented. The sheer numbers are one thing. According to the International Air Transport Association (IATA), shipping 7.8 billion doses of the vaccine by air would require 8'000 747 cargo planes. Keeping the vaccine intact until it reaches the recipients is another challenge. The type of vaccine that makes the cut will ultimately determine the specifics of the distribution process, but it's highly likely that it will require a rigorously controlled cold chain. And, according to an article by PWC, ensuring the integrity of

the products at every step of their journey will be vital. Every year, €150 billion to €200 billion worth of counterfeit pharmaceuticals, including vaccines, are sold globally. With the world in dire need of a COVID-19 vaccine, there will likely be a fierce market of fraudulent, and potentially unsafe, inefficacious vaccines to contend with.

Ensuring the equitable delivery of a vaccine to people around the world will require a global logistics system that can provide real-time tracking with high integrity and shared data access. According to WEF, this set of challenges makes it a perfect fit for distributed ledger technology, for instance, the Blockchain. As they report, Blockchain-based solutions that could store the location, state, and entire transport history of each and every vial of the vaccine are already under development, with a vast infrastructure of IoT devices and reliable and secure data communication as vital enablers.

Our generation's space race, on solid ground

Whether it is to deliver blood, a beating heart, or billions of vaccines, ensuring the reliability, integrity, and transparency of logistical operations can save lives. With the convergence of unprecedented technological opportunity and unprecedented global need, the logistical conundrum that is the COVID-19 vaccine delivery could well turn out to be our generation's space race, only this time, right here on earth. Once proven, the technologies, platforms, facilities, and networks that helped us end the current pandemic might diffuse into every other aspect of our lives in the same way that space travel brought us some unlikely, yet widespread offshoots, such as wireless headsets, adjustable smoke detectors, and artificial limbs. ■

eHealth

Always on call

Ten ways eHealth applications and wearables will make us healthier

If you are reading this, there's a good chance that your digital healthcare journey is already well underway. Not convinced? Are you wearing a fitness tracker that tracks your heart rate, your steps, or your sleep? Do you use your smartphone to track your calorie or caffeine intake, your meditation practices, or your menstrual cycle? Or do you send pictures to your family doctor or insurance company using a messaging app before heading out for a face to face consultation? These examples might seem banal. They aren't. They're harbingers of a deep-reaching transformation that we will see play out over the coming years.

Typically, we only see our doctor a few times a year, most often when we need acute care. What if, instead, you could have your vital signs checked every day, or even every hour? With health and medical sensors on your person, day in, day out, 24/7, that becomes a reality. Wearable health devices are already enabling a long list of eHealth applications, and the pipeline of new ones is even longer. And as remote health applications mature, they are graduating from gadgets and gimmicks to effective enablers of a healthy lifestyle, with a growing number of wearables receiving approval for medical use.

1. Early detection and management of neurodegenerative diseases
Despite their growing prevalence in an aging population, neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's disease still lack a cure. Catching them early, however, can help slow down their progression, while continuous monitoring with targeted interventions holds promise to enhance the life quality of those affected. Researchers are developing multiple approaches based on smart devices such as smartwatches to develop a "digital phenotype" of neurodegenerative diseases – e.g. the slowing of a patient's gait, reduced heart rate variability, and other biomarkers – that, combined, could help clinicians catch dementia and other neurodegenerative diseases early on before they cause serious harm.

2. Fall detection
On the World Health Organization's list of leading causes of unintentional injury death, the simple act of falling ranks second. Of the close to 650'000 victims it claims each year, the vast majority are elderly people. And that doesn't even factor in those who survive only to deal with the long-term consequences. Falls are also a threat at the workplace, in particular when they affect lone workers, for instance, pipeline inspectors who work on their own and, in the event of an accident, might have to wait hours or days to be found. But they are a problem with a technological solution, in the form of wirelessly connected smart devices that are capable of first sensing a fall and physical inactivity, and then sending out a call for help using wireless connectivity. Solutions range from mainstream commercial products such as the Apple Watch to dedicated devices.

"Wearable health devices are already enabling a long list of eHealth applications, and the pipeline of new ones is even longer."

3. Mental health chatbots
Stuck in a rut? Anxious? Depressed? Already today, smartphones can bring relief, connecting sufferers of mental health issues with chatbots programmed to deliver cognitive behavioral therapy. Based on research out of Standford, Woebot is a taste of things to come as psychiatry, smart devices, artificial intelligence, and counseling merge into ever more powerful solutions. Already today, the app, which is continuously under development, has proven to be effective in reducing anxiety and depression. Similarly, AI bots such as Mitsuku are being used to tackle the loneliness epidemic that is rampant, particularly among the elderly population. With the demand for therapy outpacing supply, and many still unwilling to see a therapist because of the associated stigma or cost, connected solutions could contribute to ensuring that everyone has access to therapeutic support.

4. Wearable air quality tracking
We all know that prolonged exposure to air pollution is harmful. But given that most

pollutants are invisible, and many non-odorous, steering clear of airborne toxins is far from obvious. Leveraging low power, low-cost sensors for fine particulate matter and volatile oxidative compounds, new connected consumer devices continuously have their nose out to detect the concentration of these noxious pollutants. Whether they are wearable, such as the NotAnotherOne's Atmotube, or otherwise portable, such as Plume Labs' Flow, these devices send notifications straight to your smartphone or smartwatch, while at the same time contributing to a crowdsourced map of real-time air pollution information.

5. Allergen detection
According to foodallergy.org, in the US alone, allergies send someone to the emergency room every three minutes. And as more and more developing countries industrialize, the share of the population affected with food allergies keeps getting larger. Because most allergenic compounds are well identified, it was only a matter of time before a portable solution was developed to detect them on your plate. The Allergy Amulet, still under development, promises to detect allergens in connected samples in about a minute, before your soup gets cold, displaying results in a dedicated smartphone app.

6. Thwarting a silent killer
Because it has no easily apparent symptoms, high blood pressure, a common antecedent of cardiovascular diseases such as coronary heart disease and cerebrovascular disease, is often referred to as a silent killer. As cardiovascular diseases are the leading cause of death globally, the growing number of wearable solutions targeting cardiovascular health is hardly surprising. In 2018, the Apple Watch became the first consumer wearable to be cleared by the US FDA for electrocardiogram monitoring. AliveCor's Kardiamobile is a smartphone add-on that can detect a variety of heart rhythm anomalies. And Swiss-based aktiaa has developed a cuff-less blood pressure monitoring device that can create an uninterrupted blood pressure record to diagnose hypertension before it does any harm.

7. Diabetes Management
Digital technologies have already made major contributions to making diabetes more manageable. Connected wearable blood glucose meters can track blood glucose levels 24/7 and send them to the cloud via a nearby smart device. Patients can request to automatically receive alerts when they need insulin or sugar, and even notify loved ones and caregivers when predefined thresholds are exceeded. And already today, connected insulin pens can automatically dispense the exact amount of the hormone required to stabilize blood glucose levels in a closed loop requiring no manual intervention. Once a tedious ordeal, diabetes management has already become simple enough for children born with type 1 diabetes to manage the disease themselves, albeit with supervision, from an early age.

8. Sleep analysis
The vital importance of regularly getting a good night's sleep to one's wellbeing and the risks of not doing so are only now becoming appreciated by both the medical community and the public at large. Insufficient sleep has been linked to an increased incidence in everything from cardiovascular disease, diabetes, weight gain, cognitive decline, neurodegenerative disease, compromised immune function, and even cancer, as well as societal and economic consequences due to lost productivity, accidents, and healthcare costs associated with treating them. The combination of connected sleep sensors, smartphone applications, and machine learning algorithms are transforming and democratizing the study of sleep, spurring the development of new tools to deliver sleep interventions to those suffering from insomnia and diagnose and address other sleep-related issues.[1]

9. Stress and fatigue monitoring
Whether you're driving a car, a truck, or heavy machinery, performing surgery, or working on a construction site, excessive stress and fatigue can have dire consequences. Solutions such as Ellcie's smart glasses are designed to detect fatigue in drivers by monitoring their blinking rate,

[1] https://www.nature.com/articles/s41746-020-0244-4.pdf

how frequently they yawn or let their head drop, and the temperature inside their vehicle, and send them a warning. In France, they can even automatically connect drivers to a call center for a chat that will keep them awake until you reach their next stop. Researchers are also developing stress monitoring patches that combine several biological signals, including skin temperature, skin conductance, and pulse waves to determine stress levels in real-time. By linking such a solution wirelessly to a smartphone, those wearing the patch could receive alerts when they would be better off taking a break.

10. Brain stimulation

And finally, wouldn't it be great if we could put our mind into the perfect state for whichever activity is next on our agenda? OmniPEMF's NeoRhythm headband promises to do just that, and it has two, albeit small double-blind placebo-controlled trials to back up its claims. By stimulating the brain with a pulsating magnetic field tuned at the right frequencies, the NeoRhythm headband is said to improve sleep, promote relaxation, boost energy levels, support recovery, strengthen immunity, and even reduce pain. ■

eHealth

The digital transformation of hospitals

Squeezed for resources by the ongoing pandemic, hospitals are dialing up innovation to increase capacity.

Hospitals are full of contradictions. Within their walls, cutting edge CAT scanners coexist with archaic-looking orthopedic mallets and bone saws. Patients turn to them for recovery, while their often overworked staff burn the candle on both ends. They employ the world's leading medical researchers, but are, when it comes to process, typically slow to innovate. They require highly aseptic spaces, yet they harbor some of the most resistant bacterial strains. And while their importance to human flourishing is generally recognized, their budgets are constantly under threat of being cut.

Even in normal times, hospitals operate under conditions of scarcity, in terms of medical personnel, money, space, and time. But, as should surprise no one, these are not normal times – especially not in hospitals. Confronted with a pandemic that defies comparison in our lifetimes, yet that experts have been warning about for decades, hospitals – like the healthcare sector as a whole – have been forced to grapple with a reckoning: they weren't as prepared as they could have and, arguably, should have been.

This shock therapy is accelerating the move to digitalize healthcare that has slowly been building momentum since the advent of the modern computer in the 1960s. Pushed by multiple drivers including the aging population, the rise in non-communicable diseases caused largely by poor lifestyle choices, and financial constraints, and enabled by the rise of wireless sensing and communication and cloud storage and analytics, this digital transformation will profoundly impact who goes to hospitals, how hospitals operate, and even how they are built. Here are some of the most important trends we see emerging.

Care is moving closer to home

The benefits of remote care and telemedicine are well known. According to an analysis on virtual care by Deloitte, they can (i) improve clinical outcomes, (ii) enhance the patient experience, (iii) expand access to patients and clinicians, (iv) reallocate costs and improve efficiency, and (v) enhance care coordination, improving outcomes and saving billions. But it took the visceral fear of contracting a sometimes lethal virus to make them palatable to the broad public.

In China, where the government launched the electronic medical insurance system, which covers virtually-delivered healthcare services to improve the efficiency of the healthcare system in 2019, remote consultations shot up 50-fold in the first month of the pandemic compared to one year prior. Meanwhile, US consumers also reported a marked shift in their willingness to use telehealth going forward, with eleven percent of those surveyed having used telehealth in 2019. Going forward, 76 percent are interested in adopting the technology.

This wholehearted embrace of virtual channels of communication marks an undeniable societal inflection point – one that will not easily be undone even when the level of alertness due to COVID-19 subsides. Accenture predicts that post-COVID, one in three consultations will be carried out virtually. These new channels will also be critical to implementing other eHealth solutions, transforming the relationship between patients and caregivers.

These include ambient assisted living solutions, which offer elderly individuals and those with special needs a "lifeline" they can rely on in an emergency, such as Leikr's solution presented in the Partnership section of this magazine. Physiological monitoring using body-worn sensors can offer early warnings for neurological diseases, sleep issues, or other ailments that patients can address following their doctor's recommendations. And remotely monitoring patients at home using connected biological sensors can free up much-needed hospital beds when demand surges.

Robots are moving in

We are used to seeing white-robed doctors and nurses roam hospital corridors. Robot assistants are still a relatively rare sight. But that, too, is changing, again driven by the pandemic-induced squeeze for resources. More and more robot helpers are stepping in to help with tasks they are able to carry out quicker, more safely, or with less whining than flesh and blood staff.

In a hospital in Antwerp, Belgium, patients suspected to have contracted COVID-19 were greeted and given a preliminary medical

assessment by a robot who directed them to the department based on their symptoms. Similar robots were deployed elsewhere as well, such as in the Circolo Hospital in Italy, where patients could use the robots to interact with doctors via a touchscreen.

Disinfection of hospital rooms is another activity that is perfectly aligned with hospital robots' skillsets. Companies such as Danish-based UVD Robots have developed a Wi-Fi-connected autonomous ground vehicle with a powerful UV-C ultraviolet light that can quickly and efficiently reduce the spread of viruses, bacteria, and other pathogens. Clinically tested and verified, the robots have logged extensive mileage in numerous hospitals around the world.

Other tasks that robots are being enlisted for include delivering food, medical supplies, and fresh bedsheets, with new use cases requiring more dexterity emerging as the robots gain in sophistication. Moxi, developed by Diligent Robotics, has an advanced robotic arm whose dexterity rivals that of humans, allowing it to collaborate on tasks otherwise reserved for humans. And drones, essentially robots with wings or rotors, saw their deployments soar during the pandemic, for instance delivering medical and commercial cargo in China's Wuhan and Hebei Provinces and delivering patient samples to testing labs in Ghana.

Nothing and no one gets lost

It's easy to lose track of patients, personnel, and equipment within a hospital's labyrinthine floorplan. According to a 2018 survey by nursingtimes.net, nurses spend close to 40 hours each month tracking down equipment. The same survey suggests that around one time in six they fail to find what they were looking for. With medical personnel perpetually strapped for time, this is hardly a sustainable state of affairs.

That's why more and more hospitals are turning to technology to keep tabs on people and things within their walls. While RFID tags are being used to automatically track inventories and ensure that supplies are replenished on time, Bluetooth-enabled real-time indoor location services are solving the problem for hospital staff, beds, and other mobile assets. Delivering accuracies from the room level (using standard Bluetooth beacons) down to sub-meter levels (using more recent Bluetooth direction-finding technology), these solutions leverage fixed antennas to display the location of tagged staff and equipment on digital maps of their premises.

By combining Bluetooth-based indoor location data with additional data sources, Finland-based Quuppa offers innovative ways to improve compliance for hygiene measures such as hand-washing, as well as social distancing to reduce the spread of infections. As the technology becomes pervasive in the medical environment, new applications to increase patient safety, optimize process efficiency, and free up time for better care are bound to emerge.

Scribbles are making way for digital data

Among the ongoing wave of technological innovation, electronic health records are likely to top the list in terms of their overall impact. Doctors' patient records have traditionally been paper-based, often confined to a single site and, in keeping with the popular stereotype, impossible to decipher. While essential to monitoring the status of each patient in a specific case, assembling, processing, and storing patient records was time-consuming, error-prone, and insecure, resulting in patient data that was opaque, difficult to share, and tedious to learn from.

If meticulously managed, electronic health records, by contrast, make the totality of a patient's medical history immediately accessible to their caregiver via a connected device, such as a computer, a tablet, or even a smartphone. The advantages of the approach become even more apparent when patients are transferred from one department within a hospital to another, or from one hospital to another one. Furthermore, should patients be willing to share their health records in an anonymized form for research, researchers can mine the data in search of clinically relevant insights into diseases.

Because of the highly sensitive information they contain, electronic health records have long been the grounds for privacy concerns – and rightly so, as there have already been several highly publicized leaks, some counting millions of records. For this reason, electronic health record databases are required to comply with locally applicable standards and regulations. Currently, these vary from region to region, again restricting their applicability.

Hospital buildings are evolving too

The continuum of care, the distribution of labor, and logistical processes within hospitals are evolving to reflect the ongoing trend of digitalization at the same time as lessons from the ongoing pandemic are sinking in. In light of all this change, there's no doubt that hospital buildings themselves will evolve as well. Pandemic

facilities, already well established in Asian countries following their experience with the 2002-2004 SARS outbreak, are likely to become mainstream in hospital architecture, which will have to be made generally more flexible and adaptable to respond to outlier events such as the one we are currently living through.

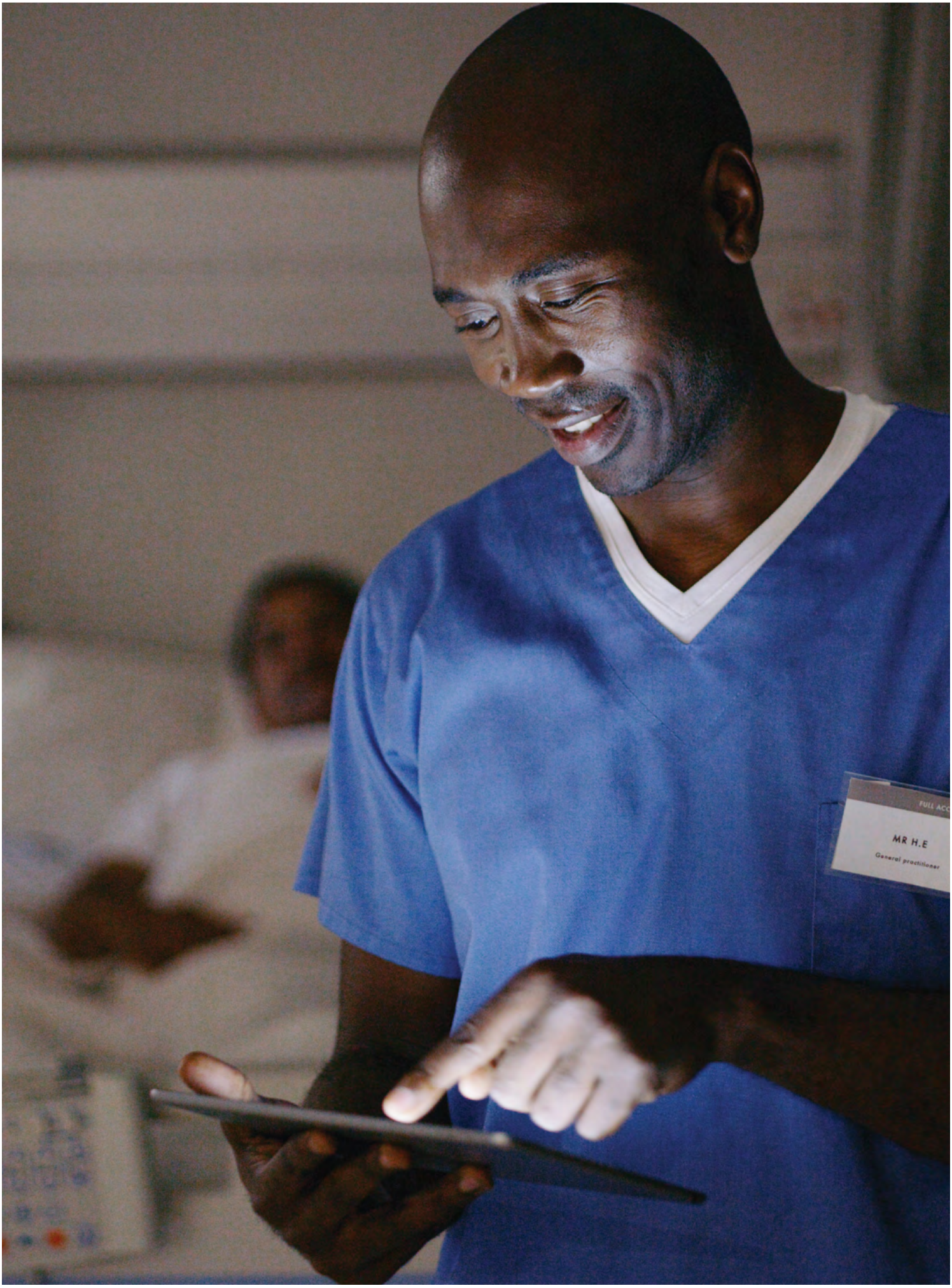
"By dialing up innovation at all levels to improve efficiency with smartly leveraged technology, at least some of the scarcity could be alleviated."

As the proportion of care delivered virtually increase, healthcare providers will find advantages in centralizing the reams of real-time digital information in command centers such as AdventHealth's "Mission Control." Bringing together data from across its network of patients and facilities, this command center lets them better optimize their scarce resources and improve the quality of care their patients receive. Such centers are likely to achieve similar goals within hospitals, for instance using GE Healthcare's "Wall of Analytics."

And while we're accustomed to seeing helicopters take off and land on rooftop heliports, hospitals will likely need to upgrade their designs to include a drone port, in particular as these unmanned aerial vehicles take over a bigger chunk of logistical operations. And as we've seen earlier, tightly integrating this new technology into the inner workings of our hospitals could unleash an additional wave of technological and business model innovation in applications that go well beyond healthcare.

Innovating to increase capacity

Ultimately, the current squeeze for resources does have a silver lining: hospitals, and the healthcare system as a whole, and being forced to step up their technological infrastructure. By dialing up innovation at all levels to improve efficiency with smartly leveraged technology, at least some of the scarcity – in particular that of time and money – could be alleviated. ■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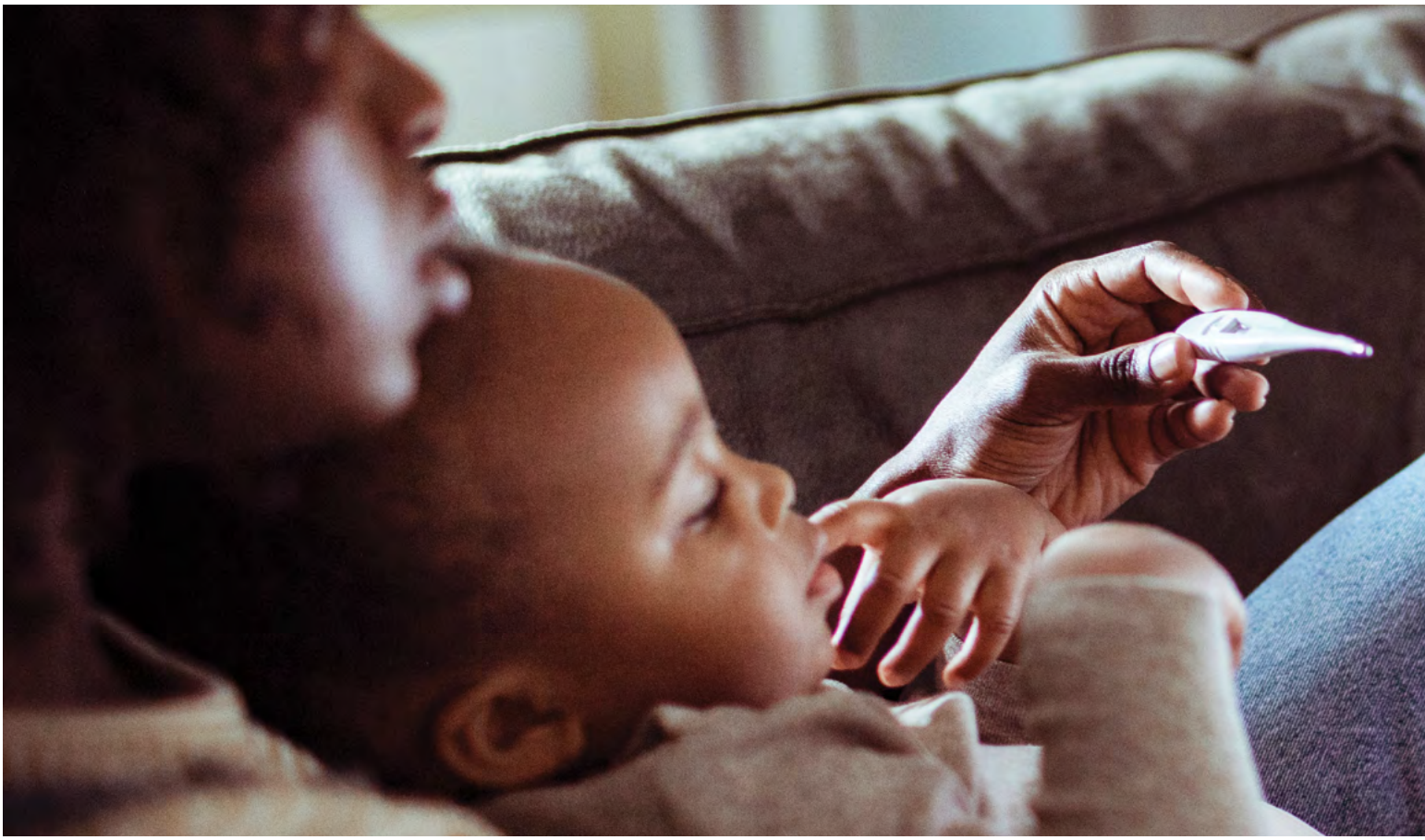
General practitioner



Enabling technologies

Emerging technologies in eHealth

Better, smarter, safer care – emerging technologies are transforming healthcare on multiple fronts.

Healthcare is fertile ground for digital innovation. In fact, it's hard to come up with a single facet of healthcare that technology cannot improve. In search of a replacement kidney? An online registry could efficiently match donors with those in need of a transplant. Afraid of spending the last years of your life in a retirement home? Smart home technology, assisted living solutions, and virtual health services can extend your autonomy by years. Need more human interaction with your healthcare provider? Digitalization can take over time-consuming, impersonal administrative tasks and free up their schedule.

Across the sector, new ideas are taking root. The transformation is being driven by fast-paced advances in wireless connectivity, data sensing, and edge, fog, and cloud computing, as well as by improvements in the abundance, availability, and analytics of data. And while uptake of digital technologies has been slower in healthcare than in other markets, the ongoing COVID-19 pandemic has demonstrated how quickly patients and healthcare providers are capable of adopting new technologies when adoption is the only viable option.

In what follows, we'll take look at five problems we're likely to face far less often than today, and the technologies that will help us get there.

Lost, then found

Misplaced, delayed, and lost items (and, sometimes, people) are common and pernicious speedbumps across the healthcare industry. Imagine the gains to everyone involved if all the hours waiting for shipments, looking for devices, and tracking down patients and personnel were put to productive use. And while it may seem illusory, there is a technological solution to the problem that is feasible today but has yet to be implemented on a large scale.

Seamless positioning combines multiple technologies to offer a location service that delivers the best available position estimate regardless of an object's or person's location. Outdoors,

it could use satellite-based positioning when available, combining it with course-grained cellular network fingerprinting cellular technology-based positioning, or, when available, finer-grained 4G and 5G-based positioning approaches that locate receivers by analyzing signal travel times to nearby cell towers. Dead reckoning solutions leveraging inertial sensor measurements could further improve accuracies and bridge transient gaps in coverage.

"Seamless positioning combines multiple technologies to offer a location service that delivers the best available position estimate regardless of an object's or person's location."

Indoors as well as outdoors, cellular network fingerprinting could be augmented with Wi-Fi access point and Bluetooth beacon fingerprinting for increased resolution. And when extremely high positioning accuracy is required, Bluetooth-based direction-finding can track down devices to where they are on a shelf, granted that the required dedicated infrastructure is available to enable the new angle-of-arrival or angle-of-departure indoor positioning approaches.

With low power wide area (LPWA) connectivity growing its footprint by the day, and satellite-based cellular connectivity on the horizon, it's only a matter of time before seamless positioning solutions let the healthcare industry benefit from equally seamlessly tracking solutions.

A guiding light

Expertise is valuable, presumably because it is so difficult to acquire. It will likely remain so until we develop brain-computer interfaces that let us download expertise from the internet like Neo in the movie Matrix. Know-how, on the other hand, is easier to share, and what better way than by having it explained visually, in person.

Ultra-reliable low latency cellular communication is slated to roll out in the coming decade as part of 5G cellular networks. As a result, augmented reality (AR), in which images are overlaid over the physical world, and virtual reality (VR), in which the physical world is blended out entirely, are likely to experience a flurry of innovation. The outcome will be increasingly sophisticated solutions that are perfectly suited to a host of healthcare applications.

Surgeons, for instance, will one day be able to practice complex operations virtually before heading to the operating theater. Once there, they could be guided through the entire procedure visually by an image projected onto smart glasses or, potentially, straight onto their retina. And surgeons won't be the only ones to benefit. Medical students in training could enjoy highly immersive physiology courses in which they dissect virtual subjects. And laypeople at the scene of a medical emergency could receive on-the-spot training to help resuscitate a victim, deliver a baby, or care for an open wound.

With sufficient reliability and low latency, the same technology could eventually make it unnecessary for surgeons to be in the same rooms as their patients. Rather than operating directly on their patients, they could do so via the intermediary of a surgical robot. It may still take years for remote surgery to become mature, but, eventually, the hype will give way to actual implementations.

It's mine!

It's no wonder that people are sensitive to health data privacy and confidentiality issues. Already today, medical records have a going rate of up to $1000 on the darker corners of the internet. According to an article on Security Boulevard, stolen healthcare records can be used to make fake medical claims, extort the victims by threatening to make public damaging information, or engage in other forms of identity theft.

But as more and more data is aggregated on the same platforms – and the trend will only accelerate as 5G gains traction – these concerns will only become more justified. The reason is clear: there's only so much information to be gained from studying, say, someone's heart rate. But

combine that with body temperature, motion, shopping habits, and medical records, and others can quickly know more about you than you would feel comfortable sharing.

"End-to-end security, from the sensor to the cloud, is one vital element in ensuring that data is not intercepted or otherwise tampered with."

It's unlikely that the push towards increased sensing, aggregation, and analytics will reverse anytime soon. Finding a way to square the circle of making data available while at the same time protecting security and controlling who has access to it will only become more important. End-to-end data security, from the sensor to the cloud, is one vital element in ensuring that data is not intercepted or otherwise tampered with.

Distributed ledger technology (DLTs) of which the Blockchain was one implementation, is another. DLTs have made strides in terms of their maturity in the years since the hype around them peaked. According to a report by consultancy Deloitte, the Blockchain will have a transformational impact on the healthcare sector, with a prime application area being digitalized health data. In particular, platforms based on DLTs can be designed to ensure that data is stored securely, in an interoperable format, with patients in full control over who does what with their private data.

A brain and then some

Sometimes, simply getting the question right is the hardest step in solving a problem. When our human capacity is stretched to its limits, technology can potentially come to the rescue, in the form of artificial intelligence. Considered as having the most transformative, far-reaching impact on the healthcare sector by many, artificial intelligence will soon assist humans in myriad ways. As Dr. Bertalan Meskó a.k.a. the Medical Futurist puts in on his vlog, artificial intelligence will be the "stethoscope of the 21st century," and it will become widespread faster than we can prepare for.

Artificial narrow intelligence, the subclass of artificial intelligence that relies on machine learning or deep learning to "teach itself" a very specific skill, will be exploited across the healthcare sector. By analyzing millions of data points, including medical imagery, written patient records, and scientific research, artificial narrow intelligence will outperform doctors in analyzing radiology images. It will usher in an era of precision medicine, when treatments are tailored to the unique genetic and behavioral properties of each individual, rather than to the standard average human being. And it will revolutionize the painstaking process of drug creation, from the initial design of active compounds to the clinical trials used to test them.

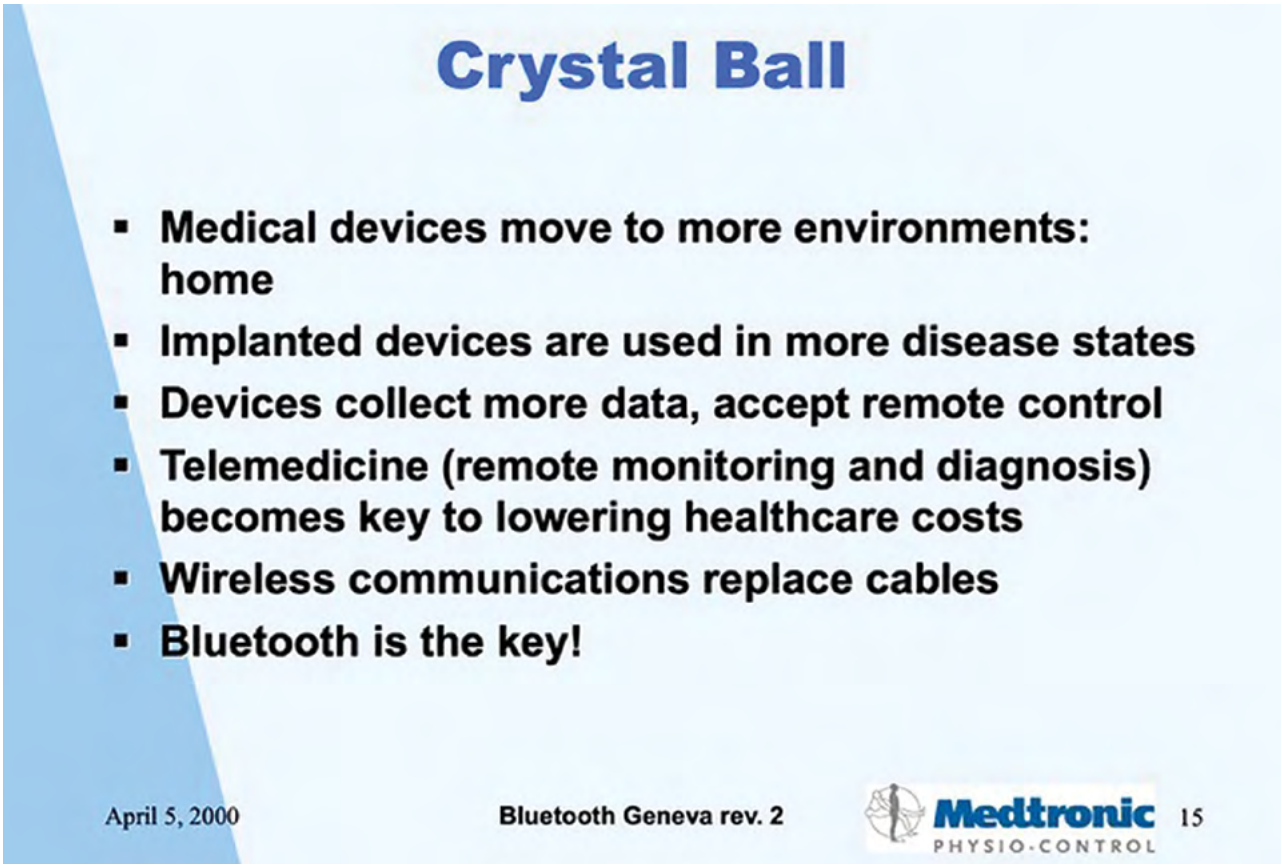
Feeding on data

If ubiquitous positioning, mixed reality, the blockchain, and artificial intelligence have anything in common, it's the fuel that powers them: data. With demand for wireless data communication on the rise across all sectors of society and the economy, 5G, the fifth generation of wireless communication technology, will provide the necessary bandwidth, coverage, and ultra-reliable, low latency communication that will serve as the backbone of the next generation of healthcare technologies. Exactly which solutions will emerge from the confluence of these enabling technologies is impossible to predict. But it's safe to guess what they will deliver to our healthcare system: better, smarter, safer care. ■

Guest article

20/20 vision - Bluetooth wireless and medical devices past, present, future

Bluetooth wireless technology formally celebrated its 20th anniversary last year, and its use to transmit medical data was understood almost from the beginning. Today it is clearly established as a key technology for use in many medical devices and systems. The vision for the next 20 years is clearly exciting.



Wireless patient monitoring can trace its beginnings with the NASA Gemini mission in 1965, and the first terrestrial (hospital) systems followed soon after using proprietary wireless technologies. Patient monitoring in the US was allocated a 'reserved' band in 2000 by the FCC (Federal Communications Commission), creating the "Wireless Medical Telemetry Service."

Also in 2000, I demonstrated a system utilizing Bluetooth wireless technology to transmit patient data from a defibrillator through a GSM telephone to a hospital computer system. A "crystal ball" slide from that demonstration outlined a rich field of medical applications including in-home remote patient monitoring and implanted devices, and predicted that wireless communications would replace medical cabling and that Bluetooth would be a key technology. By 2003, the first Bluetooth-enabled medical device was cleared by the US Food and Drug Administration (FDA) for sale by Stryker Endoscopy.

This system incorporated Bluetooth Serial Port adapter modules from connectBlue AB (now u-blox) to replace RS-232 cabling between devices in hospital operating rooms.

Wireless and medical today

The medical device field challenges all technologies with critical demands for reliability, security, power usage, and compatibility. At the same time, the systems require long-term availability and reasonable costs. Medical devices are subject to the scrutiny of government agencies, for example the FDA in the US and European Medicines Agency (EMA) in the EU.

Wireless technology provides distinct advantages over cabling for many medical use models. It allows patient mobility while maintaining electrical isolation, low cost, and low power. It is a link to the cloud for use by patients and their caregivers via both mobile and fixed gateways. Because Bluetooth technology is included worldwide in all

smartphones, tablets, and computers, medical systems can utilize available compute engines and user interfaces to enable excellent user experience and provide value to their patients and customers around the world.

In the past 20 years, Bluetooth has risen to the challenges and become the short-range wireless technology of choice for medical devices, especially outside the hospital. The Bluetooth SIG has helped enable this through its development of standard profiles and services for many common medical devices ranging from glucometers to thermometers. The use of common low-level Profiles (GAP and GATT) in Bluetooth low energy enable device manufacturers to develop customized communications protocols for non-standard devices including implanted pacemakers and pain management systems. Bluetooth continues to displace other wireless technologies formerly used in these devices due to its lower costs for materials and lower costs maintaining the previous proprietary technology.

The past 20 years have seen both maturity and exciting new modalities starting from its 'killer market' as a headset cable replacement for cellphones to the data-intensive medical and industrial markets. Bluetooth technology has continued to develop with improvements from Bluetooth 4.0 including low energy, beacons, and mesh.

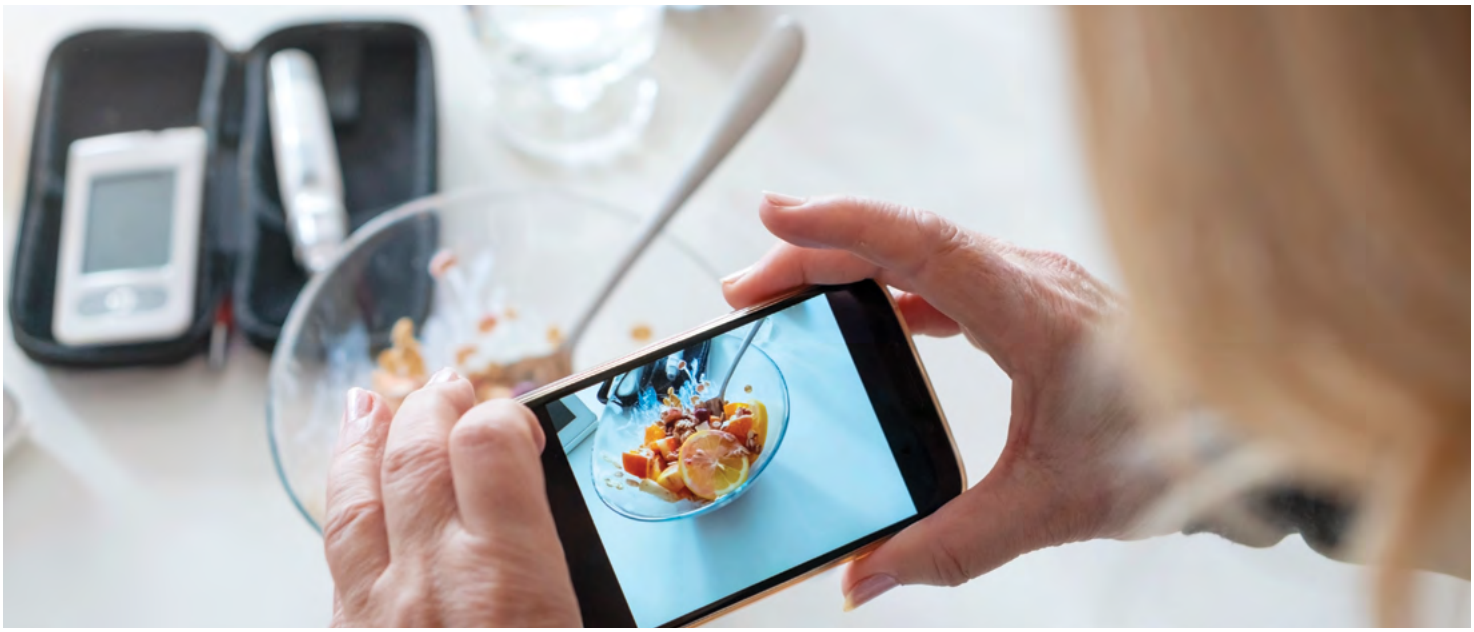
Today

Bluetooth has matured to coexist and combine in complementary ways with other technologies, especially Wi-Fi. It is used in complementary combination with longer range cellular technologies and location technologies to provide greater mobility and seamless coverage and enable flexibility of patient movement and coverage.

Emerging use models for devices ranging from hearing aids to stethoscopes are showing great interest in the most recent developments of low-energy audio technology. Markets for health and wellness solutions are growing. These devices incorporate medical-like monitoring capabilities at a lower cost with seamless integration into healthy lifestyle needs and have relaxed regulatory requirements. At the same time, consumer devices such as the Apple Watch have begun to include sophisticated medical device functions such as ECG/EKG arrhythmia analysis and warnings.

The future

What will the next 20 years bring? In many ways, it feels like the future of medical and wireless is already here. A perfect example is provided by external 'artificial pancreas' systems. People with type 1 diabetes must constantly monitor their blood sugar levels and manage food, medication, and injections of insulin to maintain



their health. In the past, separate devices have provided monitoring (often Bluetooth enabled) and insulin delivery. Complete systems have been approved that provide automatic 'closed-loop' operation, integrating the data from continuous glucose monitor devices with wearable insulin pumps and associated algorithms to keep healthy, stable blood sugar levels, resulting in better long-term health.

The future will bring more hybrid and integrated systems like the above example that will greatly improve quality of life for those with chronic diseases. Systems will include implantable component devices, and machine learning will enable those with neurological damage to move or even walk by combining implanted sensors with artificial nerves and external assistance from motors or artificial muscles.

Medical device systems will become less visible and more connected. Technologies with their roots in today's Bluetooth and 5G will combine in new and less-intrusive ways to provide seamless communication between system components and between those systems and the cloud. Wireless technologies and server-less computing will provide data interchange and blend into the cloud for computing. These systems will include artificial intelligence acting on that data to provide automatic adjustments and decision support to physicians.

If the above vision seems too far off to happen in the next 20 years, please consider what has happened in the past 20 years, and apply your own 20/20 vision. ■

Biography:
William Saltzstein has been innovating in engineering and product design for over 35 years, the last 20 of them associated with Bluetooth wireless technology and medical devices. After working for companies including HP Medical and Medtronic, he founded Code Blue Consulting in 2000 to provide expertise and experience to the wireless and medical device industry.

Bill is an inventor on 25 issued patents primarily associated with communications and battery-powered and portable medical devices. His active professional memberships include AAMI, IEEE, and Bluetooth SIG. Bill's academic career includes a Bachelor of Science in Electrical Engineering from University of Rochester.

Expert opinion

Discussing eHealth with…

William Saltzstein, President and Founder, Code Blue Consulting, and Pelle Svensson, Market Development Manager, Product Center Short Range Radio, u-blox

The confluence of wireless technology and healthcare offers virtually unlimited potential for innovation. But the road to transforming an idea into a viable product and successfully bringing it to market is bumpy, with many barriers - technological, societal, regulatory, and security-related - that need to be overcome. In an interview, William Saltzstein and Pelle Svensson discuss the past, present, and future of eHealth.

William Saltzstein
President and Founder, Code Blue Consulting

How would you define eHealth?

Pelle Svensson – I would describe it as using existing electronics and communications technologies to provide health monitoring outside the hospital walls.

William Saltzstein – I've been in the eHealth business for almost 25 years. While it's changed name, for instance, telehealth or remote patient monitoring, its goal has not changed. Basically, on the medical device side, it's a spectrum of solutions that starts in the hospital, expands all the way out of the four walls, and starts to merge today into personal health. It's not really a new concept, but I see it as being increasingly enabled by the technologies that we deliver, that is the wireless communications of various kinds that work together to provide solutions to do things like letting us stay in our homes more safely as we age.

P.S. – The European Commission talks about digital health, defining it as tools and services that use communication technologies to improve efficiency in the health sector and to cope with the increasing demand coming from population growth and more people aged 65-plus.

W.S. – We've seen that hospital infrastructure spending has been flat, in some cases even declining, and that we need the efficiency to deliver services outside the four walls of the hospitals. I think wireless solutions are the key enabling technologies that allow us to do that, safely and effectively.

P.S. – Yes, to be able to cope with the growing population and still be able to deliver good healthcare, eHealth is a must going forward. It's just a matter of how we can enable it quickly enough to make sure it gives us the benefits that we're aiming for.

What are the main drivers behind the growing investment in this sector, from hospitals to governments, especially in light of the current COVID-19 pandemic?

P.S. – According to the World Bank, the population will reach ten billion in 2050 from today's 7.8 billion. The number of people above the age of 65 is expected to climb from five percent of the total population to 25 percent in three decades. Of course, this will result in a rising demand for health services and, specifically, higher costs for healthcare.

W.S. – You've touched on one of the key points, and that's control of costs while being able to deliver these services. I see the pandemic as a driving force in pushing forward the solutions that we've needed, and in showing how they can be cost-effective. There's been a reluctance to invest in some of these technologies on a countrywide scale because the return on investment wasn't clear.

"I see the pandemic as a driving force in pushing forward the solutions that we've needed, and in showing how they can be cost-effective."

What COVID has done is to put emphasis on being able to deliver these services more efficiently so that we can reach more people and, at the same time, protect our healthcare workers. It has pushed models forward to what we knew was necessary and accelerated the timeline. The good news here is that we have the technologies to be able to deliver these solutions and apply them to these new needs.

P.S. – I think technology has come to a point where microcontrollers, sensors, and communication are available and can deliver good quality. In a study published in The Lancet, I read that global spending in healthcare will reach close to $20 trillion in 2040. I think healthcare spending will become one of the biggest economic challenges going forward.

W.S. – The other thing is that COVID has shown the entire world that our communication networks are robust and can handle the increased data traffic. We had companies that use VPNs increase from hundreds of workers to tens of thousands of workers overnight, and our networks handled that increase quite effectively and securely, proving that our communication tools are up to the task. As challenging and awful as this pandemic has been, I think the real silver lining is that the whole world has seen that we are ready for these solutions, and this gives us confidence and the ability to move forward quickly.

P.S. – The coronavirus has affected every person's life, in school, at work, etc. We are working more from home, remotely. We see globally a lot of incentives among our customers, the device manufacturers, to make products that can assist in keeping physical distance to prevent spreading the virus. It's interesting to see that in a crisis like this, there are already people that are using their creativity to try to find solutions.

I read an article about telehealth in the US. One hospital in the US with about 3'000 monthly telehealth visits reached 60'000 telehealth visits because of the pandemic. So definitely, the technology is there. We just need to encourage the use cases to be more widely used. Of course, there are some companies and some new organizations that have to help, for instance, the insurance companies in the US and the governments and so on.

W.S. – We have seen the FCC (Federal Communications Commission) and FDA (Food and Drug Administration) working together to enable these solutions to get to market very quickly. We are seeing some very innovative ways that the government agencies in the US are working together to make things happen on accelerated timeframes, and companies that would have struggled prior to COVID are now seeing the funding they need to move their innovative solutions forward quickly.

Pelle Svensson
Market Development Manager, u-blox

Human creativity is amazing. It takes a lot of hard work to put these solutions into the market. But the time is really good for new and innovative solutions.

How is eHealth concretely implemented? Which wireless technologies make it possible?

P.S. – It's about sensors, microcontrollers, and connectivity. The data from the patients has to be delivered to the caregiver through the internet in one way or the other.

I see at least two possible architectures, which I would call one hop or two hops to the internet. One hop means that you have cellular connectivity in a device that is monitoring the patient. Data goes directly through the cellular network to the internet and on to servers where caregivers can use the information. The two hop solution is more of a hybrid solution consisting of a short range technology from the sensor to a hub, which could be a home gateway or a smartphone app, and then from there to the internet, either through wired or wireless, in this case also cellular, technology.

“Human creativity is amazing. It takes a lot of hard work to put these solutions out. But the time is really good for new and innovative solutions. ”

W.S. – From the communications side, there is no one-size-fits-all solution. When new technologies come out, it's very tempting to say: "We're done now. We can focus on one single technology." I've been in communications for long enough to know that it still hasn't happened.

The challenge is, to use the medical device term, intended use: There is no single eHealth model. There can be different architectures, different technology combinations, all motivated by different user needs.

The technology needs depend on the intended use. Bluetooth is clearly the low power, low cost, first hop technology that is easy to use with a smartphone. But for something like an

implanted device with no user interaction, it might be tempting to go straight to the cloud with cellular technology. If you are on the road transporting a patient, you might need to use 5G. And when you hit the four walls of the hospital, you have to switch to Wi-Fi, the preferred network there because of its installed base and roaming capabilities.

"The challenge is, to use the medical device term, intended use: There is no single eHealth model. There can be different architectures, different technology combinations, and different user needs."

So you really have to evaluate each application, its needs, and pick the appropriate technologies. The good news is we have a lot to choose from. Everything from Bluetooth to Wi-Fi to 5G. We can add GPS technology to the mix to be able to locate people when they are ambulatory and to make sure that they aren't going near a store that sells peanuts if they have a peanut allergy, for example.

My main message here is that there is no single wireless technology today that can provide for all of these needs. And the benefit of a company like u-blox is that it offers the building blocks that you need to put together solutions that meet each application's intended use.

P.S. – Exactly. Which technology is used depends on factors like: is it a battery-driven device that's going to be used frequently, or is it a stationary one that can be powered by the mains? Everything that uses two hops to the internet needs a gateway, which means that there are configuration aspects to consider, while a cellular modem implemented directly in the patient monitoring device can be configured in the factory. Just power up and it connects automatically.

W.S. – I was recently with a group of experts talking about the impact of 5G in healthcare, and the conclusion was that, while it is an excellent technology and another valuable tool, it is not, at least in the near term, going to be the one technology that solves everything. A challenge with 5G is the need to have the carrier involved in the conversation; something that medical device companies and hospitals aren't used to dealing with. How do you handle who pays for the service and who does the provisioning? And is the device and service available on all the networks? So there are still some questions to be answered about deploying 5G for medical device technology, particularly for continuous remote patient monitoring and more critical medical applications.

P.S. – There is constant evolution and development of new features for each technology, supporting new use cases. What we use in five to ten years will not be what we have today, but rather an evolution of the technologies we have today.

W.S. – We've seen that with the evolution of Bluetooth and Bluetooth low energy, then with the new modes, from Bluetooth LE Audio to Bluetooth Mesh.

Are there any regulatory barriers to implementing wireless technologies in the medical sector?

P.S. – When implementing technology into medical devices, patient safety is important. In the US, the FDA is responsible for protecting public health and enabling the security of medical devices, while, in Europe, it is the task of the European Commission's Directorate-General for Health and Food Safety. Both publish information on making medical devices in general, and specifically wireless ones, providing guidance on how to provide patient safety, ranging from the choice of technology and where to use the

device to how it can coexist with other potential technologies in the use case it's being developed for.

W.S. – The medical device world is pretty strictly defined between those applications that need to be regulated and those that don't. A blood pressure meter is a regulated device, while a weight scale is likely not, unless it is a part of a medical device system. Some devices cross the boundary like a pulse oximeter, which is a regulated device when used in hospitals, but not if you're going to use it for mountain climbing to make sure you are getting enough oxygen. There is a regulatory process that must be performed before you're able to market a medical device.

So the regulatory barriers to entry are very real. You not only have to submit it to the US, Canada, Mexico, EU, Japan, and China; each of these regions has the ability to impose regulatory restrictions and require approval. It's quite a task to figure out what it takes to make a medical product available worldwide. And, for wireless devices, these approvals require that you are granted radio approvals as well.

There's a very large change going on right now in Europe, with a transition to what's called MDR (Medical Device Reporting), which is a different set of regulations and a different process for being approved through notified bodies. And, of course, cybersecurity is a much more important part of the process than it used to be, for good reasons. When you have a wireless signal that can be sniffed and decoded, we need to make sure that we have the appropriate features in the communication channel to protect security and privacy.

Combined with that, we need to maintain supplier quality to ensure the quality levels required to keep devices running. Because medical devices are used in proximity to other electronic equipment, interference and coexistence of medical devices have also become key in “noisy” environments, such as in ambulances. And with more and more of these solutions, interoperability, having communications protocols that are able to inter-operate and exchange communications and data from one system to another, is going to be playing a bigger and bigger role.

P.S. – We as components suppliers have good examples over the last five years where we basically have all our already certified solutions and modules going back into the test facility to make sure that we are compliant with the latest key specifications both in Europe and the US.

Can you think of an eHealth implementation that you find particularly impressive?

P.S. – There's a medical IT solution from almost 20 years ago, around the time that the term Internet of Things was being coined. We had customers in the medical area that were making devices that were used in ambulances to take sensor data from a patient, send it over a Bluetooth connection to a specially designed gateway, and then to a server on the internet. What that server did was re-package the information and deliver it to the hospital in the required data format. What is impressive is that these products are still in use, just with an updated form-factor-compatible wireless module.

W.S. – From my side, one really good example of where the future can go is the diabetes case. People with Type 1 diabetes need to monitor their blood sugar level and inject themselves with insulin to control it. The technology has evolved for decades, from hospital tests to finger sticks and the use of strips to be able to check the glucose levels frequently during the day and inject insulin.

Today, we have body-worn devices called continuous glucose monitors that can be worn for weeks at a time, continuously reporting on the level of blood sugar. The data can go to a smartphone app where users and their caregivers can make sure that they're perfectly managed. The other devices that have been developed are insulin pumps, which are external devices worn in a pouch that have a portal into the body to automatically deliver insulin. The two devices hadn't been able to work together until two to three years ago when several companies began marketing devices that use wireless technology to let the body-worn sensor deliver information to the pump and automatically keep the blood sugar levels within a very small window.

As you might expect, this benefits the patient greatly, not only because they don't have to do it manually, but also because, in the long term, studies have shown that good control of insulin and sugar levels produces benefits in terms of a longer and healthier life.

The other application that I'm really excited to see, because it's one that I actually didn't think would be a valid application for Bluetooth technology, is for implanted devices. Things like implantable cardioverter defibrillators, pacemakers, and neurological stimulation devices are implanted with a Bluetooth low energy interface connecting them to an external device such as a smartphone or external pump.

You can extrapolate about the future that we're going to have more devices helping us with chronic conditions going forward so that, as we age, we are healthier and less of a burden on the healthcare system. This is exciting. I think this is really a good example of where we're going that we would not have without the technologies we have developed in the past 20 years.

We touched on security in the previous questions. Could you elaborate a little?

P.S. – If we take the example of devices designed to control diabetes, it brings up the question of hackers and security. At u-blox, we have a very strong security program in place delivering security as a service to have top-line security for devices that require it. First, it requires a high degree of protection from malware and data tampering. Patient confidentiality is essential too: only authorized medical staff should be able to access sensitive data.

At u-blox, we answer these imperatives with LPWA products that are secure by design, which means that they include a unique and immutable device identity tied with the root of trust (RoT), a source which forms the basis for a trusted set of advanced security functionality, which we offer as IoT Security-as-a-Service. This scalable solution is also specifically optimized for e-Health applications that use resource-constrained IoT devices.

W.S. – Cybersecurity has become more important for medical devices. As we become more dependent on interoperable technologies, they become somewhat easier to get into. So it's

important that, at the level of a company such as u-blox, we take appropriate measures to make sure these devices are secure.

Another aspect that is occasionally lumped together with cybersecurity is privacy. The European Union has taken a great step forward with the GDPR to protect personal privacy. As some of these devices start to disclose our chronic conditions, we don't always want our neighbors to know about them. That's where privacy comes in. That's just a personal example, but there are other examples of where privacy is important, particularly when we start to have valuable patient information that is tied to the US social security number.

Which countries or regions are leading the pack in eHealth, and who is lagging behind?

P.S. – According to a recent report by Berg Insight, the adoption rate of health systems is increasing. In the last year, we have seen strong growth in North America, followed by some countries in the rest of the Americas, some countries in Europe, and Japan. One reason why the US is leading the trend is that they have the highest patient treatment cost. It's an incentive to use eHealth to still be able to provide the service for the patients. Other countries that recently joined the trend are China, Russia, and the Middle East.

If we look at the number of connected devices that are currently being used, we have 25 million in North America, with Europe representing 12 million devices, and the rest of the world representing five million.

But the report also looks at a few years ahead and says that the biggest increase will be coming from the rest of the world. North America and Europe will close to double in the next three to four years. In total, Berg Insight foresees doubling of the number of connected devices used in eHealth and mHealth use cases over the next three to four years.

W.S. – I think that sounds consistent with what I've been seeing. The US used to be responsible for almost 75 percent of healthcare devices. That's 20 years ago. Your numbers were very interesting to hear. According to them, we are at about half the world market and falling. And it's not necessarily because we're using less, but because the markets in the other parts of the

world, particularly outside of the US and Europe, those in Asia and the Middle East, are growing.

There are many reasons for this. One is access to the devices and the technologies. Another is general economic trends. Perhaps the third piece is that, as countries develop, different healthcare issues pop up that weren't there before. Things like pollution and certain lifestyles tend to increase healthcare issues.

"AI and machine learning will play a big role going forward."

The challenges I see going forward are the countries with large populations and low budgets. I think that we as an industry can work together to try and lower those costs and get into these markets that clearly have the need and be able to deliver those benefits.

Fast-forward ten years. What does eHealth look like in 2030?

P.S. – As we have seen, the use of eHealth has grown dramatically in parallel with the COVID-19 pandemic. And I think it's definitely here to stay, as the last couple of months have proven that the technology can deliver.

With more devices, more connectivity, and more data being collected and in need of being analyzed, there is a challenge. Will it be done by doctors? To some extent, yes. But I think artificial intelligence will come into play to do a pre-analysis of the data. Of course, the final word will always be on the doctor. And we will probably also see more implants being wirelessly connected not only to monitor patients from the outside, but also from the inside.

W.S. – I'm going to echo that. The data has to be turned into information. That information has to then be turned into assistance for decisions to make changes in healthcare or to say that someone is okay. We need to keep the physicians and other healthcare workers from getting overloaded. They need to quickly be able to understand what this information means, and how to deliver better care.

AI and machine learning will play a big role going forward. The algorithms to do closed-loop control, like the diabetes example that I gave, are going to be AI algorithms. They learn and adjust as you change your lifestyle and as you age and change.

“You should be able to have access to the expertise around the world. ”

P.S. – A trend I've seen here in Sweden in the last couple of years is doctors doing consultation using apps on smartphones. There are a couple of different companies providing this service. And it's being paid for by our medical system. We are 10 million people in Sweden. Over the last year or two, there were one million down-loaded apps for one of the suppliers. So it's a very strong trend. Doctors and patients can talk to each other, use the camera in the phone for the doctor to examine a particular part of the body, and provide prescriptions for medication. This way, you don't have to go to the doctor to see the doctor. And now these companies are collaborating with pharmacies so that, if you really want to talk to someone in person, there will be nurses in pharmacies to complement the video conferencing.

W.S. – We're seeing some of that in the US as well. I think that's another important area. It's exciting to see countries like Sweden take the lead on that. The advantage Sweden has is that its healthcare system is well controlled, well funded, and well understood, whereas in the US, in my opinion, we're not any of those.

I see that healthcare devices and the tools that companies like u-blox deliver can help people around the world be healthier, live better lives, collaborate more easily, wherever they are located. You should be able to have access to the expertise around the world.

We need communications to help move us forward. I'd like to see our devices and solutions extend to the struggling regions where people need the healthcare solutions that we enjoy. I'd really like to see healthcare without boundaries and without favorites. That’s my hope and vision for the future. ■

eHealth in numbers

Here are some facts and figures.

$1.6tn

Global economic impact of the Internet of Medical Things (IoMT) by 2025

Source: McKinsey

$269.4bn

Estimated annual savings in the healthcare systems business thanks to AI

Source: McKinsey

$52.2bn

Expected rise of the IoMT's connected medical devices segment (helping to diagnose, monitor and treat patients) by 2022

Source: Deloitte

104m

Shipments of healthcare wearables by 2025

Source: ABI Research

88%

Share of healthcare provider organizations looking to invest in remote patient monitoring solutions

Source: Spyglass Consulting Group

87%

Share of WHO member states reporting having one or more national mHealth initiatives

Source: WHO

58%

Share of WHO member states with an eHealth strategy

Source: WHO

55%

Share of WHO member states with legislation protecting electronic patient data

Source: WHO

CORE: A wearable thermometer for athletes

greenTEG's body-worn temperature sensor continuously monitors core body temperature with accuracies rivaling those of ingestible sensors.

For all its benefits, we pay a high energetic cost for being warm-blooded: about 10 percent of our daily energy expenditure goes into thermoregulation – that is, stabilizing our body temperature at a cozy 36.5 – 37.5°C. Upward deviations from that window can spell trouble, whether they are caused by excessive effort, such as during an ultra-triathlon, or by a viral infection, such as by COVID-19.

To catch such temperature spikes when they first become apparent, continuous temperature monitoring would have tremendous diagnostic value. But because accurate core temperature sensing typically involves inserting a probe into our bodies, generating such a continuous temperature record, in particular when on the go, has long been impractical.

Operating out of Zurich, Switzerland, greenTEG, a company specializing in the development of heat flux sensors, have developed a solution to that challenge: a non-invasive wearable device that continuously monitors core body temperature with accuracies rivaling those of ingestible sensors – that is, to within 0.25°C. The solution leverages their extensive expertise in the development of heat flux sensors and complex algorithms.

Initially intended to help athletes avoid overheating when training for and competing in extreme environments, such as ultra-marathons or triathlon competitions, CORE was designed to provide unique insights into performance, allowing them to differentiate between mere exhaustion and more dangerous overheating. Earlier this year, the product developers at greenTEG were quick to adjust their solution to also address new challenges brought about by the COVID-19 pandemic. Today, target groups include the general public that is seeking to return to work safely, business owners and patrons concerned with protecting their workforces' and customers' wellbeing, and individuals in risk groups.

CORE, the first non-invasive and continuous core body temperature monitoring device, was

© Core

released in May of this year. About as big as a thumbprint and worn close to the body with a patch or a belt, CORE translates sensed data into a very accurate estimate of the core body temperature – commonly defined as the temperature of blood as it leaves the heart's aortic valve – using a sophisticated machine learning algorithm specifically trained for the task.

Their device is based on a passive sensor, which means that the sensor operates without requiring any power. It uses a u-blox NINA-B306 short range radio module to send sensed data via Bluetooth low energy or ANT+ to a user's smart device – a smartphone, fitness tracker, or smart watch.

"We needed a small and pre-certified low power Bluetooth module that could help keep the size of the overall solution to a minimum while offering the connectivity options, the considerable memory, and the reliability our application required," says Holger Hendrichs, VP of Sales and Marketing at greenTEG. "The u-blox NINA-B306 looked like a promising candidate. When we found out that it interfaced with Garmin devices using the ANT+ protocol, for us a critical feature, our choice was clear."

Since May 2020, the solution, CORE, has been marketed as a wellness and workforce protection device for B2B customers. During the Tour de France in September 2020, CORE was also launched to B2C customers with an advanced sports algorithm that is able to pick up the photoplethysmogram (PPG) signal used to monitor blood flow from a 3rd party device. greenTEG worked with a professional UCI (Union Cycliste Internationale) world team to use the CORE during all 21 stages of this year's tour. Their data were received live, and the results were published to CORE's social media platforms. ■

Learn more:
www.corebodytemp.com

A medical wireless gateway – packed snuggly into a watch

Developed in the pre-COVID-19 era, a blueprint for a wearable wireless medical gateway holds the promise to boost the autonomy of patients requiring 24/7 monitoring and increase capacity of ICUs.

Compact, highly integrated, and qualitatively impeccable: Leikr's state-of-the-art solutions raise expectations for IoT wearables to the next level. Their prototype of an assisted ambient living and telemedicine watch, developed in collaboration with u-blox and other partners, is a case in point. Their smart medical watch securely connects medical IoT sensors to cloud-based eHealth platforms. We sat down with Leikr CEO Lars Møller - virtually using Microsoft Teams, to talk about what sets their wrist-worn wireless gateway apart from the crowd.

COVID-19 has been a stress test for healthcare, and a potent driver of eHealth solutions. Clearly, there are still many open challenges. Which ones is Leikr focusing on?

Lars Møller - We see the upsides that remote monitoring and telemedicine can have with regard to the current COVID-19 pandemic. First, telemedicine means that you can treat and monitor patients without physical contact – an important advantage when you are treating a virus that spreads easily. And now we see that this kind of healthcare solution can help increase capacity at the hospital or clinic, either by taking patients out of the clinic and treating them at home, or by enabling doctors and nurses to treat more people by using the technology to monitor more patients at the same time.

But we and u-blox have been working on this telehealth solution for some time, well before COVID-19 came into the picture. Telemedicine is most interesting when it helps to react to events within 15 to 30 minutes, for example when blood oxygen levels trend away from acceptable values. You can then go in and treat a patient by delivering medication before it gets severe. This avoids people being sent to the hospital with an acute situation because they were not treated in time.

How do you achieve such short response times when the patient is at home?

L.M. - Let's say you're dealing with patients with chronic obstructive pulmonary disease (COPD), who often suffer from infections. If you detect that their blood oxygen is low and their body temperature is rising, there's a very good chance that an infection is under development, in which case you can ask the patient to take antibiotics.

Left to themselves, it's a hard balance for patients: they know that if something goes wrong, they really end up in trouble. Because of that, they may be a little sensitive about the situation, which might provoke symptoms that are not really there, and call in to say that they are not feeling well. In such a case you can check in and say, well, your blood oxygen looks fine, so there is probably no need for alarm.

What makes your solution unique?

L.M. - The short answer is that it's portable, so it's always with the patient. There are other non-portable wireless gateways that relay physiological data from medical sensors to the cloud, but they all suffer from the fact that patients need to stay in their proximity, restricting patient mobility to rooms

© Leikr

that are within coverage of the stationary gateway. This, of course, lowers the life quality of the patients, who could live a somewhat normal life if they were allowed to walk around while being monitored.

There are solutions out there today that use standard cellular networks, but these often provide poor connectivity inside patients' homes. The LTE-M and NB-IoT connectivity offered by the u-blox SARA-R5 gives us, in technical terms, up to 20 dB better link coverage. In practical terms, this translates to the ability to communicate through an extra concrete wall, which means that the chances that data gets through from the patient in their home is much higher when compared to using standard cellular technology.

Bluetooth low energy connectivity via the u-blox NINA-B3 module gives us a reliable connection to multiple sensors on the patient, and opens the door to enhancing our solution to include Bluetooth-based indoor positioning to locate patients and medical personnel. Of course, when we are outside, it is most important to have a powerful GNSS receiver, and the u-blox M8 multi-constellation GNSS receiver is interesting to us because it uses the combined accuracy of all four constellations.

And finally, the security features offered by the SARA-R5 module let us meet any level of security requirements that we receive from our customers. Furthermore, the possibility to manage data using MQTT-SN truly makes u-blox a one-stop-shop for all of the components of the IoT product, removing the need to negotiate with operators to get a globally certified cellular solution.

Learn more:
www.leikr.com

How do you see the solution being deployed in practice?

L.M. - We foresee two solutions using the same design: In the first scenario, patients can wear the watch, which receives data from other medical sensors and sends it to a backend platform. Alternatively, it can go the other way, with the patient data flowing from medical equipment to the watch, this time worn by the medical professionals. In this scenario, it expands the capacity of doctors and nurses, because even when they leave the patient's room, they are still able to monitor their vital signs.

This is particularly interesting in the context of COVID-19, where we know many patients are going on respirators in ICUs, and the capacity of medical staff is being challenged like never before. One part of it is getting all the equipment together. The other is having sufficient personnel to oversee and react on the data. By having the data sent to the watch, medical personnel can attend to the needs of one patient while still monitoring the critical patients in neighboring rooms.

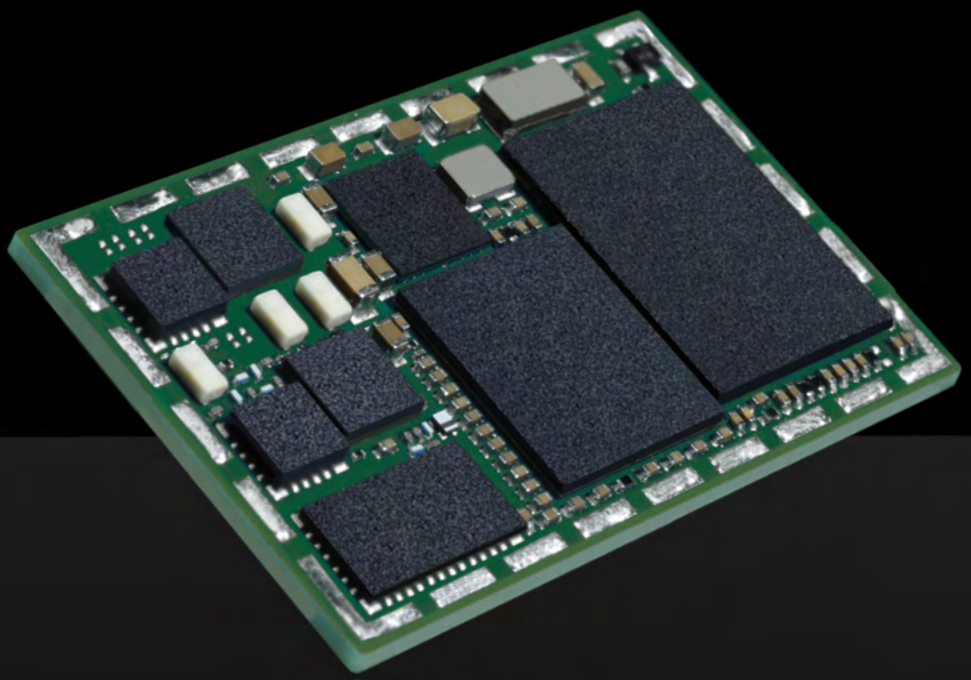
So what is next for Leikr?

L.M. - The pandemic has been a wake-up call that not everything is best treated in hospitals and clinics, and that there is a lot of value in being able to treat patients remotely. This is something that we will certainly be looking into in the future. ■

Biography:
Lars Møller has a master of science in communication from DTU Denmark. He has more than 20 years of experience in telecommunication including at Nokia as Product Concept Manager. As CEO for Leikr he has refocused the company to a B2B oriented market for critical communication operations. Today Leikr delivers high-end products for professional sport, critical tracking, and telemedicine.

Products

In the spotlight



The latest in positioning and wireless communication technologies and services

Combining industry-leading quality, robustness, sensitivity, and performance with innovative features, u-blox delivers solutions, services, and components that meet the needs of even the most demanding designs. We focus on business-critical applications where products need to perform 24/7 with maximum reliability, handling exceptions with minimal disruption to the overall system. Our customers expect improved productivity, quick turnaround, and a head start on their competition.

u-blox SARA-R5 series LTE-M modules featuring IoT Security-as-a-Service

eHealth applications require confidentiality and authenticity to ensure that only the patient and the healthcare provider can access sensitive data. Software and data tampering pose a huge risk for patient safety. With the coronavirus crisis, these topics become even more relevant.

The u-blox SARA-R5 LTE-M modules featuring IoT Security-as-a-Service solve the longevity and safety imperatives of IoT devices for sensitive or confidential applications. SARA-R5 modules are based on the u-blox UBX-R5 cellular chipset and the u-blox M8 GNSS receiver chip. They are secure by design – each module has a unique and immutable identity based on a robust root of trust (RoT) that forms the basis for a trusted set of advanced security functionality, available as u-blox IoT Security-as-a-Service.

By bringing all technology building blocks in house and having full hardware and software ownership, u-blox can guarantee long-term device availability and provide lifetime support of the entire platform, from silicon to cloud.

SARA-R5 modules are 5G-ready, meaning customers will be able to (software) upgrade their deployed devices once 5G LTE has been rolled out by mobile operators, extending device scalability and lifetime.

IoT Security-as-a-Service is a disruptive solution that makes it extremely simple to protect your data from malicious third parties, both on the device and during the transmission of data from the device to the cloud. Out-of-the box, simple, secure, and cost-effective onboarding to leading cloud IoT platforms enables you to focus on scaling your business more quickly, while protecting your revenues and reputation.

Learn more:
www.u-blox.com/product/sara-r5-series
www.u-blox.com/iot-security-service

NORA-B1 series – High performance. Security.

Packing the punch of a dual core MCU, our brand new Bluetooth 5.2 NORA-B1module is designed to meet the needs of performance-oriented applications such as industrial machine control, asset tracking, remote controls and gateways, connected power tools requiring continuous motor control, and advanced medical wearables with demanding security requirements.

Based on Nordic Semiconductor's latest nRF5340 Bluetooth low energy chipset, the first to host a powerful Arm® Cortex® M33 dual core MCU, our recently announced NORA-B1 series comes with the Arm® TrustZone® and CryptoCell-312 for enhanced security.

With global certification and operation at up to 105 °C, the new NORA-B1 measures only 10.4 x 14.3 x 1.8 mm and will be available in several antenna variants.

Learn more:
www.u-blox.com/product/nora-b10-series

M10 - 10th generation GNSS technology

Tailored to the needs of wearable and industrial applications, the u-blox M10 platform delivers ultra-low power positioning in an ultra-compact form factor without sacrificing accuracy and availability. With 12 mW power consumption in continuous tracking mode and high RF sensitivity that cuts the time required to establish a position fix, the u-blox M10 platform is ideal for small battery-powered applications. The platform features advanced jamming, spoofing, and RF interference mitigation, as well as Super-S technology to boost performance in weak signal environments or when used with small antennas, making it ideal for compact product designs.

Learn more:
www.u-blox.com/m10

It’s exponential: Our sustainability potential

In our first corporate Sustainability Report, we reaffirm our commitment to contribute to a better future, encouraged by the exponential potential of IoT to promote sustainability across our planet.

Those of us already working in IoT can most likely agree that there is no lack of imagination and potential across our industry. Innovation abounds when we think of what humans can accomplish with a challenge, a network, a microchip, a SiP, a satellite, an antenna, and a battery.

Along with the obvious potential energy savings and emission reductions IoT can bring, our industry is transforming human behavior and positively impacting societies; socially, environmentally, and in terms of economic development.

u-blox customers around the world are using IoT to transform environmental management, agriculture, education, social care, transportation, energy management, and building automation, among many other aspects of our daily lives. These innovations often create low-carbon business models or have the knock-on effect of carbon emission reduction due to efficiencies and other contributing factors. They also often overcome barriers to information, knowledge, or much needed human interaction, making a significant positive social impact.

One of the fastest-growing areas of IoT innovation is in the healthcare sector. With healthcare systems worldwide under more pressure than ever before, IoT is rapidly reshaping how patient care is delivered. Innovative connected care solutions are extending healthcare to the patient beyond the physician’s office or hospital setting, providing patient-centric care and reducing the load on our stretched healthcare systems. Chronic care management, remote monitoring and medication management, including AI for proactive healthcare strategies, are some of the areas leveraging IoT.

“We take our role as a contributor to the innovative global IoT community seriously as we all work together to further sustainability. We see it as our responsibility to produce our products sustainably.”

Sustainability is becoming an inherent part of our company culture with every decision we make – at all levels of the business. Our first Sustainability Report is now available. It documents our performance and achievements related to environmental, social, and governance (ESG) factors. We will be publishing it yearly to increase transparency and address areas for improvement. Here are some of the highlights of what we have achieved and what our plans for the future hold.

In 2012, we signed the United Nations Global Compact, the world's largest corporate sustainability initiative encompassing the 17 Sustainable Development Goals (SDGs) established by the United Nations as a blueprint for achieving a better and more sustainable future for everyone. They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace, and justice.

In 2020, we renewed our Global Reporting Initiative (GRI) Materiality Analysis to identify and prioritize the areas where u-blox can make a significant economic, environmental, and social impact - areas that are important to, and highly influence, the decision-making of u-blox and our stakeholders.

We have identified several topics, which we have grouped into five areas and aligned with the SDGs to form the basis of our Sustainability Strategy:

- Business ethics, privacy, and security
- Employees
- Environmental responsibility
- Supply chain responsibility
- Communities

Our specific sustainability goals, projects and commitments are all designed to contribute towards one or more of the SDGs. ■

Learn more and download:
www.u-blox.com/its-exponential-our-sustainability-potential