Embracing Healthcare 4.0

Digitalizing healthcare as a
key enabler for high value care

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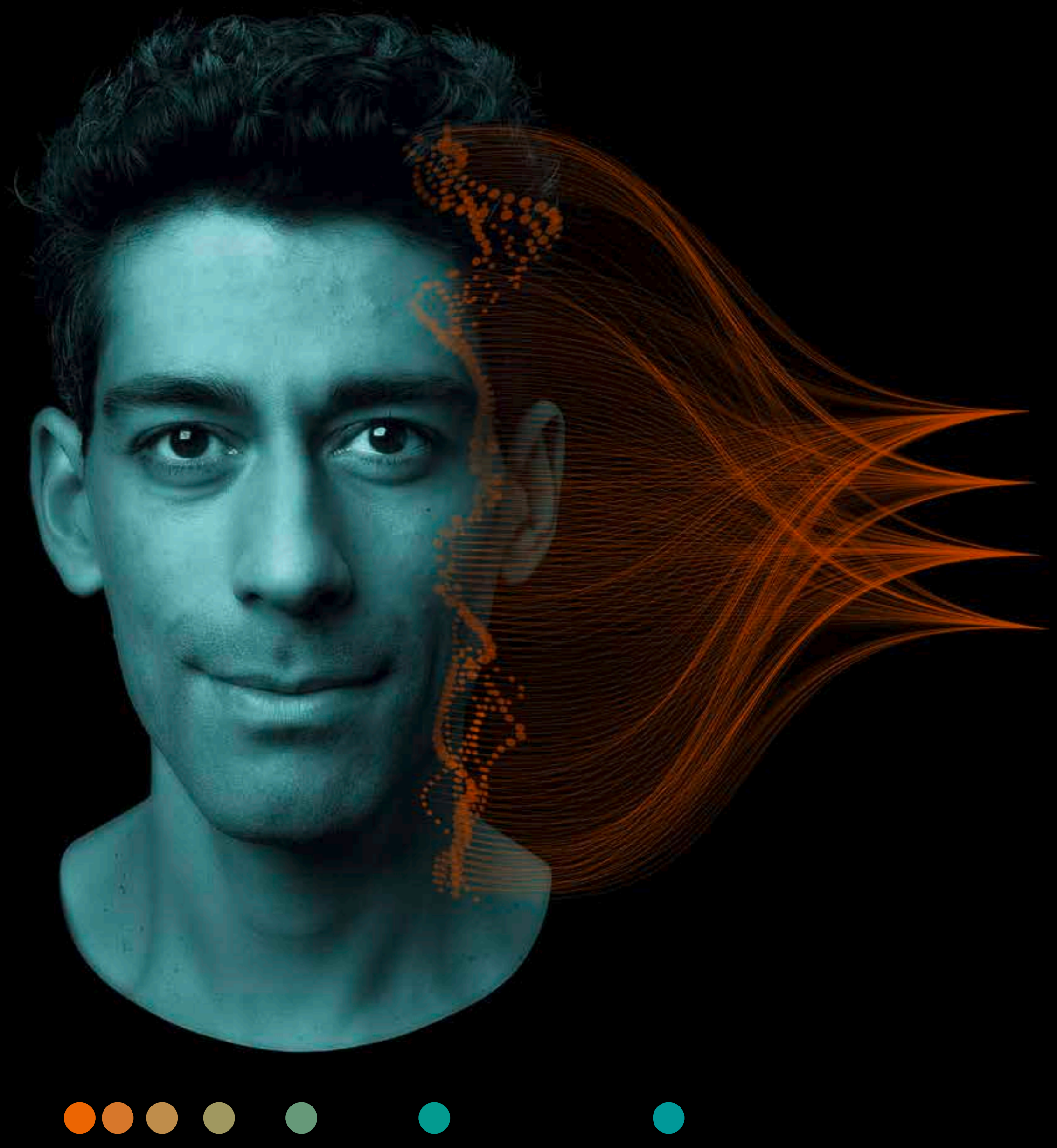

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Healthineers

In little more than a generation, digitalization has almost completely transformed modern life, with far reaching impacts that we now take for granted. Similarly to the industrial revolution that transformed production and shifted mass populations two centuries ago, the digital revolution has had sweeping changes that were not limited to manufacturing, but in the way people communicate, conduct business, and even how they receive and provide services across all industries, including healthcare. Digitalizing healthcare will be a key enabler to provide high value care. It will help to expand precision medicine, transform care delivery and to improve the patient experience.

The digitalization of healthcare is underway, yet it is not so obvious, partly because the industry has been slower than other sectors to utilize the technology. But make no mistake – the revolution is arriving at a hospital or clinic near you and not a moment too soon. With populations aging, chronic diseases rising and medical costs skyrocketing, the healthcare universe is in dire need of the improvements that digitalization will bring in terms of saving costs, improved diagnostics and more effective care. In addition, the global shortage of doctors, nurses and technicians demands for improved efficiency and the need for technology to help bridge the demand-supply gap in services. The current practice of medicine can lead to a fragmented or "siloed" picture of a patient, depriving providers of the full power of advanced analytics that accrue to digitalized healthcare. According to a survey of IT leaders by MeriTalk, poor data integration could be responsible for $342 billion in lost benefits every year as government health and human services agencies struggle to manage different datasets. 62% of laboratory tests and 35% of radiology tests are not followed up on, thus resulting in missing critical diagnoses.

Future efficiency gains are an imperative in the United States where healthcare costs are a source of widespread concern. They now account for nearly one fifth of total US economic activity, nearly double their share of EU economies, according to a recent Harvard Business Review article. With rising life expectancies and the increasing occurrence of chronic diseases such as diabetes and obesity, costs as a percentage of overall economic activity are expected to continue increasing.

The visible part of the healthcare revolution has already manifested itself in medical instruments and procedures. For example, the cyber knife that is being used for delicate brain surgery, or even robotics that perform prostatectomies. With the combination of Artificial Intelligence (AI), Internet of Things (IoT) and ever improving imaging techniques, great leaps forward in diagnostic accuracy and more finely targeted therapies are also being made. Data from the healthcare sector of the digital universe is growing at a 48% annual rate, and the challenge is to translate that flood of data into meaningful information. That's how AI, with its capacity to link it to data sources within IoMT, can make a huge difference.

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"Digital twins," as the computerized individual models of physical organs or the complete bio-physiological human system are called, are enabling medical professionals to create models of the human body to help personalize treatment by virtually simulating outcomes and effectiveness. A digital twin of a human could in the future serve as wellness coach predicting individual risk and preventing sickness.

In use for some years now, digital twins have been utilized in other industries to help in optimizing processes in manufacturing, machine modeling and workflows. They link the real and digital worlds, this stems from an intuitive technique that leverages AI to turn data into actionable insights. This is accomplished by using millions of pieces of curated data and then leveraging them to train deep learning neural networks, which then approximate parts of a combined multi-scale physiological model.

With AI sifting through millions of records and profiles to detect links or similarities between biological characteristics and disease, doctors can now detect problems that otherwise remain imperceptible. Future health issues can be highlighted when providers analyze genomes and proteins to identify patients at risk for diabetes, cancer and other maladies before they strike, this is an example of how digitalization is potentially shifting much of the industry's focus to preventive care.

Transitioning to Digital Technologies

Much like the late 1800s, when medicine adjusted to the transformative discovery by Roentgen of the X-ray, the industry faces challenges as it shifts to new paradigms. Regulators must balance the need for AI and data sharing with patient privacy. Staff must also be trained to maximize the benefits of a technology that is new to them. Doctors accustomed to patients' office visits will have to adapt to practicing "telemedicine" that would mean treating patients who are sometimes located hundreds of miles away.

Although the Boston Consulting Group singled out the medical technology subsector, such as imaging, as being ahead of the curve, the firm's recent study of healthcare digitalization found the industry to be lagging behind generally in its adaptation to new technology. But it also found that the industry is catching up in a transformation that involves tectonic shifts. The changes perhaps can be broken down to four areas of digitalization, whose titles may sound arcane but will become increasingly familiar to healthcare professionals and patients in years to come.

The Internet of Medical Things

They may not realize it yet, but diabetics who wear blood glucose monitoring devices, just as everybody else who uses mobile gadgets to sense and transmit their "consumer-derived" medical data, are players in the rapidly expanding Internet of Medical Things (IoMT), a trend that is enhancing connectivity and altering the doctor-patient relationship. Data is sent from these "things" to physicians via internet, but the information can also flow through to broader databases and analytics systems to enhance shared research and feed the AI.

The use of wearable sensors emitting digital patient data is booming and "will become the most important and prolific source of real time health data that we will have," said Babson College information technology professor Tom Davenport as quoted by Harvard Business Review. By the end of the decade, Business Insider Intelligence predicts that there will be 24 billion Internet of Things (IoT) devices in use the world over, or about four per every human on the planet.

The market for these devices in the healthcare industry, a category that includes everything from "smart" hospital beds and thermometers to electrocardiograms and medicine dispensers, will reach $646 million by 2020, according to Business Insider, up from $95 million in 2015. Although, these figures do not actually include sales of health-related sensors, but the less critical mobile digital devices for sports and weight loss. According to Harvard Business Review those consumer devices have attracted a combined $14 billion in investment since 2011.

An exciting possibility would be the ability to provide secure networking between patients and healthcare providers via the patient's electronic health record. This would also give the individual the ability to actively participate in their health management by being the mediator if their own data. Users can decide by themselves who has access to their records and thus are able to make their relevant healthcare data available where needed. This could potentially allow a patient to spend less time in a hospital, allowing a treatment to be controlled by the doctor to the patient at home. Imagine the possibility of having a doctor's visit from the comfort of home. Armed with this and other information, patients become more involved in their well-being, better able and motivated to "safeguard their own health", and to seek "affordable, responsive care at their convenience."

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Growing amount of players in the rapidly expanding Internet of Medical Things (IoMT) Illustrations: Dmitri Broido

The benefits of remote monitoring of chronic diseases are paramount, especially for patient comfort. Patients with chronic diseases can better collaborate in the treatment process and benefit from a more continuous and coordinated care. In many cases, chronically ill patients now can be monitored at home and avoid hospital visits and stays, with their attendant high costs and greater risk of hospital-acquired infections.

The IoMT includes more than mobile devices. It includes cloud-based platforms hosting applications that will bring together siloed data from various kinds of devices, that have been obscured from each other throughout the healthcare industry. In doing so, create useful data to bring healthcare insights and professionals together in order to advance medicine and human health.

Through platforms, institutions, hospital chains, or integrated delivery networks can generate data insights, be it from operational or clinical data, allowing for transparency and instant access to statistics. This will empower healthcare professionals to identify improvement potential on all levels of execution.

The benefits don’t end with statistical optimization but extend far beyond the numbers. A more concrete example would be radiation dose optimization in medical imaging by using benchmark efficiencies in each type of scan. This is an important milestone in reducing dose to the patient. Consolidated data insights can also help with regards to asset optimization to help department managers in healthcare centers to improve utilization rates of available equipment.

Healthcare 4.0

Healthcare 4.0 refers to the latest evolutionary stage of healthcare digitalization, in which advanced analytics software and AI is helping doctors and hospital managers make more accurate diagnoses and better treatment decisions. Huge volumes of data are flowing into the cloud not just from doctors' offices and imaging centers, but also from remote devices and sensors worn or operated by patients. The data is helping to shape better informed healthcare management decisions, while raising hopes for significant gains in efficiency and cost control in the coming future.

Healthcare 1.0 was in the beginning of digitalization in the early 1990's when doctors changed from hand written notes to logging patient data into computers which were then stored and managed with systems such as PACS and RIS. Although the change gave doctors better and faster access to patient data, nothing really changed in doctor-patient workflow. Next came Healthcare 2.0, in which hospitals began to adopt systems to integrate and manage the digital data that staff were collecting on their individual computers and instruments. Workflow at hospitals and doctors' clinics began to change as managers adapted to patient trends and this was made evident by all the data being aggregated in clinical environments.

Healthcare 3.0 blossomed with a main objective of compiling all patient data into electronic healthcare records (EHR) to which every individual had full access. In addition to data collected by doctors, individuals could add extra information to their account, such as self-monitoring data from wearables or genomic information.

With the rising deluge of data being processed with AI, came the thrust forward into the latest iteration, Healthcare 4.0. These immense volumes of information are coming in from multiple sources connected to the expanding IoMT. Healthcare 4.0, in its roots, assumes that digitalization is no longer just a technical distinction, but a trend transforming healthcare processes and business models, thus enabling healthcare providers to expand precision medicine, transform care delivery and improve the patient experience.

Healthcare 4.0 is all about capturing the vast amounts of data and putting it to work in applications. The increasing utilization of remote care and "telemedicine" are signs that these applications are becoming a reality. For example, the outsourcing service provider Telemedicine Clinic reports, that its interpretations of images sent from a remote location increased to 450,000 cases in 2016 from 100,000 in 2010. The ability to send images via the internet to highly specialized radiologists can only result in better diagnoses and more targeted treatments. This is expected to help the market to reach a value of $4 billion in 2019.

"Healthcare 4.0 is all about capturing the vast amounts of data and putting it to work in applications."

Healthcare 4.0 allows providers to connect more closely with their patients

Artificial Intelligence

In simple terms, Artificial Intelligence (AI) is the process by which sophisticated software enables computers to mimic or even emulate human intelligence and decision-making. How does it do that? By applying software algorithms, which is a decision-based process or a set of rules to be followed in problem solving operations or calculations, in this case, by a computer.

Algorithms are used extensively, for example, in internet search engines and language recognition on smart phones. Although, intelligent algorithms have been used for some time in segments of the imaging field, new methods of machine learning rooted in "deep learning" are much more powerful. AI systems will take this algorithmic learning and apply it to analyze and learn from patient data, providing insights for doctors in making more informed and accurate recommendations. In the next five to ten years, AI will transform diagnostic imaging by speeding up critical workflows, preventing diagnostic errors and reducing missed billing opportunities.

Put more simply, AI and its "predictive analytics" helps medical professionals to recognize patterns common to past cases and apply that learning to new patient cases, whether it's through imaging procedures or laboratory results. The big distinction between AI and other non-AI software is that it has the ability to learn and improve over time from new data and experiences.

The important base material for AI-powered "outcomes" is an important "connector": Individual electronic health records (EHR) that help aggregate patient histories with in-vitro, in-vivo, genomics information, lab data and much more. With patient permission and understanding, AI-powered technology will take this vast amount of data and transform it into actionable insights. This AI-assisted technology generally has been dubbed the diagnostic decision support system (DDSS) and surveys have shown it to improve diagnostic accuracy by nearly 9%. Significant gains have especially been reported in recent years in AI-assisted cardiac risk assessment. AI can cull through hundreds of thousands of cases to calculate where a heart patient fits into a risk "stratification" to inform cardiologists' decision making.

Contrary to popular belief, AI simply cannot replace the medical proficiency of a radiologist. Although, what it can do is help relieve some of the workload being placed upon radiologists, by reducing some of the more tedious tasks involved. The problem is that there are not enough radiologists being certified each year to keep up with growing demand, due in part to the continuously growing amounts of radiology exams. To keep up with this increasing demand for the expertise of a radiologist, it will be the use of AI that makes their jobs more efficient and effective.

AI is a critical element in the rise of "digital twins", a computerized model of an organ, and the ability to simulate, in advance, how the real organ will respond to a procedure or treatment. AI makes the digital twin not just a pretty image on a surgeon's or radiologist's computer monitor, but it will use it to run simulations to make informed predictions of which actions will produce what results.

"AI can cull through hundreds of thousands of cases to calculate where a heart patient fits into risk "stratification" to inform cardiologists' decision making."

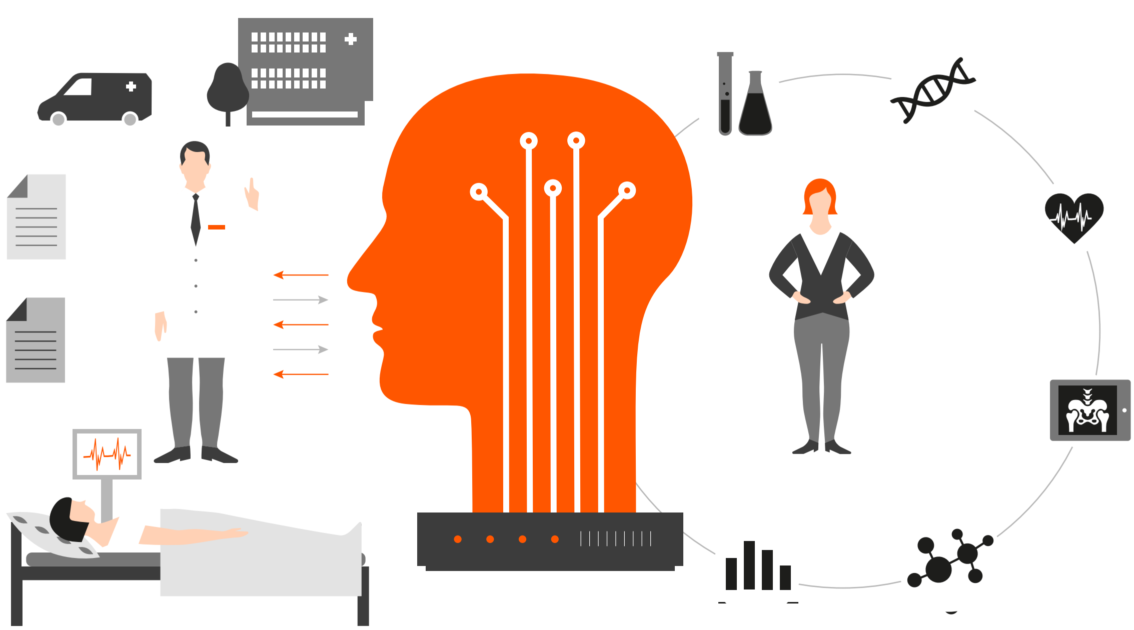
Perhaps one of the more dramatic recent outcomes related to digital twins, was the successful separation of conjoined sisters in 2017 by surgeons at the University of Minnesota who first consulted a three-dimensional model of the sisters' intertwined hearts. They wore virtual reality goggles to navigate the girls' organs and identify critical anatomical defects before altering their original strategy, which was later credited with saving the girls' lives.

Other breakthroughs include AI applications to help tuberculosis screening, especially in regions with limited medical resources and personnel. They are also benefiting from deep learning algorithms for analysis of chest scans to identify people who have an increased likelihood of the disease and need for further testing. A recent US clinical trial using AI to analyze head images, came up with improved detection of intracranial bleeding, yet another lifesaving advance. Many other AI applications, including for the analysis of lung and liver cancers, are at a practical development stage and a growing number of algorithms are now approved for clinical use by the US Food and Drug Administration.

New AI-powered advances in image interpretation for computed tomography (CT) data sets are changing the way we look at the reading process. AI already has the ability to look through the vast amount of information generated by the machines and automatically highlight abnormalities, segments anatomies, and matches results with reference values. This can speed up the reading process by reducing the time of visualization and reporting through software that automatically performs measurements and prepares results for reports.

One of the many challenges for clinical adoption of AI, according to a study by Canadian radiologists, will be to integrate AI-powered software into picture archiving and communications systems (PACS), the means by which millions of diagnostic images are stored on accessible databases. This is something that developers should keep in mind for their AI-powered solutions.

Ever cautious, the FDA has nevertheless been receptive to AI and cognizant of the efficiency, cost cutting and research gains to be gleaned therefrom. The FDA recently permitted marketing of some AI-driven healthcare tools, for example: tools to interpret images of the eye to detect diabetic retinopathy, tools to analyze indications of a stroke using computed tomography angiography (CTA), as well as technologies to detect hard to identify wrist fractures.



AI helps analyze and evaluate data and thus helps in decision-making

Cybersecurity

Many medical professionals and healthcare managers are concerned about cybersecurity, and their concerns are not misplaced. Patient records, such as EHRs, are coveted by hackers for their high street value estimated at $50 each on the black market, according to a Harvard University study. Why? Because they contain social security numbers and credit card information that identity thieves can use to drain bank accounts and run up credit card purchases. Some patient diagnoses even have been used by organized crime for blackmail purposes.

Sophisticated hackers are also attempting to steal intellectual property: such as experimental procedures for surgery, test and studies results, trial subject information and drug formulas, the same Harvard study found. According to a 2016 investigation by the Ponemon Institute, the average US healthcare facility is a victim of one cyber-attack per month, and half of them "experienced the loss or exposure of patient information." Likely adversaries include not just individual hackers and criminal groups, but political groups, paparazzi and terrorists. UCLA's medical center has even said it blocks millions of hack attempts per year. The methods hackers use to gain access to records include physically accessing data with USB drives, the installation of ransom spy-ware and theft of hospital staff's mobile devices.

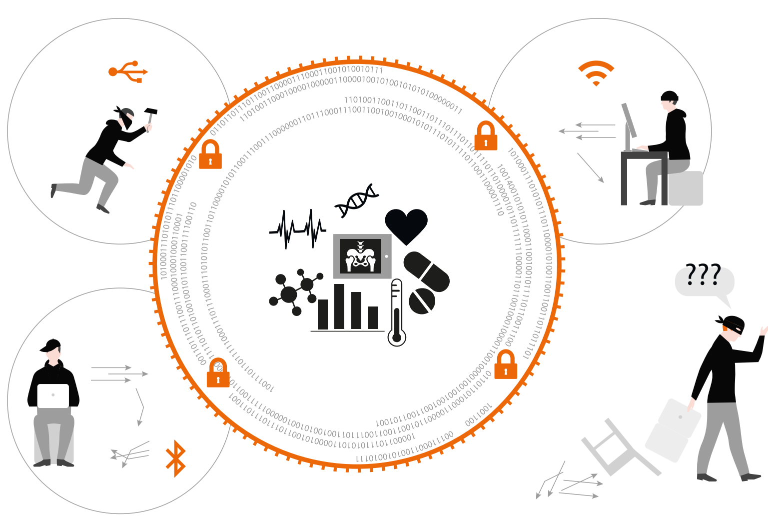
The greatest risk to healthcare facilities may be the management's and medical staff's lack of awareness of the sophistication and determination of hackers, the researchers found.

The American Hospital Association recommends a slate of measures that institutions can take to boost cybersecurity, including:

- The creation of a dedicated team to first assess current cybersecurity measures in place and establish procedures to improve it.
- Using experts to set up contingency plans in the case of a cyber-attack.
- Engage in regional or national information sharing organizations to learn more about cybersecurity issues and safeguards.

Unfortunately, hospital managers are far more likely to devote resources to acquiring new technology than setting up a security apparatus to protect what they have. Of course, the responsibility of protecting the hospital infrastructure and data lies with the hospitals, but vendors must ease this burden by delivering security measures already built into their products.

After all, a car company wouldn't sell a car without locks. At a bare minimum, vendors need to be complying with internationally accepted standards and procedures upon delivery. One thing that cannot be forgotten is that there is no such thing as "100%" security, even with the strongest security policies, but what can be done is to provide dynamic yet reliable tools and after sales services. Services that regularly update, monitor and establish connections to help strengthen the partnership between vendors and hospitals to keep up with the ever-evolving cybersecurity threats.



Cybersecurity: Managing risks in the digital age

The scientific overlay is not that of the individual pictured and is not from a device of Siemens Healthineers. It was modified for better visualization.

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