

The Hospital of the Future Starts Today



From electronic health records to the practice of precision medicine, **technology has fundamentally changed the way we practice patient care.**

Where We Were

Scalpels, syringes, stethoscopes, and microscopes, all are examples of significant technical advances in medical care for their time. These instruments were developed to not only help doctors become more efficient but also to improve patient treatment.

Today, this practice remains unchanged. The reasons for advancements in the medical industry are based on the principle of bettering patient care while increasing efficiencies for physicians and healthcare providers.

Where We're Going

Technology enables us to leap forward in the way healthcare professionals deliver patient care. Whether it's quickly pulling up patient health records, sequencing genomes, or digitizing pathology slides, technology is driving human progress and changing the way patient care is delivered. Healthcare organizations are turning to technology to achieve the Quadruple Aims- reduce costs while improving population health, the patient experience,

and overall team well-being and productivity. The overall goal of the quadruple aim is to provide a framework for organizations to help avoid effects such as physician burnout, while striving to reduce costs and provide better care at a higher efficiency than before.¹ This is obviously no easy feat, however turning to technology and data may help.

Healthcare data is expected to exceed 10ZB by 2025.

Source: IDC White Paper, sponsored by Dell Technologies, Storage Infrastructure Better Enables Healthcare Providers to Get the Most Out of Digital Transformation, doc #US49765522, October 2022

By leveraging technology to enhance patient care, data subsequently is being generated at tremendous rates. Simply put, healthcare data is exploding. Patient data is comprised of health records, medical images, billing, and insurance information, and more recently, analytical, clinical, and descriptive measurement data being sent from the edge by Internet of Things (IoT) devices and wearables.

This data is one of greatest resources a health institution can have as it can unlock even greater insights into patient care and expand the care continuum into the home. However, it would be nearly impossible for one individual to analyze and make sense of all that information for one patient, never mind all the patients across a health system.

When it comes to data, technologies like Artificial Intelligence (AI) and Machine Learning (ML) can make a substantial impact on the speed in which we collect and analyze data and may help in clinical analysis and diagnosis. As many health systems are becoming part of an Integrated Delivery Network (IDN), these networks may turn to technology such as AI and ML to improve care quality while expanding the care environment from hospital to home. In an effort to support the Quadruple Aims, AI may be helpful across this broader network. So, what does this mean in healthcare?

IDNs and individual care facilities are turning to technology and AI as they begin to deploy new workloads and advanced tools. We are only beginning to scrape the surface on the topics outlined in this paper as many could warrant their own discussion. This paper will outline how AI and ML, along with new technology, can change patient care and help healthcare organizations gain efficiency while delivering better quality care and reducing costs.

Electronic Health Records



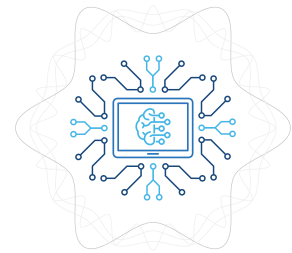
When technology in healthcare is mentioned, most people think about Electronic Health Records (EHR).

EHRs have become the standard for storing patient records, greatly increasing the quantity of data that physicians have on a patient at any given time. This portfolio of patient data encompasses a large portion of, if not their entire, medical history and it enables physicians to make an educated diagnosis and develop a customized treatment plan at the point-of-care.



Some doctors have struggled to adopt EHRs, which require extensive IT integration into the patient and physician relationship. The result has forced doctors and other clinicians to interact with devices in front of their patients, which can lead to feelings of disconnect. If this practice is completed after the exam, crucial information can be left out of the record by mistake and can distract doctors from effectively running their practice.

Having a holistic and complete health record is as important as ever. As patients turn to direct interaction with their own records, more demand is placed on the EHR software and supporting infrastructure. In order to meet and exceed overall patient expectations, this data must be easy to find, updated in real time, and allow direct access to physicians and care facilities. EHRs must allow integration with wearables and other mobile medical devices as the care continuum expands beyond hospital walls.



With the introduction of a type of AI called Natural Language Processing (NLP), doctors can use spoken language to add information to EHRs. NLP is a computer's ability to comprehend natural language intelligently. While AI is working in the background populating the patient's record, doctors can engage with their patients instead of a computer. A crucial aspect of this advancement is the time it would give doctors back to spend with patients and avoid burn-out.

2X amount of time physicians spend on EHR admin vs time spent with patients.

Source: Christine Sinsky, Lacey Colligan, Ling Li, et al; Allocation of Physician Time in Ambulatory Practice: A Time and Motion Study in 4 Specialties. *Ann Intern Med.* 2016;165:753-760. [Epub 6 September 2016]. doi:10.7326/M16-0961

Enterprise Imaging

PACS & VNA

Electronic imaging, or the digitizing of medical imaging, changed the world of radiology. The idea of shifting from film to filmless was as disruptive as changing from paper charts and folders to EHRs. Advances in medical imaging are still being made today, with hospitals having entire Picture Archiving and Communication Systems (PACS) devoted to storing and accessing departmental medical images.

An emerging practice in medical imaging has been the deployment of vendor-neutral archives or VNAs.

The shift from departmental siloed imaging storage to a VNA allows physicians to look at inter-disciplinary images within records for a full view of patient care. VNAs provide doctors with agile storage and recall of both DICOM (digital imaging and communications in medicine) and non-DICOM format images and files in the same archive with supporting documentation. By leveraging a VNA, healthcare systems can access images from across the continuum and different locations, simplifying the archive of images from mergers, acquisitions, and organic growth.

Encounter-Based Imaging

Encounter-based images are typically taken at the bedside or outside of the traditional imaging departments. These photos and videos include visible light images, point-of-care ultrasounds, gate study videos, and behavioral study videos, to name a few. These images are typically not

ordered and not stored in the PACS or VNA, often getting left out of the patient record entirely. Better outcomes are achieved by creating a single enterprise imaging archive for traditional and non-tradition encounter-based images and videos, reducing care disruption and duplicate exams.

Medical imaging encompasses everything from MRIs, CAT scans, and X-Rays to sonograms, mammograms, bedside imaging, and now even pathology.



As more medical imaging becomes digitized, the doors open to more advancements in healthcare.

Digital pathology

Traditionally, biopsy samples from patients were taken and sent to the pathology department, where they were placed on glass slides and examined under a microscope. This process worked well for its time but the logistical nightmare that was transporting and storing physical slides quickly became obsolete when more advanced technology was implemented. In today's digital world, this is not an appropriate allocation of resources.

With digital pathology, whole slide imaging scanners can read and digitize samples. This gives pathologists a high-resolution image that can be viewed on large monitors by multiple doctors at once. These images can also be sent electronically anywhere in the world in a matter of seconds for expert analysis, which reduces time to diagnosis and accelerates time to treatment.

An emerging imaging workload for healthcare and research institutions across the globe is digital pathology.

Like most medical imaging, digitizing whole slide images produces enormous file sizes, which requires data storage. But once stored, these digital images open the door for AI/ML analysis.

AI & ML for Enterprise Imaging

AI and ML in medical imaging can automate tasks, recognize patterns, and help analyze images for anomaly detection. As an AI algorithm analyzes medical images, it can flag them for review by a medical professional. This helps with efficiency as providers can spend more time on studies and cases where an abnormality has been recognized, which is a more efficient use of specialists' valuable time. By helping to build an archive of images tagged and searchable by diagnosis, AI can also accelerate cohort curation and help simplify comparative studies.

The ability to capture and digitize medical images in high-resolution, thanks to sophisticated technology, enables the practice of advanced visualization. With modern imaging technologies, advanced PACS/VNA viewing software, and the use of AI, images can now be layered together or

separated to tease out insights from within these images. By combining multiple images, 3D models can be built that allow manipulation of the image data, enabling care teams to study different aspects in new ways. Physicians and surgical teams can leverage advanced visualization to assist with presurgical planning by simply seeing more of the patient before they enter the operating room. In pathology, AI can improve the accuracy of diagnosis and help automate many of the manual time-intensive steps, such as sample identification, disease pattern recognition, and clinical classification. The final decision still rests with pathologists, but AI/ML augmented decision trees gives them time to focus on more challenging cases, reducing the administrative work associated with handling every sample, even the ones that are disease-free.

The use of AI/ML for medical imaging can aid in clinical decision support, increased diagnostic confidence and operational efficiency, helping to speed time to diagnosis and accelerate care.



Personalized Health

Precision medicine indicates a fundamental shift towards personalized patient care. The ability to build a specific treatment plan for patients based on their genome was once thought to be impossible but life sciences and healthcare institutions are now leveraging Next-Generation Sequencing (NGS) with other practices such as digital pathology to make this a reality. Years ago, it took 10 years and 3 billion dollars to sequence an entire genome. Today, the technology exists that allows institutions to sequence 1,000 whole genomes in a single week at a cost of \$3,000 per genome. These advancements bring this technology to more medical professionals for use with the broader public.

For example, an oncologist can discover a tumor in a cancer patient and send a sample to pathology. Using digital pathology, one of the top pathologists in the world for this cancer type can quickly analyze the slide and discover that this patient needs treatment immediately. Not only can the genome of the patient be sequenced, but so can the tumor. Because of what was found in the genome, the oncologist can create a personalized treatment plan known to be effective on this exact type of cancer. This is not the future; this is happening today due to advancements in human progress and technology.

With the continued adoption of new technology and the ability to harness new insights, we can begin to transition from personalized health to preventative care. By harnessing the power of the genome, preventative measures can be taken for those at high-risk of developing health issues in the future. A well known example of this is with variation in the BRCA gene which is associated with breast and ovarian cancer in woman. Early detection allows for precautionary measures to be taken if desired based on the findings from the genome.

Preventative medicine can even go a step further when the data of bedside devices is harnessed and analyzed. Many bedside devices collect patient data every second, with the average patient bed having 10 to 15 connected medical devices at a given time.² Beyond data collection for remote monitoring, the information generated by these devices can be stored and analyzed by AI algorithms. By doing so, patterns and events seen by the bedside devices can begin to be associated with outcomes. Harnessing this data, care providers can gain new insights into patient data and may leverage findings to practice preventative care.

5G

Many IoT and wearable devices send data over a local network or through the internet on a wireless network. Sending data over a wireless network can be susceptible to bandwidth issues like any other workload. This is what makes the introduction of 5G so crucial to healthcare. As data and analytics are sent and reviewed faster, patient outcomes improve.



5G will reduce the latency commonly found on 4G networks by 95%, down to 5 milliseconds.

Source: Agathoklis, M., & Tilstra, L. (2019, January 8). Verizon CEO Hans Vestberg keynotes 2019 consumer electronics show. Verizon: Wireless, Internet, TV and Phone Services | Official Site. <https://www.verizon.com/about/news/verizon-ceo-hans-vestberg-keynotes-2019-consumer-electronics-show>

5G also opens the door to advancements in telehealth. Physicians delivering care in rural areas can leverage 5G and cloud computing to build out EHRs, treat and communicate with patients, and monitor outcomes regularly. This would bring professional healthcare to those who may never have had access to it before.

Healthcare Edge

When discussing virtual health, most thoughts go to telehealth — connecting with care providers from the most remote parts of the globe, vastly changing availability and expanding patient population. The adoption of telemedicine grew during the global COVID-19 pandemic enabling the continuation of care outside of traditional healthcare settings and into the home. In fact, research by McKinsey suggests that COVID-19 caused telehealth use to increase by 38x versus usage before the pandemic.³ This shift introduced a whole new generation to the use of connected devices for physician interaction — meaning devices in our pockets can now not only connect us to our EHR, but also directly to our doctors.

Virtual Health or Remote Care also describes remote patient monitoring (RPM), which collects and monitors vital signs and other data using a body area network. Many bedside devices and wearables can send this data to a central monitoring station. RPM can span from the hospital to the home with the ability to stand up virtual ICUs with remote access to patient data or monitor patients at home as they manage their chronic conditions. The expansion of patient monitoring into the home supports multiple aspects of the Quadruple Aim — reduce costs while improving

population health, improve patient experience, and improve productivity. When patients can be monitored remotely, they are able to recover at home and in many cases leave the hospital sooner. Allowing patients to recuperate at home typically leads to better patient outcomes, experiences, and helps keep costs down by shortening hospital stays. This also allows for the reallocation of resources to care for more patients. AI algorithms can be applied to the incoming data from patients at home to help the care team monitor their wellbeing.

Another emerging tool in the realm of virtual health is the adoption and deployment of healthcare chatbots. These conversational, and in some cases, human like, platforms utilize AI and ML to respond to patients using text or voice to setup appointments, ask screening questions, and many other uses. For example, use of this technology can be leveraged for completing a COVID screening before a patient walks into an office, to interact with a patient based on vital signs sent by a wearable, or even check on someone's mental health. No matter the specific use, chatbots are designed to take some of the burden off of medical professionals and supporting staff while giving patients faster access to information.

Among healthcare organizations, 28.1% already rely on RPM, while 29.7% are piloting, researching, and evaluating it as a technology option.

Source: IDC White Paper, sponsored by Dell Technologies, Storage Infrastructure Better Enables Healthcare Providers to Get the Most Out of Digital Transformation, doc #US49765522, October 2022

Another aspect of remote care is telemonitoring and telesitting. This workflow enables at-risk patients to be watched for violence or falls without staff in the rooms. With AI, algorithms can be trained to analyze video feeds from the patient's room to predict falls or violent outbursts and alert staff before an incident occurs. Simply put, the

hospitals of the future will have their own eyes and ears that automate event orchestration for better healthcare. By focusing Artificial Intelligence (AI) on the right problems, such as in-patient remote monitoring, hospitals can have real-time access to actionable data to improve productivity while ensuring HIPAA compliance.

TELEMONITORING

**78% fewer
patient falls⁴**

TELESITTING

**66% less
workplace violence⁴**

Secure Care

Among the most targeted by cybercriminals, the healthcare industry has become the target of phishing, cyberfraud, or ransomware attacks that risk the entire institution and its data. Due to the highly personal information held within a patient record, criminals try to access files to exploit hospitals for funds or sell on the black market, with personal health information sometimes going for up to \$1,000 per patient record.* These cyberattacks result in loss of revenue and patients, a battered reputation, and legal troubles if HIPAA or GDPR requirements are violated. As

hospitals prepare for the future, a cyber resiliency strategy is imperative. These types of attacks have been on the rise since 2020 with 28% of these attacks being filed as ransomware.⁵ However, a recent IDC survey suggests that only 60% of healthcare organizations felt as though they were prepared to handle the increase in data and the security requirements around it.

Source: IDC White Paper, sponsored by Dell Technologies, Establishing Uncompromising Data Availability for Healthcare Organizations, doc #US47447321, February 2021



The value of health records can add up to **\$1,000 per patient** due to their richness as a source of data and PHI.*

**Source: IDC White Paper, sponsored by Dell Technologies, Storage Infrastructure Better Enables Healthcare Providers to Get the Most Out of Digital Transformation, doc #US49765522, October 2022*

Despite ransomware making up most of the news these days for cyber attacks in healthcare, it's important to note that hospitals and care facilities may be subjected to many forms of malicious activity similar to those of any other business. These "attacks" can range from manipulation of data such as patient information to alteration of images, to outside devices carrying malware or other destructive software. To help avoid these situations, hospitals need to protect their data and network both physically and virtually.

To protect against cyberattacks, institutions should look for solutions that not only keep patient data protected onsite and ready for fail-over or disaster recovery, they must isolate data from production using a cyber vault and implement intelligent software that can alert of malicious activity. AI can help here, too, by helping to identify threats and assist in recovery if an attack should happen.

Wearables & IoT

The Internet of Things, as it relates to healthcare, allows for real-time data monitoring and analysis using medical devices and wearables connected to a network. Like many other industries, internet-enabled medical monitoring devices found in hospital rooms to wearable devices such as fitness trackers provide vast information streams, opening the door for exponential data growth.

The average number of connected devices per hospital bed in the U.S. is 10 to 15.²

IoT in healthcare has led to a massive amount of data production. According to BMRC, connected devices allow healthcare providers to do such things as monitor patients from great distances, manage chronic disease, and manage medication dosages.⁶ Data from these devices may be added to clinical research to give more insight into the participant's experiences. Whether it is a simple data analysis from heart monitors to catching a heart attack before it occurs, this data can allow institutions to practice preventative medicine.⁷

Analyzing the individual data sent from each of these devices would be impossible. Using AI at the edge of the network, data streams can be interpreted in real-time with abnormalities flagged for review. This can be seen with video surveillance in hospitals where AI runs against video feeds of hallways and patient rooms, alerting staff to respond to patients that might have fallen or failed to take their medication on time.



Edge gateways reduce transfer and storage costs of large data sets by locally processing, buffering, filtering, and securing data. Using analytics as an aggregator and filter at the Edge can result in the following:



Improving patient safety and monitoring recovery through computer vision solutions in the hospital and at home



Expanding chronic disease management and preventative medicine with sensors that can alert providers to clinically meaningful changes and recommend early intervention



Managing pharmaceuticals and hindering drug diversion by tracking medication from manufacture to consumption

Source: Dell Technologies, 21 JAN 2020; At the Cutting Edge of Healthcare: IoT Data in Preventative Care. Retrieved 18 FEB 2020. Retrieved from <https://mhealthintelligence.com/news/at-the-cutting-edge-of-healthcare-iot-data-in-preventative-care>

Dell Infrastructure for Healthcare

The healthcare industry is developing and changing at an incredible rate, with technology becoming the driving force. Yet the workloads and emerging technology mentioned above only touch the surface of what healthcare technology and medical professionals are experiencing. By using our technology to improve the healthcare experience,

it is our commitment that by the year 2030, together we will have helped one billion people. As you begin to adopt these technologies and lean on AI and ML to support the Quadruple Aim, turn to a trusted IT infrastructure partner like Dell Technologies to help you on your journey.



Dell PowerEdge: PowerEdge servers offer enhanced performance across the widest range of applications. From rugged servers for the edge to High Performance Computing (HPC) Solutions that include NVIDIA GPU- and Intel FPGA- acceleration, the PowerEdge portfolio can support your business across workloads.

Dell PowerStore: PowerStore is a unified storage array that can simultaneously run block- and file-based applications. With PowerStore's AppsOn capability, coupled with compute and storage in a single appliance, PowerStore can easily be deployed at the edge. This capability is well suited for bedside device data aggregation and remote monitoring workloads. PowerStore also supports traditional block-based database workloads, including those for EHRs.

Dell PowerFlex: PowerFlex offers a software-defined architecture enabling a wide range of configurations and deployments ranging from edge to data center. PowerFlex offers six-nines of availability and as a clustered system can be utilized for workloads that are sensitive to latency, such as EHRs.

Dell PowerVault: The PowerVault product family offers entry-level block-based storage arrays that are purpose-built to be simple and performant. PowerVault ME5 storage delivers the performance, capacity and operational simplicity that price-sensitive, small to medium-sized businesses demand. PowerVault ME5 supports many types of workloads, including HPC, databases, VDI, safety and security, select Edge use cases and more.

Dell VxRail: VxRail is hypercovered infrastructure jointly engineered between Dell and VMware for a seamless, curated, and optimized experience. This deep integration combined with the simplicity of VxRail HCI System Software and the performance of next-generation PowerEdge servers, provides an ideal platform across core, edge, and cloud.

Dell PowerProtect: The PowerProtect portfolio encompasses data protection offerings from software that supports replication and protects data, to backup hardware and cyber solutions. CyberSense is fully integrated with the Dell PowerProtect CyberRecovery vault solution and helps to identify clean data after an attack to assist with recovery.

Dell ECS & Dell ObjectScale: ECS and ObjectScale are object storage platforms. ObjectScale is software-defined and well-suited for cloud-native applications. ECS is a scale-out platform often utilized for large archive environments or large data lakes, enabling analytic and research workloads.

Dell PowerMax: The PowerMax family offers availability, performance, and scalability to enterprise customers. PowerMax has long been trusted with EHR deployments in healthcare, thanks to its trusted data replication capabilities and its ability to deliver six-nines of availability. Offering NVMe and all-flash storage technology, PowerMax delivers on performance.

Dell PowerScale: PowerScale is an industry leading scale-out network-attached storage platform. Offering all-flash, hybrid, and archive nodes, petabytes of storage, and simplified management, PowerScale is deployed for large file environments. PowerScale is also utilized in HPC environments such as genomic sequencing as it features high-throughput and massive scale that can keep up with compute-intensive workloads. PowerScale Cyber Protection offers an integrated cyber solution that enables data to be replicated with a secure AirGap.

Validated Designs: Accelerate time to value with solutions designed for intelligent businesses while taking the guesswork out of deploying technology. Validated designs are tested and proven configurations for workloads such as AI and HPC, reducing time to deploy and may eliminate the need for testing components

Multicloud: This mix of public, private and edge Cloud architecture provides organizations with various flexibility benefits. Not all applications are right for a given Cloud solution, and a multicloud infrastructure lets IT teams deploy appropriate workloads solutions. Because public, private and edge Clouds offer distinct advantages, enterprises are likely to deploy some combination of each. Dell Technologies can help you build solutions for the multicloud world.

Dell VxBlock: VxBlock simplifies IT deployment and transforms operations by bringing together compute, storage, networking, and data protection in fully-engineered systems and validated designs from Dell Technologies. Leverage our trusted portfolio in a turnkey system to support your mission-critical workloads such as EHRs.

Dell APEX: Dell APEX offers simple and consistent cloud experiences delivered as-a-Service. The enables users to provision quickly, scale on demand, and pay as you go across your entire multicloud, multi-edge, and multi-data center environment. With Dell APEX you can consume best-of-breed Dell Technologies innovation as-a-Service, unlocking the flexibility you need for your business to adapt and thrive.

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visit [DellTechnologies.com/Healthcare](https://www.delltechnologies.com/Healthcare)

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