# The Machines are Here & are Improving Healthcare:

## The Influence of Artificial Intelligence on Healthcare


Booz | Allen | Hamilton

## How is AI Reshaping Healthcare?

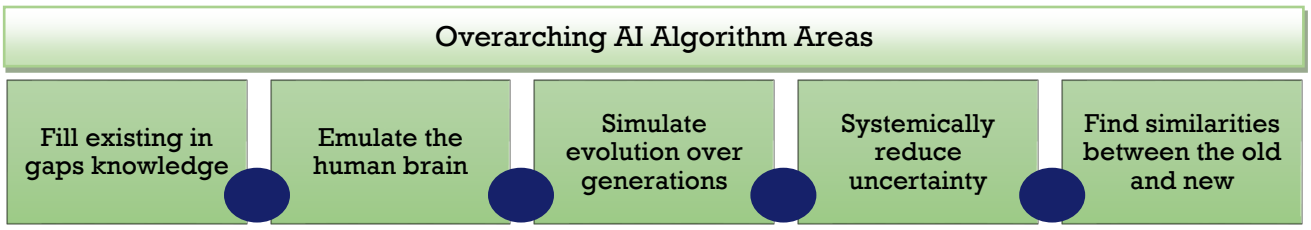
Artificial intelligence (AI), and its sub-disciplines, machine learning (ML) and deep learning (DL), are beginning to play a significant role in healthcare. As AI moves out of research labs and into real-world applications, it is becoming a disruptive force in transforming patient care. These technologies, coupled with affordable data storage and computational power, enable healthcare organizations to analyze an immense volume and variety of data. Intelligence allows for progressively deeper insights which lead to proactive care, reduced future risk, and streamlined work processes. AI technologies are providing innovative solutions for precision medicine, organizational efficiency, and improved health outcomes.

Due to the significant volume of data created during patient care, the healthcare industry is well positioned to take advantage of the advancement and commoditization of computer algorithms and hardware. AI enables more automated decision-making on important data sets emerging from the Internet of Things (IoT), electronic health records (EHRs), and patient-generated health data. AI also gives machines the ability to mimic human behavior, an increasingly valuable feature in an industry that is experiencing high costs, high rates of physician burnout, and an increased focus on the patient experience.

On September 6, 2018, eHealth Initiative Foundation and Booz Allen Hamilton hosted a multi-stakeholder roundtable meeting to discuss expert opinions on the challenges and opportunities for AI and ML in healthcare. The meeting convened senior executives from provider, government, technology, pharmaceutical, clinical research, and professional organizations, representing radiology, pathology, cardiology, and other groups. This brief addresses the state of the field and includes examples of how AI and ML are being used within the industry; the challenges and barriers to the adoption of AI; current federal government initiatives; and where AI and ML may be headed in healthcare's future.

## State of the Field

Artificial Intelligence (AI) is a broad term that goes beyond machine learning and deep learning. The foundation of intelligence is learning. Moving between deductive and inductive reasoning during the life cycle is a learning technique for both humans and machines. The machine learning process develops models by exposing algorithms to various types of data, such as medical claims, electronic health records, genomic data, and biometric readings. As algorithms process new data, they can independently adapt their models over time and modify their "knowledge" to perform better in the future, enabling AI to choose activities with the highest likelihood of success. There are thousands of AI algorithms that's purpose can generally be mapped into the five areas below.[1]



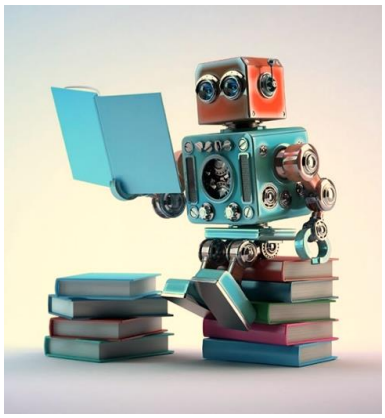

Some healthcare organizations are beginning to use data to improve the efficiency, quality, and cost of their products and services. In the pharmaceutical sector, AI is helping researchers speed up the historically slow development of new medicines and treatments. Data from ongoing clinical trials are being used to identify neurodegenerative disorders[2], optimize clinical trials[3], and speed up the drug discovery process[4]. Other real-

world applications of AI by researchers include image-based disease detection for diseases such as lung cancer and melanoma, as well as AI for text extraction. Clinical text processing, imaging, and diagnostics are particularly good for the present use of AI in EHRs, while speech enabled EHR platforms, patient monitoring, and disease prediction are poised to become viable solutions in the future.[5]

## Considerations for Starting the Machine Learning Journey

CHRISTUS Health System began their ML journey last year and is interested in growing this function as an extension of their analytics program. Hiring a data scientist and three data engineers has allowed the organization to develop a big data analytics platform. To strengthen their ML models and expand their data sets, CHRISTUS has been exploring external partnerships, in addition to what they have built in-house. When assessing their challenges, CHRISTUS realized the need for more data and the importance of a mature, well-implemented, data governance program to drive use case scope, adoption, and compliance across the organization. Other challenges have included the maturity of the infrastructure and workflow processes that help integrate insights from the ML systems and efficiently and effectively adopting other inputs into the decision making. CHRISTUS is using multiple EHRs which creates silos and difficulty when feeding data into ML models. Multiple EHRs also increases the breadth of data integration because of the variety of sources and data points. With the tech platform Apache Spark, CHRISTUS is working toward integrating data from multiple EHRs into one platform.[6]

## Machine Learning to Improve Hospital Length of Stay and Re-admission



CHRISTUS Health System is focused on accurate predictions and results, and are working with the C-suite to prioritize implementation and refinement of ML use cases that lead to better health outcomes:

- Length of Stay (LOS) and Average Length of Stay (ALOS) prediction
- LOS per patient
- Daily ALOS prediction by facility
- Patient show and no-show prediction
- 30-day readmission prediction

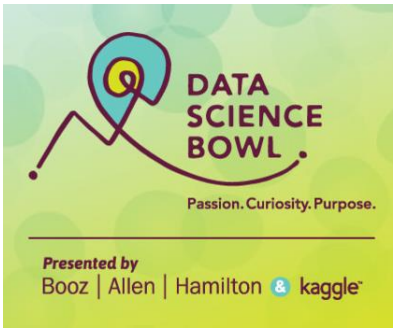
Using AI to predict LOS and re-admission has already been proven beneficial in several studies. For hospitals' admission management, the ability to predict LOS as early as the preadmission stage might be helpful in monitoring the quality of inpatient care. Additionally, the ability to predict an individual patient's LOS as an initial assessment of their risk is critical for the development of efficient admission policy and better resource planning and allocation, especially when resources are limited. In a 2016 study to develop artificial neural network (ANN) models to predict LOS for inpatients with one of the three primary diagnoses—coronary atherosclerosis (CAS), heart failure (HF), and acute myocardial infarction (AMI)—ANN correctly predicted LOS between 64% and 92% of the time depending on the diagnosis.[7]

Children's Hospital of Orange County (CHOC) developed a model to predict patients' risk of unplanned readmission within 30-day. The tool allows CHOC's care management staff, physicians, and others on the care team to proactively focus on patients determined to be at high or moderate risk of being readmitted, prior to their initial hospital discharge. Their model outperforms any other readmission model in pediatrics.[8] In the context of CHOC's patient population, more than 50% of patients labeled as high-risk to be readmitted, were in fact readmitted. Moving forward, CHOC is developing interventions for these patients and evaluating which are most effective in preventing readmissions.[9]

## Machine Learning Helps Detect Lung Disease in CT Images

Traditionally, lung cancer detection has relied upon radiologists reviewing each individual image for a patient. Technologists have struggled to use ML to assist radiologists in sorting through images and identify images that are clear of lung disease. In recent years, low-dose computed tomography (CT) scans have shown great potential for early detection of lung cancer, however they also have high false positive rates that can lead to unnecessary treatments. Patients are sometimes flagged as potentially having lung disease and undergo further testing to rule it out, which causes unnecessary costs and delays for those patients who are ultimately deemed healthy.

Using imaging data from the National Cancer Institute, the winners of the 2017 Data Science Bowl created algorithms that can accurately determine when lesions in the lungs are cancerous. The Data Science Bowl is a competition brings together data scientists, technologists, and domain experts across industries to take on the world's challenges with data and technology.[10] Preliminary findings demonstrated a meaningful decrease in false positives and the current best-in-class approach was outperformed by 10%.[11] If these algorithms could be replicated across the country, patients might receive earlier diagnosis and begin treatment sooner.




## Janssen Applies AI to Predict Dementia

Diagnosing dementia and other neurodegenerative disorders is a challenge to clinicians. There is no definitive test to assess the likelihood that a person may develop dementia. Janssen Research & Development, LLC, a company within the Johnson & Johnson group, and their technology partner are working to use AI to analyze the linguistic diversity of patients in relation to dementia.

Using Janssen's growing collection of speech data acquired from ongoing clinical trials, the software detects and records over 400 quantifiable variables in a patient's speech pattern. These variables are then analyzed for complexity, articulation, and content, and compared with the usual speech patterns of those diagnosed with Parkinson's disease, multiple sclerosis, and Alzheimer's disease. This partnership between two innovative companies may one day lead to the ability to predict dementia and other neurodegenerative disorders.[12]

## Scanning EHR Data for High-Risk Conditions in the ED

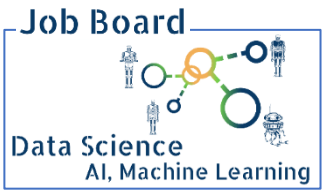
Emergency department (ED) providers have limited time to sort through hundreds of documents in a patient's electronic health record. New technology uses AI to sort through thousands of pages of text in a matter of seconds. Dictation Lens, a recent finalist in the Cerner code app challenge, is a smart document viewer currently in a pilot phase at MedStar Health. Clinicians are testing the app, which processes patient information pulled from the EHR, through an algorithm designed by data scientists at Booz Allen. Using ML, clinicians use the interface embedded in the EHR to filter keywords and jump to the part of the EHR that is most relevant, including high-risk medications and conditions. This feature reduces the time that clinicians need to review notes, as well as the possibility that critical information will be missed[13].

## CHALLENGES TO THE ADOPTION OF AI AND ML IN HEALTHCARE

Although AI has opened a multitude of opportunities for healthcare to improve quality, efficiency, and cost, many more strides need to be made before AI reaches its full potential. Across the healthcare spectrum, organizations face various challenges:

> "Typically, 80% of machine learning is data curation. In healthcare, it is multitudes worse."
>
> *--David Parish, Google Cloud*

- **Access to data sets that are large, clean, and unbiased.** Machine learning often requires large data sets in order to develop effective models. Some organizations have limited resources and those that can afford to pay for this data are not sure if it is high quality and reliable. These issues are leading the industry to explore ways to better use smaller data sets, improve existing data, and take advantage of new technologies and standards, such as blockchain-based data-sharing and FHIR HL7. These technologies can break down barriers and facilitate data sharing, giving organizations access to the volume and variety of reliable data required to inform model development.
- **Curating data is complicated, and takes time and money.** Even if an organization has access to large data sets, they must prepare the data for analysis. A lack of widely adopted metadata standards and inconsistent quality of metadata can render analysis problematic. *Data curation* complements data governance and is a means of managing data to make it more useful for discovery and analysis. Curation requires significant financial investments in tools and the workforce. Without the process, organizations run the risk of producing machine learning models based on factually inaccurate information. Data curation includes authentication, management, archiving, representation, preservation, and retrieval.
- **Data ownership is unclear.** Healthcare organizations have historically collected patient information but recognize that individuals have a right to their own data. Organizations want to allow patients control of their information but also want to promote methods of data exchange that will support medical diagnosis and machine learning within and between healthcare institutions.
- **Privacy concerns abound.** Some organizations feel as if a *comprehensive* strategy around privacy and ethics is missing from the conversation. Machine learning uses millions of sensitive patient information data points across various stakeholders. Data must be protected, and security professionals are tasked with applying their expertise in a new context.
- **De-Identification liability.** De-identification is the process used to prevent a person's identity from being connected with information. When sharing data with vendors, providers are faced with the challenge of determining who will take responsibility if there is an issue related to improper de-identification. In general, providers may not be able to afford to pay fines related to issues caused by a vendor, the lawyer fees accumulated during negotiations, and insurance policies.
- **Access to a knowledgeable, sustainable, and agile data science workforce.** Healthcare organizations do not have enough data scientists to conduct AI and ML activities. Some find they are unable to offer salaries comparable to technology, consulting, data, and AI companies, and struggle with developing the necessary teams. Organizations would like to see pipelines established that train and develop recent data science graduates, enabling a workforce that is capable of addressing the needs of patients in today's technology-driven world.




- **Lack of core digital technologies and strategies for the ethical development and deployment of AI solutions.** Before adopting AI and ML, organizations need to commit to aquiring core digital technologies to support AI and to building a strategy for the ethical development and deployment of AI solutions. A platform with essential data management and computational tools is a necessary, as is a strategy that will enable the respsonsible diffusion of AI throughout the organization.

## FEDERAL INITIATIVES THAT SUPPORT AI/ML

AI is impacted by current federal policies and initiatives. Agencies such as the Food and Drug Administration (FDA), Department of Health and Human Services (HHS), and the National Institute of Standards and Technology (NIST) are attempting to close gaps in data, promote standards that enable AI/ML, and build an innovative workforce.

### HHS Data Strategy to Leverage Advanced Analytic Tools & Predictive Modeling

HHS is currently in the process of building and implementing an enterprise-wide data strategy. Every day, agencies across the federal government collect data that can be used to understand the health of the population of the United States. Sharing this data across agencies is essential to minimize costs, maximize efficiency, and leverage advanced analytic tools and predictive modeling. Developing a data strategy that is core to the function of organizational performance includes the implementation of a cohesive data governance structure, a platform that encourages data sharing, acknowledgment of data as an asset, and designing policy around evidence.[14]

A small team of HHS staff, led by Chief Data Officer Dr. Mona Siddiqui, recently interviewed leadership and staff from various HHS agencies, including the National Institutes of Health (NIH), Centers for Disease Control (CDC), FDA, Centers for Medicare and Medicaid Services (CMS), and Agency for Healthcare Research and Quality (AHRQ), to determine the biggest challenges and opportunities in sharing data between agencies. To determine priority areas, the team asked departments how they could be more effective and efficient. A recently released report highlights the technical, legal, and cultural challenges that prevent data from being shared across agencies and opportunities for making HHS a more data-driven organization.[15] The next step is identifying use cases for data integration and analysis and implementing a proof of concept that demonstrates the business value of data sharing. HHS has already initiated data science training programs and found positive demand from staff.

### New Regulatory Framework to Promote Innovation at the FDA

The FDA recognizes the promise that AI holds for the future of medicine. It is developing a new regulatory framework to promote innovation and support the use of AI-based technologies. Algorithms and code are in cultivation for community use through academic and start-up partnerships.[16] A transparent benchmarking system to track the algorithm performance of AI is also underway, which would help payers and providers compare AI systems against standards of care provided by humans. Other areas of exploration include working with AI experts in sectors that are already widely using AI platforms and better understanding of the ways real world data flows from various areas—pathology slides, electronic medical records, wearable devices, and insurance claims data.

The FDA is striving for a more holistic approach. The agency found that most patients do not have access to clinical trials, therefore trials do not truly represent the population. Through their Oncology Center of Excellence's Information Exchange and Data Transformation (INFORMED) initiative, the FDA is working:

- To incorporate diverse pipelines of real-world data into the big data environment
- Towards the transformation of FDA's existing clinical trial data sets into a common standard
- To develop a big data environment for storage and mining of transformed data sets and programs, which support the creation of a data science workforce[17] [18]

## An Integrated Data Platform Concept at NIST


The mission of NIST is to "promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life." In this vein, NIST is applying AI and ML technology to advance its various mission areas including material science, robotics, and biomedical imaging. NIST is also working to develop measures and standards that will facilitate trust, reliability, and understandability of AI/ML technology. The "Diagnostic Cockpit of the Future" is a proposed integrated data platform concept promoted by the Academy for Radiology & Biomedical Imaging Research, its members, and NIST. Stakeholders have been convening to discuss how a "diagnostic cockpit" platform would give clinicians access to the data required to diagnose patients, while AI would facilitate data analysis and visualization, and decision support.

This type of system would require large volumes of data, creating a need for standards for large and complex data streams. The group seeks to leverage and augment existing standards and is focused on identifying standards such as for new data formats, imaging protocols, performance metrics, human/computer interfaces, and data visualization techniques.[19] The next phase of the project will be to determine a proper implementation and collaboration environment, identify relevant standards and gaps, collect on the order of 100 comprehensive datasets from 10 different institutions, further refine the core functional requirements of the diagnostic cockpit, and identify potential sources of funding for resulting initiatives. [20]

## WHERE ARE WE HEADED?

Today, machines are able to outpace humans on a number of complex tasks and can respond to human commands, select the best treatment for disease, learn human tastes and preferences, and perform narrow tasks better than humans. While AI has the potential to revolutionize the future of healthcare, it is important to separate the hype from reality. Without the ability to intuitively understand the context of a situation, AI cannot comprehend in the same way as a human. AI cannot speak conversationally about any topic chosen, understand human emotion or humor, or teach itself new skills independently.

In the buildup around AI, there has been concern for large-scale job loss in the healthcare industry. AI may automate some medical tasks in the future, but for now, it acts as an opportunity for a more human-centric approach to augmentation. Augmentation combines the speed and accuracy of AI with the perception, empathy, and experience of humans to create better outcomes. Rather than completely replacing the jobs of human diagnostic teams, AI tools can perform complex weighing and correlation-finding calculations in a shorter amount of time, allowing for faster identification of patterns and a reduction in the cognitive burden of human diagnostic teams. These tools would not be used for tasks that physicians can do easily, but rather for problems that machines can solve more easily and accurately, and ultimately, more affordably. AI does not make decisions for physicians and can instead act as a safety net, reviewing longitudinal information in the EHR and reducing adverse safety events.

> "One model does not rule them all. You may have the best answer for your world in a soda straw, but it may not be the best one overall."
>
> *-- Josh Sullivan, Booz Allen Hamilton*

With AI and ML in play, more non-traditional organizations are entering into the healthcare space. Google Cloud is in a position to collect and use huge volumes of data for ML and recognizes that, in the next 20 years,

healthcare will be the biggest part of the market. Healthcare is a valuable investment of its resources. For organizations planning to leverage these technologies to improve patient outcomes, operational efficiency, and costs, three key considerations exist:

- **Think through the entire process before implementation.** Determine whether the necessary data is available and how performance of algorithms will be monitored throughout a continuous, lifelong learning cycle.
- **Think carefully about the utility of the algorithm.** The threshold for acceptance depends on the use of the algorithm. A model that is appropriate for one use case may not be applicable to others. Also consider whether it will impact the way business is conducted in any material way.
- **Determine how much it will cost to integrate AI into the workflow.** Consider the use of already existing tools and do not invent new workstreams.

If the healthcare industry wants to recognize the potential of AI, careful planning and consideration are necessary. As AI advances and the industry begins to benefit from it and other initiatives, healthcare entities need to decide the specific uses of AI within their organizations and how those uses fit into workflow and operational costs. Although AI can offer providers relief from time-consuming tasks, AI's primary role should always be to support and augment. The federal government is attempting to address challenges through various initiatives, but organizations are still challenged by inadequate access to data sets and a skilled workforce, while questions related to privacy, liability, and data ownership linger. Over time, AI will help the industry improve care, efficiency, and costs.

## END NOTES

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