



## **The future of artificial intelligence in health care**

How AI will impact patients, clinicians,  
and the pharmaceutical industry

# Contents

<b>Introduction</b>	<b>3</b>
<b>AI in health care: A high-level view</b>	<b>4</b>
What is AI and how could it improve health care?	4
Creating more complete patient profiles through NLP	5
Using ML to improve insights into prevention and treatment	6
<b>The impact of AI on patients, clinicians, and pharma</b>	<b>7</b>
Patient-facing AI: Improving experiences, costs, and outcomes	7
AI for clinicians: Tools for more effective diagnoses and treatment	8
AI for pharma: Reduced time and cost for drug discovery	9
AI for more informed and effective treatment plan design and delivery	9
From clinical to operational: How big data and analytics can improve outcomes and efficiency	10
<b>Looking ahead: The future of AI in health care</b>	<b>12</b>
A better patient journey	12
New ways to deliver care	14
New risks to address	15
Leveraging lessons learned	16
<b>Summary</b>	<b>17</b>

# Introduction

Artificial intelligence (AI), in varying forms and degrees, has begun to appear in a wide spectrum of technologies, from the phones we use to communicate to the supply chains that bring goods to market. It is transforming the way we interact, consume information, and obtain goods and services. Health care is no exception. In health care, the impact of AI, through natural language processing (NLP) and machine learning (ML), is transforming care delivery. As is the case in other industries, it is expected that these technologies will continue to advance at a rapid pace over the next several years.

After briefly describing AI, NLP, and ML in the context of health care, this paper explores how current and future applications of these technologies might impact patients, clinicians, and the pharmaceutical industry, and enable meaningful improvements in the practice of medicine and health care over the next decade.

# AI in health care: A high-level view

## What is AI and how could it improve health care?

The Oxford Dictionary defines AI as “the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.”<sup>1</sup> In health care, those tasks can range from simple to complex, and include everything from answering the phone to medical record review, population health trending and analytics, therapeutic drug and device design, reading radiology images, making clinical diagnoses and treatment plans, and even talking with patients.

For discussion purposes in the context of health care providers, AI in health care may be grouped into three broad categories:<sup>2</sup>



Patient-oriented AI



Clinician-oriented AI



Administrative and operational-oriented AI

Another important categorization schema to consider is artificial narrow intelligence (ANI) vs. artificial general intelligence (AGI). ANI is a category description for systems designed for specific tasks. Like many industries, health care has adopted the ANI category of AI in silos to perform distinct functions. ANI is currently available today in many forms (e.g., voice-to-text software, map applications, chatbots, etc.). The technology is easily within reach of most businesses and is designed to perform simple tasks faster, cheaper, and with less error than a human performing the same tasks.

AGI describes theoretical systems that have the capacity to reason across a variety of topics and activities. AGI in health care, or in any setting, is still in very early stages of development. The system would theoretically be able to do the job of all the human resources along the patient journey. The extent to which AGI is implemented and the controls placed around what systems should and should not be allowed to do, is still a matter of hot debate.<sup>3</sup> The current trend in most industries is use of narrow AI<sup>4</sup>, and for the purpose of this discussion, we are referring to ANI whenever we mention AI.

As is the case with any evolving science, there is debate over classification and overlap of its branches. For the purposes of this discussion, we are focusing on two distinct branches of AI, namely natural language processing (NLP) and machine learning (ML). These branches can be thought of as slightly overlapping subsets of AI. This overlap is explained further in the following sections, and a schematic representation of these relationships is shown in figure 1.

## Creating more complete patient profiles through NLP

NLP is AI that converts human language into a structured and understandable format that computers can then use to perform various computational analysis and other tasks. Computers have no built-in understanding of human language. Without further instruction, they cannot dissect human sentences to identify sentence structures such as nouns, verbs, and adjectives, much less determine which noun an adjective refers to or comprehend the concept of negation. As such, this data is in an unstructured format. NLP attempts to address these deficiencies by running text through a program designed to codify human language, called an NLP engine. The output of the NLP engine is a set of structured information reflecting the content of the submitted text that computers can understand and act on.

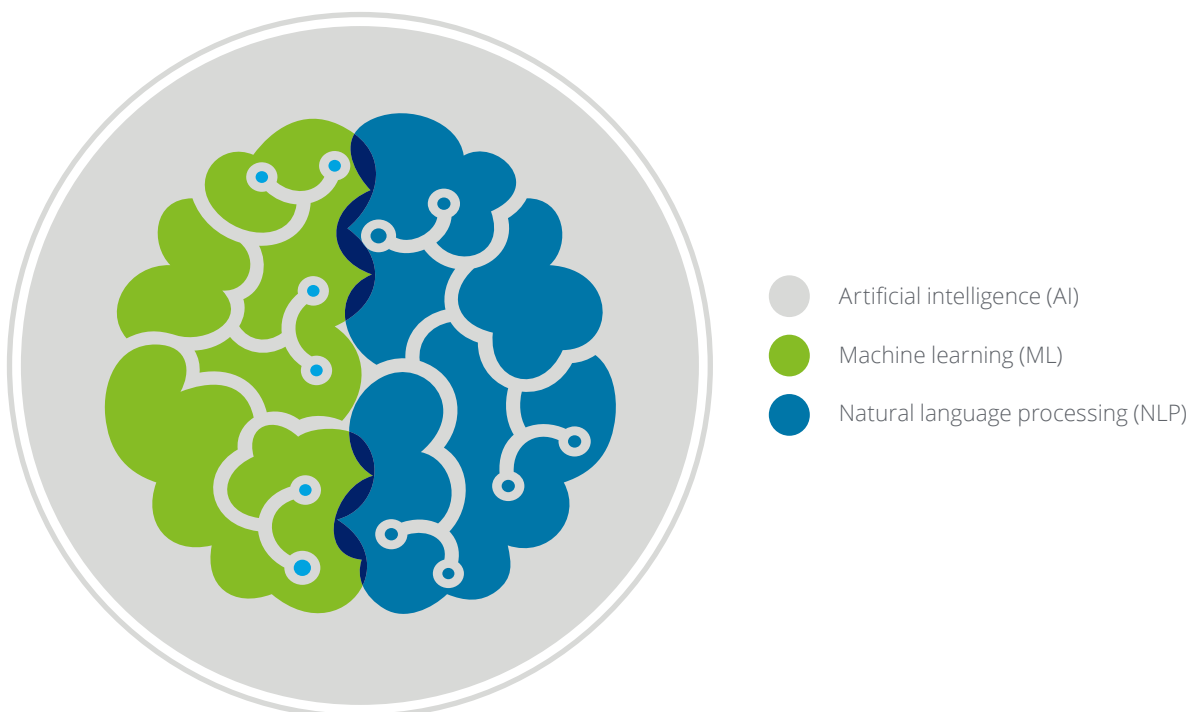
While NLP can be applied to many fields and industries, its use in health care is particularly important. Although the increasing use of electronic medical records has resulted in much more clinical information being documented in a codified and structured fashion, there is still a significant amount of clinical information that is documented via a variety of unstructured methods, including dictation, typing, and writing. Even though this unstructured “free text” can provide valuable information to a human who reads it, any valuable information contained within it cannot be analyzed and

used by a computer until it has been codified and structured. Within health care, the use of NLP therefore allows free text information that has been entered into the patient record to be turned into potentially useful data that a computer can use.

An example of NLP applied in a clinical setting is the conversion of information from transcribed history and physical dictation into data representing the patient’s problem list, medication list, allergies, past medical and surgical history, family history, and social history that can be stored in a codified fashion in an electronic medical record. Other health care use cases for NLP include converting the information in a transcribed mammography interpretation performed by a radiologist into codified mammography registry information, and adding non-codified information contained in electronic documents from other hospitals to the patient’s existing electronic medical record as codified data. When supplemented with the use of speech-to-text applications that convert spoken words into text, NLP can be used to turn dictated speech into structured and codified information that is usable by a computer application.

Referring back to the overlapping area in figure 1, NLP solutions often employ machine learning algorithms to achieve their results (see explanation of machine learning below).

Figure 1. Machine learning (ML) and natural language processing (NLP) are subsets of artificial intelligence (AI) that are often used together to achieve specific results.



## Using ML to improve insights into prevention and treatment

Machine learning (ML) is also a branch of AI. At its most basic, ML is the practice of using algorithms to parse data, learn from it, and then make a determination or prediction. This “learning” enables systems to act without being explicitly programmed to do so. While this concept has existed for some time, the ML of today has gained fresh momentum due to new cognitive computing technologies.

ML can enable a faster and more accurate analysis of massive quantities of data; this is especially important as the concept of big data becomes the norm in many industries and fields of study. In the past decade, ML has given the world self-driving cars, practical speech recognition, more effective web search, improved fraud detection, and a greater understanding of the human genome. As previously mentioned, ML algorithms are often employed to solve NLP tasks (see the overlapping area in figure 1).

In the health care industry, ML is a fast-growing trend, given the huge amounts of data coming in from various sources (e.g., research and development, physicians and clinics, non-physician clinical workers, wearables, patients, etc.). While wearable devices have been available in various forms for a number of years, the more recent popularity and complexity of wearable devices like smart watches

and exercise trackers has resulted in much larger sets of real-time personal health data that can be tracked and assessed. A current problem is that all of these sources of health care information cannot easily be reconciled into one central hub. ML can help find ways to effectively collect this data and better analyze it for more effective prevention of illness and better treatment of individuals, as well as populations.

In addition to applications in diagnosis and personalized medicine, ML has the potential to be used for a variety of health care goals including better drug discovery and manufacturing, clinical trials and research, improved accuracy of radiology and radiotherapy diagnoses and treatments, the development of smarter electronic health record (EHR) and health information exchange (HIE) systems, and the prediction of epidemic outbreaks.

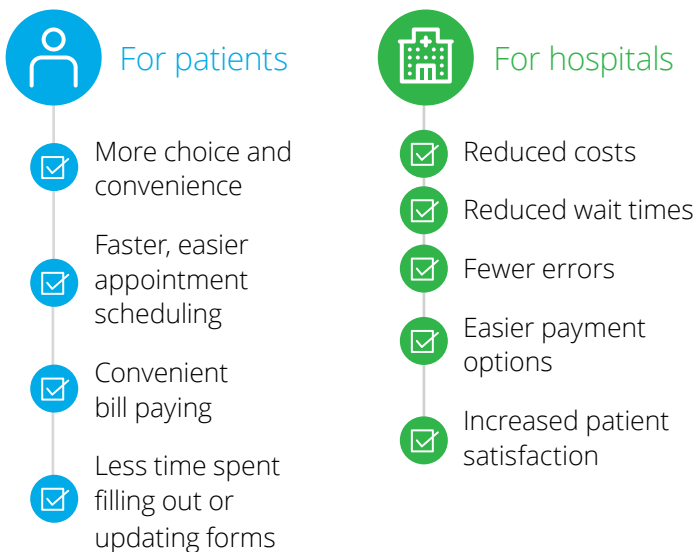
Although notable challenges such as concerns regarding data governance and the breakdown of data silos exist (especially in health care), ML has huge potential for changing how we approach different aspects of medicine for the betterment of care.

# The impact of AI on patients, clinicians, and pharma

## Patient-facing AI: Improving experiences, costs, and outcomes

Patient self-service is a model that emphasizes choice and convenience by allowing patients to rapidly and easily complete tasks such as scheduling appointments, paying bills and filling out or updating forms—all at their own convenience. Patients are able to use devices such as phones, tablets, and laptops to complete these tasks at times and locations that fit into their schedules. Movement towards self-service in health care follows self-service trends in other industries, such as retail and travel. Implementing self-service programs helps hospitals to realize benefits such as reduced cost, reduced patient waiting times, fewer errors, easier payment options, and increased patient satisfaction.<sup>5</sup>

### Patient self-service benefits



Intelligent self-service leverages ML and NLP by analyzing information, customizing patient experiences, and expediting processes to further increase convenience and efficiency.

Increasingly, provider organizations are developing interactive online portals with chatbots for patients to complete these activities as well as medication refills and simple administrative tasks. Similar to virtual health assistants (VHAs), chatbots use NLP, concept extraction, and sentiment analysis technologies to create an interactive experience. In some cases, image analysis is added to read bar codes, photos, or handwritten notes.<sup>6</sup> These types of user interfaces create a personalized experience and are available 24/7. As health care providers continue to pursue methods for increasing patient satisfaction, intelligent interfaces are poised to make a difference. By empowering patients to do certain tasks at their convenience with 24/7 access to knowledge and chatbot functions, typically resulting in smoother encounters with the health systems, intelligent interfaces have demonstrated their ability to bolster patient satisfaction scores.<sup>7</sup>

Patient self-service can also help streamline provider operations by routing patients straight to an appointment or directing them to visit the registration desk, based upon predefined rules, thereby allowing the registration team to focus on a select group of patients who have a greater need for their value-added services. The administrative and operational benefits of patient self-service using ML and NLP have been well documented in current real-world scenarios. As patients arrive for their appointments, self-service check-in has been reported to significantly reduce traffic at the front desk.<sup>8</sup>



## Your.MD details

The team has built an advanced medical data model and then used AI to adapt it to each person's unique profile. They also use machine learning to automatically improve the service and learn from every interaction, so the more people that use Your.MD, the better it gets for everyone globally.<sup>9</sup>

## Ada details

Ada started out as a doctor-facing application, helping clinicians to make better decisions. The same database and smart back end is now being offered to consumers to access, albeit with a much more consumer-friendly front end.<sup>10</sup>

freeing staff to do higher-level work. Later, as appointments are completed, point of service (POS) payment collection (e.g., with kiosks or tablets) has been shown to increase copay collection. In fact, when integrated with payer systems, the use of these systems results in increased payments for the patient-responsible portions of the invoices at the time of service.<sup>11</sup> Capturing revenue at an earlier phase in the revenue cycle has been a welcome, if unexpected, benefit of POS payment collection. Through ML analysis of payment patterns, intelligent interfaces can also determine the best way to collect payments from patients.

Another emerging application that leverages these types of technologies is the AI personal health assistant. One example in the personal health assistant space, Your.MD, acts as a personal health assistant that provides users with information on diseases, health searches, and health services via a chatbot that leverages NLP and ML to understand and respond to customer needs and requests.<sup>12</sup> Ada, another health assistant, asks users questions to create a user profile and perform personalized assessments when the user is not feeling well.<sup>13</sup> Babylon Health not only uses AI to provide health advice based on questions the user answers but also provides the technology to support video appointments with providers.<sup>14</sup>

Beyond health assistants, NLP and ML are also being used as part of other patient-oriented functions. One firm's solution, for instance, is an application that uses visual images to verify that patients have taken their correct medications at the correct times. It uses AI to support analyzing the images for both facial and medication recognition and to confirm that the medication has been ingested.<sup>15</sup>

## AI for clinicians: Tools for more effective diagnoses and treatment

Similar to what is happening in the patient user space, there are many clinician-oriented applications that incorporate NLP and ML. In the imaging space for instance, AI is currently being used in computer-aided detection (CAD) systems to retrospectively learn about how different clinical abnormalities appear on imaging studies by analyzing both image data and associated clinical information. After reviewing an extremely large number of images and associated clinical data to achieve an adequate level of learning, CAD systems are able to use the knowledge they have learned to prospectively identify areas of abnormality on imaging studies and generate a differential diagnosis for the finding. CAD is currently being reviewed for use for a variety of imaging studies, including mammography to identify areas suspicious for breast cancer for the radiologist to further assess, and high-resolution CT scans of the chest to evaluate hundreds of images in a study to identify areas suspicious for lung cancer that need additional radiologist review.<sup>16</sup>

In the future, advances in AI will likely create additional capabilities for CAD solutions. Over time, it would not be surprising to see the accuracy of CAD systems for some imaging studies exceed that of radiologists, with CAD systems potentially becoming the primary interpreters of imaging studies and radiologists only reviewing imaging studies that exceed a certain level of uncertainty of the CAD/AI system.

In addition to applications in radiology, CAD is also used in dermatology to help diagnose skin lesions. CAD dermatology systems learn about the various appearances of dermatological lesions by reviewing large numbers of photographs of lesions along with the dermatological diagnoses associated with them. Mirroring how CAD functions in radiology, these dermatologic CAD systems can then use the knowledge they have acquired to prospectively identify dermatological lesions that are at high risk for being malignant. Although the findings of these systems are typically reviewed by a dermatologist, these dermatology CAD systems can make it easier for non-dermatologist primary care physicians to screen skin lesions.



Finally, another company, Beyond Verbal, has developed software to analyze vocal patterns to identify emotions for uses beyond health care.<sup>17</sup> Interestingly, some initial health-related studies have found specific associations between some voice patterns and some disease processes. While more studies need to be done in this area, the initial findings point to voice analysis potentially being used as a non-invasive marker for some disease processes.<sup>18</sup>

## AI for pharma: Reduced time and cost for drug discovery

Pharmaceutical development has historically been a long and expensive process. Biological systems are complex, and this adds many layers to the process of drug discovery and development. A molecule that is identified to modulate a specific step in a particular biochemical pathway may do so very effectively, but its effects on the rest of the biological system must also be understood. Many compounds that perform exceedingly well in a lab setting cannot be used in biological systems due to adverse reactions. The number of variations in bio-molecular structures and the number of molecules with potential to become therapeutic drugs is staggering. The sheer volume of tests that must be run keeps the costs high and the pace slow. ML coupled with NLP is well suited to sort through thousands of pages of research results to make the process more efficient. The AI system then draws connections between relevant data points and is able to narrow the number of candidate molecules by an order of magnitude.

The goal of drug discovery is to identify small molecules that selectively modulate functions of target proteins. Without a lead or a hint, it can be a simple hit-or-miss process. Historically, guidance has been provided by naturally occurring compounds that have been used medicinally for hundreds or thousands of years. As such, the natural world has provided a large number of molecules from which many modern drugs have been developed. In more modern times, many drugs that do not occur naturally have been discovered and developed de novo. And while discovery has historically been a haphazard process, modern pharmaceutical development employs strategies and methods of evaluating a very large number of molecules for specific desired targets.

Yet even with modern methods of high-throughput screening for molecules identified for particular targets, results are often suboptimal because biological systems are complex, and molecules that work well for modulating one step in a process may have adverse interactions in other parts of the biological system. These issues may not become apparent until later in the drug development process after a huge number of tests are run, taking time and money but failing to return a viable result.

Newer techniques in molecular analysis, called “machine-vision” image analysis, allow AI systems to predict which molecules might be effective for which biological targets, and thus accelerate the process of drug discovery. Similarly, simulations of chemical interactions can be performed to assess a drug’s efficacy in disease treatment. A possible application of this technology is rapid and accurate identification of vaccines for certain viral infections. This could have huge benefits for certain quick-spreading diseases that have often eluded scientists such as Ebola or Zika, or even the quickly mutating HIV. While some drug companies have been using AI to study the deep chemistry of drug interactions (e.g., how a chemical and one protein may interact), the way forward would be to use AI to probe entire biological systems to see how a drug might affect a patient’s own tissues.<sup>19</sup>

Through the analysis of large amounts of data and the use of “machine-vision” image analytics, AI is promising to help reduce the time and cost in drug discovery by identifying candidate molecules. Although the impact of ML and NLP have yet to be determined in subsequent stages of drug development, researchers have high hopes for the technology’s potential impact.

## AI for more informed and effective treatment plan design and delivery

Designing treatment plans in oncology is another major area in which AI is being leveraged. Treatment plans are often complex and must take into consideration many factors such as available treatment modalities and the preservation of healthy tissue when targeting cancerous cells. These processes can be extremely time-consuming and pose significant challenges.

There are thousands of clinical trials being conducted around the world in all subspecialties of oncology. Reading and assimilating all of the current information would be a monumental task for a single oncology practice, much less one physician, but a computer with ML and NLP can interpret thousands of pages of study results and compare the data to a specific patient case for the physician.

Another difficult and time-consuming task in oncology is determining the best way to deliver the treatment, such that it targets cancerous cells and avoids damage to surrounding healthy tissues. This is especially difficult, for example, in head and neck cancers, where many vital structures are in close proximity and in relatively small spaces. Radiation oncologists and their staff can spend hours mapping the anatomical structures, and calculating radiation absorption at various angles and beam strengths, in order to plan the best way to deliver the therapy (i.e., building the treatment plan).

Here again, ML coupled with NLP has consistently demonstrated value. ML systems are able to create treatment plans in minutes or even seconds, as compared to the hours it might take a human oncology team. Respondents in prostate cancer clinical trials comparing ML-generated treatment plans with those created by expert human planners ranked the ML plans as equivalent. Moreover, most respondents had difficulty differentiating between plans created by human experts and those created by the ML system.<sup>20</sup>

## From clinical to operational: How big data and analytics can improve outcomes and efficiency

The health care industry historically has generated large amounts of data, driven by record keeping, compliance and regulatory requirements, and patient care. Big data analytics is the field dedicated to examining large structured and unstructured data sets (i.e., big data) to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful information that can help organizations make more-informed business decisions. As noted earlier, ML is a critical part of the big data analytical process since it enables the faster and more accurate analysis of massive quantities of data.

A use case for big data analytics in health care is medical record mining and identification of hidden trends. Analytics can be used to examine data for trends across entire population or to compare

an individual to others with similar histories. For example, we can explore the potential of predictive analytics and big data in emergency care. By analyzing the data in thousands of medical records, data science tools can enhance emergency care through clinical predictions based on trends identified among similar cases. Patients' risks could be stratified more precisely with large pools of data and lower resource requirements for comparing each clinical encounter to those that came before it, benefiting clinical decision making and health systems operations.<sup>21</sup> Similarly, predictive analytics and big data can be used to optimize pharmaceutical outcomes. Predictive analytics that leverage big data will likely become an indispensable tool for clinicians in mapping interventions and improving patient outcomes.<sup>22</sup>

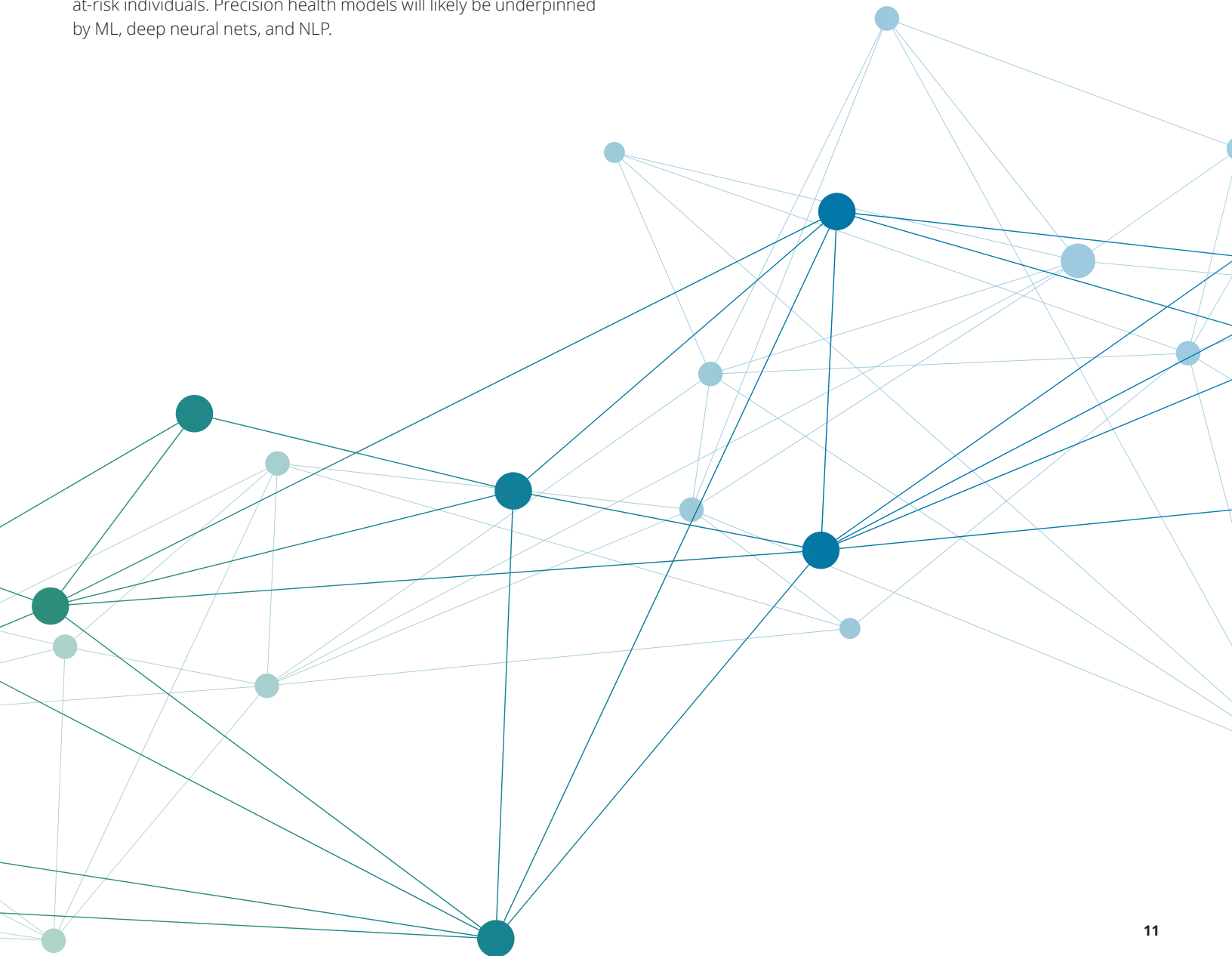
Another field that could garner significant benefit from big data analytics is the field of genomics. Genome analysis and disease predisposition planning are cornerstones of precision health, which is an emerging approach focused on improving an individual's health by diagnosing, preventing, and treating a future illness through wellness and prevention interventions. Enabled through integrated technologies, precision health combines advances in genomics medicine with enhanced data collection from the electronic health record, environmental sensors, wearables, and other devices.

Determining a diagnosis involves not only assessing clinical information, but also an analysis of data generated by a patient's life style, biometric data, genetics, and current situation (work, home, stress, socioeconomics). For some disease processes, a patient's genomic information (and to a lesser degree AI) is already being used

to design a personalized treatment plan with the aim of optimizing the clinical outcome. In the near future, precision health is poised to disrupt the business, operational, and technical models of health care companies to an even greater degree by combining genomic analysis with more robust ML and other AI capabilities to optimize treatment and reduce the prevalence of (and potentially even eliminate) certain illnesses. The ability to recognize a future health risk and intervene with preventative measures will fundamentally alter the paradigm of health care.

Today's paradigm is "disease management," where providers wait for individuals to become ill and present with symptoms. In the future, health care organizations will find themselves increasingly focused on true "health care" (e.g., disease prevention) by proactively monitoring healthy individuals, performing preventative and wellness interventions, and managing prevention and wellness for at-risk individuals. Precision health models will likely be underpinned by ML, deep neural nets, and NLP.

Moving from clinical to administrative and operational benefits, data analytics has and will continue to play a significant role in efficient and profitable management of health systems. Analytics permeate every level of a health care organization. Operational efficiencies and cost-reduction through analysis of performance metrics can be achieved from the front-end contact center to back-end offices, and everywhere in between. Likewise, countless organizations have increased profitability through revenue cycle optimization. Systematic assessment of clinical documentation integrity programs and coding operations based on data analytics has uncovered unclaimed annual revenues of up to \$80 million, depending on the size of the health care system.<sup>23</sup>



# Looking ahead: The future of AI in health care

## A better patient journey

While each of these existing and in-development technologies that leverage NLP and ML hold individual value, the real health care benefit in the future will likely be the synergies obtained through combining the power of AI-related technologies across the entire patient journey. While we cannot predict the future with 100 percent accuracy, we can consider future scenarios that are likely to happen. Take, for instance, a future scenario of an overweight male patient who is a former smoker with diabetes and atrial fibrillation. In the future, that patient is likely to have access to wearable devices to track blood glucose levels, heart rates and rhythms, and exercise levels over time. That information may be synched up to a central monitoring system that uses ML to recognize abnormal or undesired pattern changes. When an abnormal pattern change is recognized, the monitoring system can automatically notify the patient's provider and instruct the patient to schedule an appointment (or tell the patient to call the paramedics, or seek emergency care or urgent care should the identified pattern change be more critical).

Once the patient arrives at the provider's office, the patient can check-in and register at a voice-enabled biometric kiosk that utilizes NLP to obtain registration data. Assuming the patient has no balance due on his account, the patient does not need to pay at the kiosk or take the time to see anyone at the front desk to discuss an account balance.

Prior to the provider seeing the patient, the provider can review the relevant data sent over by the patient's wearable devices, along with the reasons why the alert was generated and a list of potential diagnoses generated by the wearable monitoring system's AI capabilities. Once the provider sees and examines the patient, the provider then dictates the visit note.

After the note has been dictated, NLP and ML turn the text in that dictated note into codified information behind the scenes, use that codified information to update the codified information in the patient's electronic medical record, and automatically generate the necessary billing information to send to the patient's insurance company for reimbursement. In addition, based on the information provided by the wearable monitoring system as well as the electronic medical record, a treatment planning system can use a combination of NLP and ML to recommend adjustments to the patient's current treatment plan (including medication dosages and frequencies as well as meal and exercise routines) to address the patient's specific clinical situation.

During the visit, the patient mentions feeling tired and having a cough for the past six to eight weeks, so the provider orders lab tests along with a chest CT scan, given the patient's smoking history. Patient and provider are notified of the results via the patient portal and provider portal. The results include an abnormal chest CT with a mass initially identified by CAD as having a 75 percent probability of being lung cancer, a finding that the interpreting radiologist agrees with. The patient is again prompted by an NLP-powered chatbot to make a follow-up appointment with the provider, and then with the oncologist after a biopsy confirms the lung cancer diagnosis, to discuss the results and next steps.

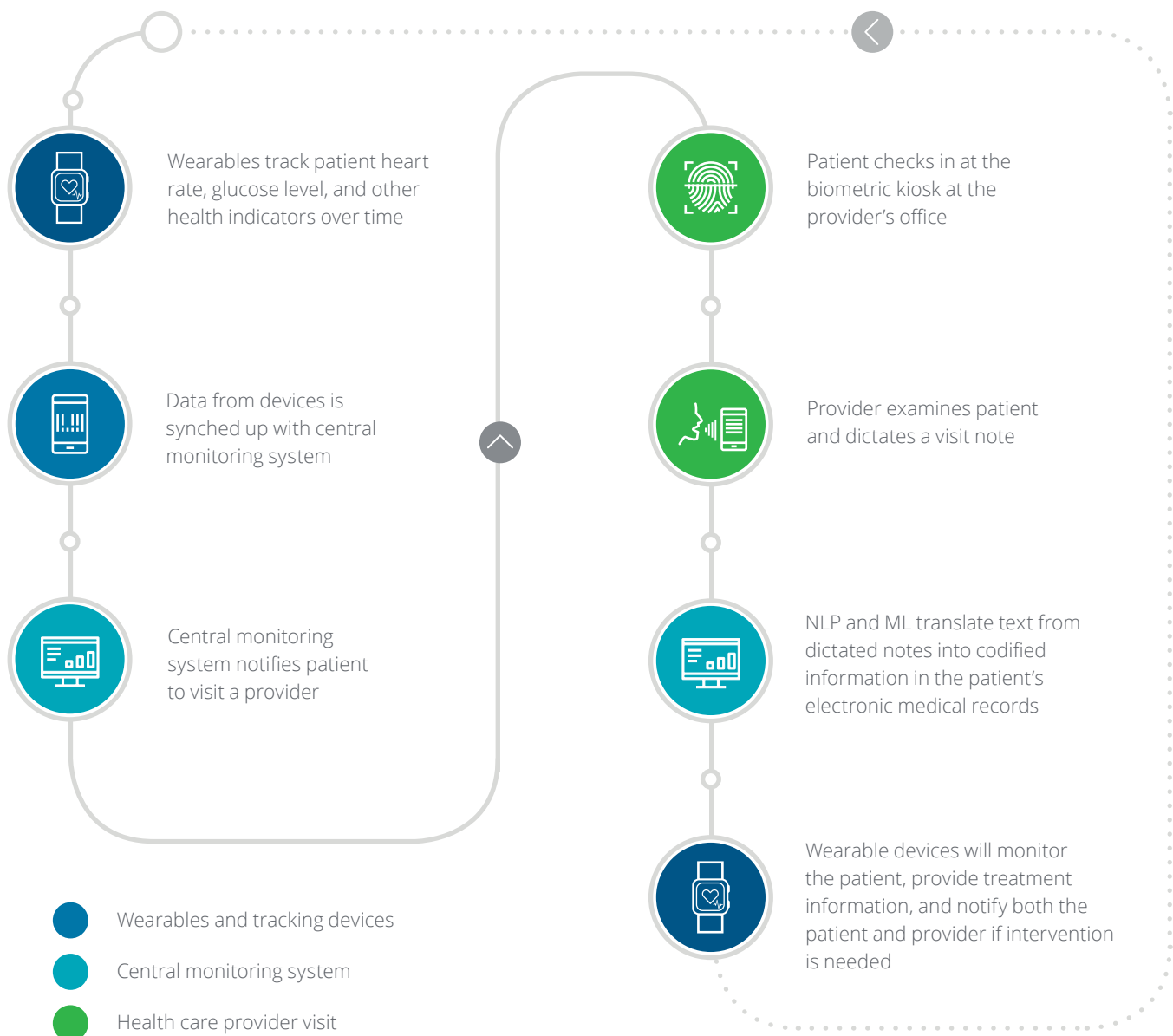
Prior to meeting with the patient, the oncologist can review the patient's electronic medical record and imaging findings, then use NLP and ML to review evidence-based medical literature for potential treatment options or clinical trials that specifically apply to the patient. Once a treatment option is chosen, ML can be used to

tailor the treatment plan to the patient's specific clinical condition. Both while the patient is undergoing treatment and after treatment, wearable devices will monitor the patient and again notify both the patient and provider should the AI-enabled monitoring system determine that intervention is needed. ML can then also suggest the best course of action based on the patient's clinical condition and prescriptive analytics, and monitor patient behavior in order to provide incentives for appropriate behavior.

Finally, this patient's data, along with data from other patients, is de-identified and entered into a population health database. That database, with new information being added daily, is continuously being mined using NLP and ML for potential associations across a broad set of data in an effort to identify previously undiscovered causes and treatments of diseases.

This scenario exemplifies many of the potential benefits to the patient, provider, payer, and pharmaceutical industry of leveraging the power of AI across the patient journey.

Figure 2. Patient journey



Proactive oversight of the patient's health using NLP and ML to monitor data from wearable devices can mean quicker interventions and changes to treatment plans, potentially resulting in patients being less ill when they present for treatment, making it easier for providers to treat patients, and lowering costs for insurers.

Kiosks with NLP and ML for registration and check-in can save patients time, reduce front-desk resource costs, and increase the accuracy of information for the provider office and insurers. Using NLP and ML to codify a provider's dictated note saves the provider time—because dictation is much quicker than other forms of data entry—but benefits the patient, the provider, and the insurer by codifying information dictated in the visit note and generating a more accurate and complete bill to send to the insurer in a more timely fashion. Having CAD systems do a preliminary review of imaging studies can help radiologists improve both their productivity and accuracy, and using AI and ML to support abnormal results triggering patients to make appointments means that patients can be proactively treated earlier in the process when they are less ill. The use of NLP and ML to review the literature for treatments specific to a particular patient's clinical situation helps providers and patients by making a positive outcome more likely and helps reduce costs for insurers by avoiding treatments with lower likelihoods of success. It can also benefit the pharmaceutical industry by allowing their products to be used in clinical situations where they are more likely to be successful in treating the patient. Finally, the use of NLP and ML to mine population health data can benefit patients, providers, insurers, and pharmaceutical companies by identifying previously unrecognized linkages and potential new treatments.

## New ways to deliver care

Increased use of AI in health care will also influence the types of new entrants into the health care industry as well as impact how providers, clinicians, and other staff will work in the future.

New entrants into the health care market (whether they are payers, providers, pharmaceutical, technology, or other health care companies) are likely to deem the use of technologies such as NLP and ML in their day-to-day activities as a necessary requirement to create a competitive advantage over existing health care organizations. As a result, a higher percentage of health care related activities will become automated, allowing providers, clinicians, and staff to focus more of their time on skills sets and top-of-license activities that create greater value add.

Providers and nurses, for instance, could spend more time taking care of patients than entering information into an electronic medical record. Front office staff could spend more time interacting with patients and addressing their concerns rather than checking patients in. Providers, clinicians, and staff will also find themselves interacting more with systems that rely on AI, meaning that they will need to learn how to best leverage their capabilities, adjust workflows to incorporate their use, and become more comfortable using these systems in their daily activities.

The use of AI also allows greater flexibility in where care can be given. The growing ability of medical devices to use AI to remotely monitor patients and proactively send an alert early on when something unusual is sensed allows more care to be delivered at home, away from health care facilities, with lower cost. This means that clinicians will likely be performing more of their activities outside of the typical health care environment where they are performed today. Patient home visits by both providers and nurses could become more frequent not only because it can lower the cost of care but also because it can increase patient satisfaction.

In addition to affecting how and where health care work will be performed, the use of NLP and ML will likely also impact health care talent models themselves. AI will allow providers, clinicians, and staff to focus on more top-of-license skill sets and activities. In addition, there is likely to be greater reliance on physician extenders in combination with NLP and ML (as well as physician supervision) in order to reduce cost and leverage physician time. Developments of new types of talent models are also likely to occur. Given a shift toward more care at home away from the health care environment, it would not be surprising to see local health care crowdsourcing models of licensed professionals develop that will be able to serve as a local and home extension for health care organizations.

Health care providers should consider preparing for the inevitable changes related to NLP and ML discussed thus far by addressing a number of considerations, including:



Process and  
governance  
considerations



Organizational  
and cultural  
considerations



Financial  
considerations

## Process and governance considerations

The foundation for examining new ways of working rests on a solid governance structure and trusted teams and processes. To this end, organizations should consider creating an innovation steering committee. This group should hold regular meetings to identify processes that could be automated or enhanced by the implementation of different NLP and ML technologies. Organizations can dramatically improve quality by investing the time and resources to create solid information governance structures. The organization should also engage the innovation steering committee to identify places that the Internet of Things and big data can be leveraged to benefit the organization's new digital strategy. For example, one strategy to increase value and decrease cost is to leverage third party cloud-based data storage structures and NLP and ML tools to build a smarter, more efficient business. These third party vendors can offer scalable data storage that would normally be prohibitively expensive, and provide a Software-as-a-Service (SaaS) approach for NLP and ML solutions that decreases the cost and complexity of owning and maintaining hardware on-site.

## Organizational and cultural considerations

When looking at organizational and human resource aspects of this transformation, organizations should develop analytics teams in order to be able to leverage as much information from patients, providers, and the populations as possible to enhance provider care and operations. Generating clean data is especially difficult for providers due to the complex and multiple-source nature of clinical data. However, since many decisions, both business and clinical, will be made based on this data, it is essential to create a culture and the associated processes to promote the creation of clean, complete, and timely data from internal sources. From a purely cultural standpoint, health care organizations could look to other industries for inspiration, since many are in a better position to take risks associated with innovation than health care provider organizations, where patient lives are at stake and taking uninformed risks is simply too risky.

## Financial considerations

From a financial standpoint, organizations must be willing to invest in adequate data center and IT infrastructure solutions (in addition to analytics teams) to allow the technologies to operate as intended and produce the desired results. Some models, such as SaaS, require less infrastructure to be held and managed by an organization, and each case should be analyzed individually.

## New risks to address

It is also important to understand some of the potential risks that arise with greater use of technologies such as NLP and ML. The codification of information using NLP makes it easier to share that data across organizations, meaning that policies and procedures related to sharing of data across organizations, including de-identifying the data that is shared in some situations, need to be developed to protect patient privacy. Security against hackers or other non-authorized entry also needs to be implemented and maintained at industry-leading levels to prevent unauthorized access to protected personal and health information.

In addition to addressing security and privacy concerns introduced by the use of AI, organizations also need to make sure that providers as well as other clinicians and non-clinicians understand that AI is being used in daily workflows to improve quality of care and improve productivity but is not intended to replace clinical and non-clinical training and judgment. Technologies such as NLP and ML, at least in their current state, still require some level of human oversight. Given the current state of technology, clinical recommendations generated by AI should always be evaluated by appropriately licensed clinicians to make sure that the recommendations make sense for the patient's particular situation. Similarly, clinicians should not become so dependent on the use of technologies involving AI that they lose the clinical skills that they were taught in training and expanded upon in practice.

As is the case with any significant paradigm shift, the evolution toward AI takes time and work. There are significant technical challenges to fully integrating the front-end and back-end systems. Moreover, the move toward patient self-service represents movement away from the status quo, shifting control of some functions away from clinicians toward patients. To compensate for increased control by patients, new rules governing policies, processes, and procedures must be developed to ensure adequate levels of staff and resource utilization and efficiency.



## Leveraging lessons learned

A number of lessons have been learned based on previous Deloitte NLP and ML health care projects:

- 1 Although small NLP and ML projects may seem straightforward and fairly quick to implement from the client's perspective, it typically takes longer and costs more than anticipated for the early adopters to implement these capabilities. This is because the early adopters not only have to go through the typical steps in the implementation cycle but also must spend additional time and effort up front performing business case validations and development of a proof of concept, taking an average of 3-4 extra weeks and 8-12 extra weeks, respectively.
- 2 One way to reduce some cost and complexity of NLP and ML projects is to leverage open-source technologies and supplement them with limited customization rather than trying to develop a customized solution or to customize proprietary software.
- 3 Any solution that is developed must not only account for average transaction length and average number of transaction volumes, but also be robust enough to address potential longer transaction lengths and high periods of peak transaction volume without resulting in significant transaction delays.
- 4 Involve personnel on NLP and ML health care projects who have a good combination of both technology and health care backgrounds. Personnel with this combination of backgrounds have a clearer understanding of what the end users need the technology for and how they want to use it (e.g., providing AI capabilities within mobile apps). They also have a more complete understanding of the technology solutions that can best address end-user needs.
- 5 The selection of the data used to train any AI/ML model must be done carefully in order to make sure that it accurately represents the production data and does not incorrectly train and bias the model.
- 6 Articulating an expected return on investment (ROI) for an AI/ML project can be tricky, since training of models is an ongoing process. As the model receives further training over time, the ROI would be expected to gradually increase. Therefore, any expected ROI that is articulated should also include the time period and time frame over which it is expected, in order to account for any impact of model learning.

# Summary

While AI—including NLP and ML—is already being utilized to varying degrees in the health care environment, their use will become increasingly important in health care going forward as a way to:



Improve provider and clinician productivity and quality of care



Enhance patient engagement in their care and streamline their access to care



Accelerate the speed at which new pharmaceutical treatments can be developed while reducing the cost in doing so



Personalize medical treatments by leveraging analytics to mine the huge amounts of noncodified clinical data that currently exist

While each of these technologies has value in itself, their true value lies in the synergies obtained through their use together. In addition, increased use of NLP and ML also introduces the need to develop organizational policies and procedures (and likely regulations and laws) to govern their use. More importantly, NLP and ML should be considered tools to support the practice of medicine by providers and clinicians but should not be relied upon to the extent that the art of medicine itself is lost.

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# Endnotes

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