# AI in Healthcare: Keys to a Smarter Future

Artificial Intelligence (AI) is receiving a lot of attention from investors, the press, and the labor force across all industries. While AI has already achieved widespread adoption in certain sectors, the complexities of healthcare have resulted in slower adoption. However, the urgency and opportunity still exist, and properly managed AI will be a boon to healthcare by helping automate the most mundane and repetitious tasks, enabling providers to focus more time on patient care.

This paper examines the progress and adoption of AI across all sectors, the challenges and promise of AI in healthcare, and takes the position that integrating this technology into existing workflows at the point of care is essential to widespread adoption. It's also a guide for healthcare professionals to understand how, when, and where AI can be most effective and achieve the greatest impact.

Over the past several years, AI has multiplied productivity across a range of human endeavors, and its widespread adoption into everyday life is accelerating at a rapid pace. In the U.S., 85% of Americans report using at least one of six devices, programs or services that feature elements of artificial intelligence.[1] It helps us travel along the fastest possible routes (and will shortly power self-driving cars), it makes smart recommendations about the media we consume, and it accurately auto-fills tedious forms. AI is all around us, seamlessly integrated within the devices, programs and services we consume, enabling us to make more informed decisions.

While AI is becoming ubiquitous, we have yet to realize the game-changing clinical, operational, and financial opportunities that await us in healthcare. However, AI has already begun making progress to solve process inefficiencies, tedious and expensive procedures, guard against human error, and promises to usher in a new era of patient care. Unlocking this potential will require a closer collaboration between the creators of AI and the providers who use it since the contours of healthcare are complex, dynamic, and highly regulated.
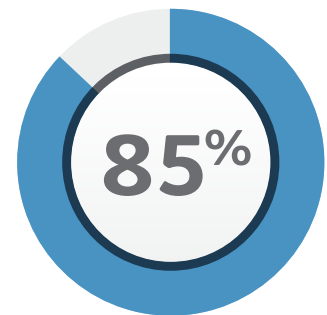
85%

In the U.S., **85%** of Americans report **using at least one of six** devices, programs or services that feature **elements of artificial intelligence**.[1]

gehealthcare.com

## Stepping Back: What is AI and where do we find it today?

AI is simply the ability of machines to simulate human intelligence. One approach to developing this intelligence is machine learning, a subset of artificial intelligence, where computers learn inductively without being explicitly programmed. Machine learning at its most basic is the practice of using algorithms to parse data, learn from it, and then make a determination or prediction about something in the world.[2] Further along the AI spectrum is deep learning. Deep learning is a technique of machine learning that processes data using neural networks, leveraging learning algorithms that mimic the function of the human brain.

The concept of AI has been around since the advent of computers in the mid-20th century, but several technological advancements have come together to enable superhuman AI performance in recent years. These are:

1. The increase in computing power as described by Moore's Law, which states that the number of transistors in a dense integrated circuit doubles approximately every two years. AI has now extended its reach beyond the centralized processing centers of traditional computing and is now embedded in and distributed through many small devices and sensors.

2. The tremendous volume of data produced by the growing presence of sensors and computers that produce, capture, distribute, and store data. This 'Big Data' is especially prevalent in healthcare: Hospitals are now producing 50 Petabytes of data per year,[3] coming from the variety of SaaS products, EMRs, medical devices, wearables, and medical images.

3. Variety of data—amount and quality— has enabled the development of increasingly complex algorithms, fueling the journey from artificial intelligence to machine learning to deep learning.

The performance of these algorithms have now reached astonishing levels. One of the first major breakthroughs in superhuman levels of AI performance occurred in 2015 as researchers correctly categorized images with 96% accuracy as part of the ImageNet Challenge.[4] AI's level of performance has only improved since as it asymptotically approaches perfection.

As observed earlier in this paper, the most successful AI applications are often not the main attraction, but fit neatly into the contours of everyday life by augmenting and enhancing existing routines to the point where we begin to take them for granted. As Alfred North Whitehead famously observed, "Civilization advances by extending the number of important operations which we can perform without thinking of them."[5]

Deep Learning

Machine Learning

Artificial Intelligence
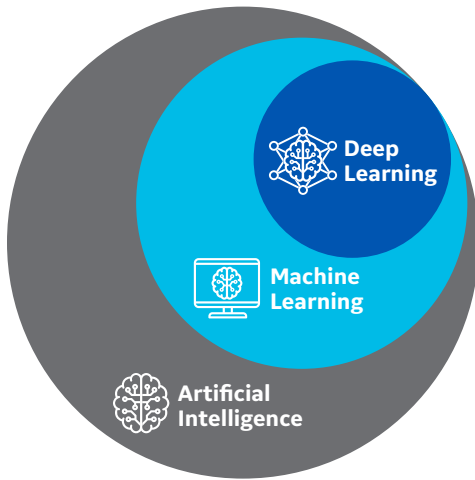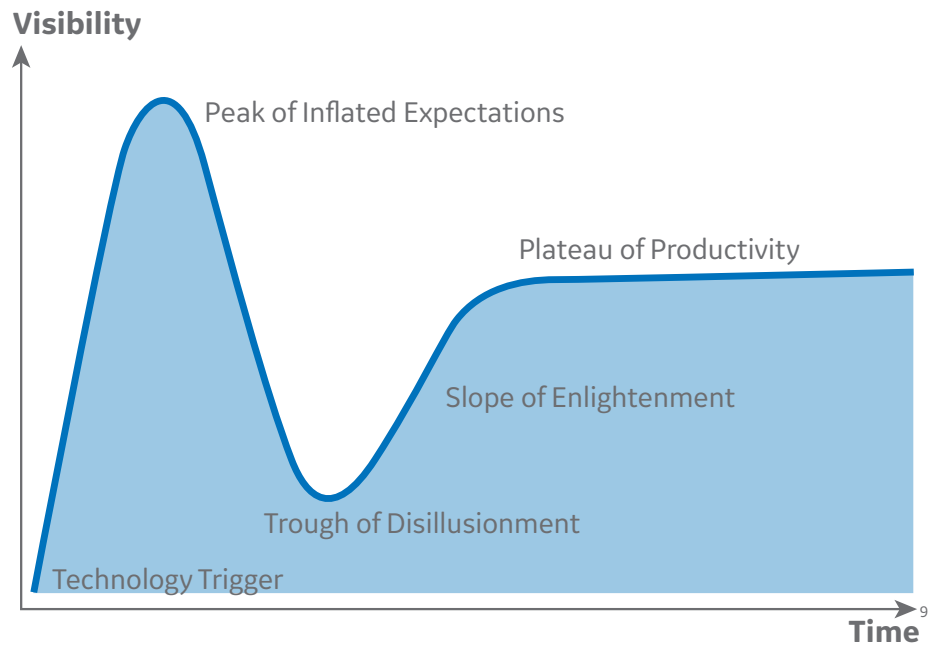
Hospitals are now producing

50 Petabytes

of data per year.[3]

Back to Healthcare: AI is showing tremendous promise, but widespread adoption remains elusive

Some AI applications have grabbed headlines with their potential to radically improve human life, extend physician capacities to counteract labor shortages, minimize the variability of treatment cost and quality, and otherwise transform the industry.

Investment patterns have reflected this great promise. Corporate venture capital firms nearly doubled their investments in AI companies to $3.8B in 2017[6], and healthcare has consistently been the top industry for AI investments, accounting for just under $1B of venture investing for the past couple of years.[7]

The adoption of AI in Healthcare has not been on par with the urgency and investment pattern within the industry. Despite the tremendous potential of AI to improve healthcare, there are inherent industry challenges. One challenge is information overload. Many health systems are not equipped to process the massive amount of data they produce. Currently, less than 3% of the data being produced by hospitals each year is actionable, tagged, or analyzed.[8] There are many reasons for this, including data privacy concerns, high regulatory hurdles for new 'black box' technologies, lack of clear reimbursement pathways, and the difficulty of data curation, which needs to be pristine for AI algorithms to work properly. An additional challenge is new paradigms of care like wearables, DNA testing kits, or mobile health. These disruptors are moving patients and their data outside of the hospital, and creating silos of information across disconnected data sources.

Visibility

Peak of Inflated Expectations

Plateau of Productivity

Slope of Enlightenment

Trough of Disillusionment

Technology Trigger

Time[9]

Identifying the right opportunity for the use of AI in healthcare is also a critical success factor that must not be underestimated. AI's potential to enhance human and machine capability must align with key organizational priorities, goals, and mission. Misalignment of these factors have led to costly setbacks for even the largest, most well-established players in the past, providing valuable lessons for an emerging market.

A helpful guide for understanding the place of AI in healthcare today is the Gartner Hype Cycle curve seen above. If AI is a viable technology, then setbacks are inevitable and not a reflection of its ultimate destiny, but rather reality checks that have helped move AI beyond the 'peak of inflated expectations.' AI entrepreneurs and early adopters are learning from their mistakes, and are becoming better at developing healthcare-appropriate products.

NVIDIA's Vice President of Healthcare, Kimberly Powell, believes that, "now more than ever it's critical to bring together technology companies, industry leaders and clinicians to choose the most impactful uses of AI and ensure safe and seamless integration into the practice of medicine."

Despite the fact that healthcare is a high-interest industry for AI investment, AI products in the space will require more careful design and testing than those in other industries. Companies innovating with AI in healthcare need to be prepared to invest the time, effort, and expertise to create products that focus on the needs of providers and patients. Unlike previous technology booms in Healthcare, close collaboration with healthcare providers is foundational for successful AI adoption in the space. This deep collaboration will unlock untold benefits, establish new skills sets, best practices, and revolutionize thought around patient care in pursuit of greater adoption of AI.

How AI Will Succeed in Healthcare

Equipped with a firm understanding of healthcare requirements and clinical workflows, companies embedding AI into existing technology-enabled workflows will be the first to enjoy significant adoption among healthcare providers. AI can now travel up the 'slope of enlightenment' on the Gartner Hype Cycle.

Another helpful theory for understanding the potential of AI in healthcare is Clay Christensen's construct of medicine progressing along a spectrum of poor to better understanding from his book *The Innovator's Prescription*.[10] The journey begins with 'intuitive medicine,' characterized by the hero doctor who must hold everything within his mind, and who uses a wide array of tools at his disposal to provide the best care possible given a highly incomplete understanding of the ailments and therapies at hand. This is the era of medicine that most hospitals were designed for at around the turn of the 20th century.

'Empirical medicine' begins when enough high-quality data has been collected to begin establishing patterns that strengthen or weaken competing diagnostic and treatment theories, but there's still ample room for argument.

Finally, 'precision medicine'—using this historical definition[12] —arrives once a completely clear causal chain of pathology, diagnosis, and treatment is established and widely accepted by the profession. Ear infections or common colds are two conditions firmly within this realm; they are easily identified, diagnosed, and treated often with nothing more than a single pharmacy visit.

Once a medical condition is so well understood, the medical community can develop set protocols and algorithms to define workflows on a robust base of evidence. These workflows become more and more refined as they're repeated thousands and millions of times, eventually becoming mindless and even tedious. This is where technology can intervene.
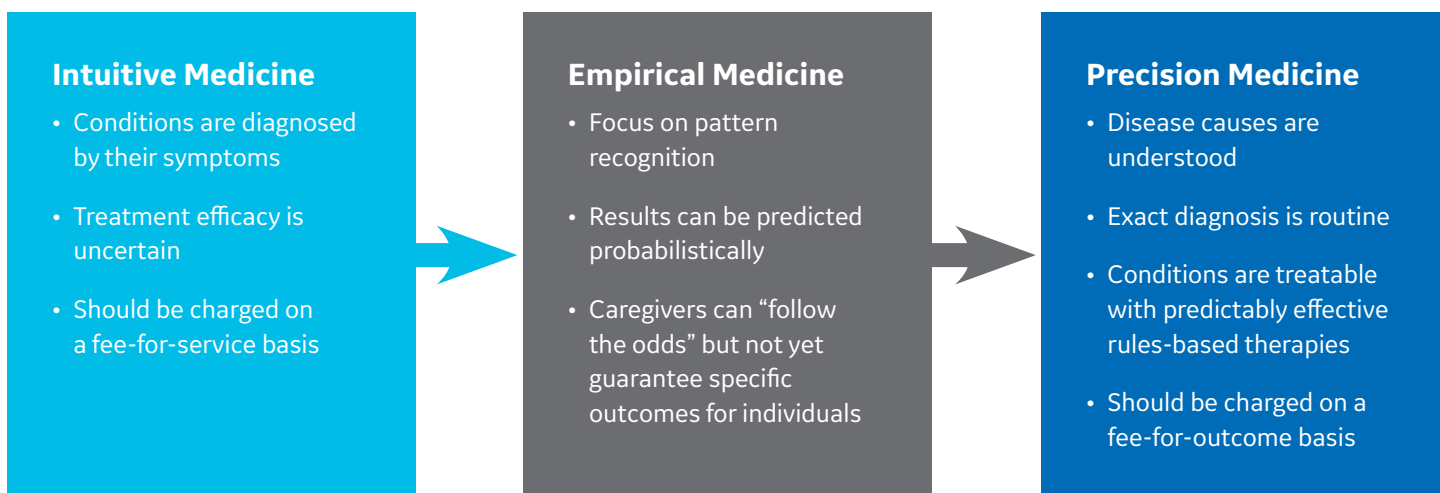
AI tends to take over the easiest, most repeatable, and tedious tasks from humans first; therefore, successful AI in healthcare will likely first emerge for applications that have reached a certain level of mindless repetition. In fact, the progress of AI along the continuum of computing capability mirrors that of human learning in medicine. Just as the increase in valid medical data leads to empirical and finally precision medicine, the creation, capture, and aggregation of data are first able to tell you what happened in the past, then predict what will happen in the future, and finally what you should do next.

Take radiology for example. While automating the interpretation of images has captured the imagination, more humble applications around workflow optimization, tele-radiology, staffing fulfillment, provisioning, and asset management, are where AI is beginning to take hold and deliver transformational results in radiology today.

For example, Arterys is providing image interpretation and workflow support to radiologists that can reduce a 90-minute scan to a 20-minute scan. Additionally, the technology can provide support so that scans previously read exclusively by specialized (and rare) radiologists can now be read by all radiologists. MRI scans of infants that used to require anesthesia and sedation are now accomplished much more quickly with simple swaddling because the technology can accurately render 3-D images that can be examined from all angles.

Providers should welcome the best AI

Intuitive Medicine

- Conditions are diagnosed by their symptoms
- Treatment efficacy is uncertain
- Should be charged on a fee-for-service basis

Empirical Medicine

- Focus on pattern recognition
- Results can be predicted probabilistically
- Caregivers can "follow the odds" but not yet guarantee specific outcomes for individuals

Precision Medicine

- Disease causes are understood
- Exact diagnosis is routine
- Conditions are treatable with predictably effective rules-based therapies
- Should be charged on a fee-for-outcome basis

technologies with open arms. Ashley Clary, Vice President of Imaging Services at the innovative Ochsner Health System, explains AI's place in terms of a much needed solution to help leverage the growing amounts of data available. Contrary to the general anxieties our society is struggling with regarding the potential for superhuman AI to replace both unskilled and even skilled labor, the radiologists at Ochsner are welcoming of the technology. They also welcome the opportunity to "come out from behind the curtain" to connect more with patients, and work on higher level clinical problems rather than routine image readings, such as complex clinical decision-making and interventional radiology.

Indeed, embedding AI into clinical work-flows, to whatever corners of the earth they may extend, will yield profound results for clinicians and their patients. Ironically, these transformative AI enabled outcomes will quickly feel invisible, making way for a more personal doctor/patient experience, as Alexander Fogel and Joseph Kvedar persuasively argued in a recent *Nature* article.[13] Far from disintermediating care providers, AI can empower them do their best work by freeing up their attention to do what only a human can.

Conclusion

As in everyday life, AI in healthcare must be tailored to the existing contours of evidence-based medicine to achieve widespread adoption and deliver maximum impact. Its first widely adopted applications in healthcare will be integrated into clinical workflows to augment and improve current medical practices to achieve higher levels of performance, speed, and convenience, and the innovators who accomplish this will be those with the deepest understanding of existing clinical workflows and who align AI opportunities to the highest value problems within healthcare to merit C-level support. In order for large health systems to adopt AI at scale, the technology will need to show clear ROI both financially and through improved quality of care. The first AI innovators to 'cross the chasm' into mainstream adoption will be those seamlessly embedding the technology to augment existing applications and devices.

AI holds tremendous promise to expand access to quality healthcare by freeing up human attention to focus on higher value problem solving while ensuring a uniformly high quality of performance.

As Dr. Mark Michalski, the Executive Director of the Center for Clinical Data Science at Massachusetts General and Brigham & Women's Hospitals puts it: "AI won't replace radiologists, but radiologists who use AI may replace the ones who don't."

References

1. http://news.gallup.com/poll/228497/americans-already-using-artificial-intelligence-products.aspx
2. https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/
3. "The Digital Universe Driving Data Growth in Healthcare," published by EMC with research and analysis from IDC (12/13)
4. https://www.economist.com/news/special-report/21700756-artificial-intelligence-boom-based-old-idea-modern-twist-not
5. Whitehead, Alfred North. An Introduction to Mathematics, chapter 5. 1911. Williams & Norgate, London.
6. https://www.cbinsights.com/research/report/corporate-venture-capital-trends-2017/
7. https://www.cbinsights.com/research/artificial-intelligence-healthcare-deals-funding-investors/
8. Cisco report: The Internet of Things. How the Next Evolution of the Internet Is Changing Everything - http://www.cisco.com/web/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf
9. https://en.wikipedia.org/wiki/Hype_cycle
10. Christensen, C. M., Grossman, J. H., & Hwang, J. (2017). The innovators prescription: a disruptive solution for health care. New York: Mcgraw-Hill Education.
11. https://www.christenseninstitute.org/blog/does-reduced-health-spending-mean-reduced-care-quality-just-the-opposite-says-disruption-theory
12. The term 'precision medicine' has today come to describe the technology-enabled customization of healthcare to individual patients; borrowing from Christensen's 2009 book, we use the term differently in this paper to describe the advancement of medical knowledge.
13. https://www.nature.com/articles/s41746-017-0012-2

Imagination at work