BRAINX

Artificial Intelligence in Healthcare

A BRAINX PERSPECTIVE

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***BrainX provides consulting services and expert opinions on topics related to artificial intelligence, database research, and their application in healthcare. With the unique expertise of founders and a vast network of consultants and subject matter experts, we can help develop a vision, strategy, and design for the implementation of AI solutions in healthcare.**

Introduction

Overview of Artificial Intelligence (AI) in Healthcare

Speed of data accumulations and the volume of data generated in healthcare by far exceeds the capacity of humans to process and use it in a meaningful way: in 2020 the volume of healthcare data doubled every 73 days. Furthermore, healthcare data is multimodal, multidimensional and complex, therefore AI solutions can potentially unlock its value to the fullest extent in improving population health and delivering personalized precision medicine.

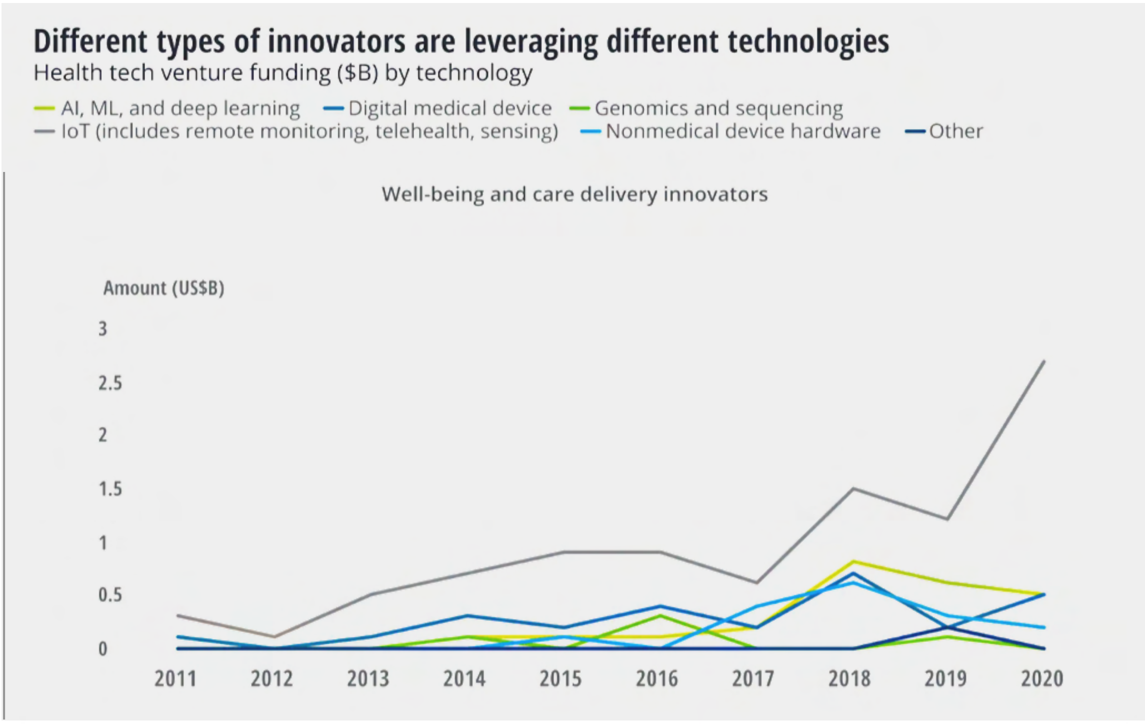
Value-based healthcare demands personalized, patient-centric, and evidence-based processes. The most important question we face now is not "if" AI makes its way into the everyday practice of medicine but rather how it can be utilized wisely for the benefit of the patients, healthcare providers and society. For now, the biggest promise of AI is to facilitate or take over repetitive, time-consuming tasks and deliver to providers the context-specific information at the right time, thus enabling more time spent in direct patient care and reducing burnout. All of the above are much needed considering the aging population and the need to fill 40 million new health-sector jobs worldwide which will be needed by 2030 (according to the World Health Organization). There will be a projected shortfall of 9.9 million physicians, nurses, and midwives globally. AI can shift human resources where they are most needed: for the direct care of patients.

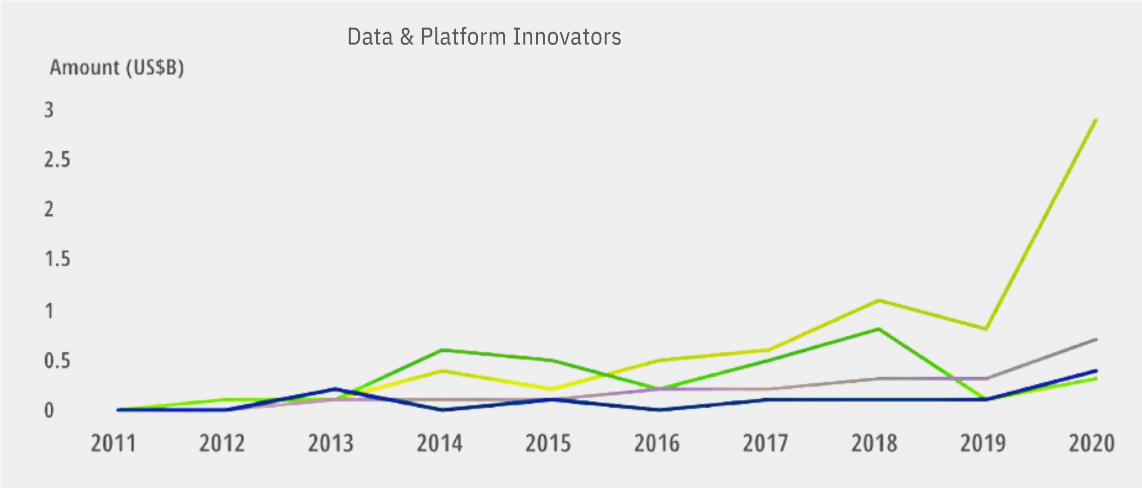
The number of AI companies including startups aiming to develop implementable healthcare solutions and their market capitalization is growing exponentially. Large tech companies like Google, Microsoft, Amazon, IBM, and others have been trying to establish themselves as providers of AI healthcare solutions, however with mixed success. According to the report by EIT Health and McKinsey & Company, the private sector will continue to play a significant role in the development of healthcare-related AI, with venture capital (VC) funding for the top 50 firms reaching $8.5 billion in 2021.

Based on CBInsight reports, out of all the industries, healthcare AI has already attracted the most investments across all AI sectors: in Q1'21 alone, the sector drew 115 equity deals and record-high funding of over $2.5B. Along with increased funding for the development of AI technology there is continuous year to year increase in the number of FDA approved AI/ML-enabled medical devices (www.fda.gov).

Below:
Figure 4

Funding for AI in Healthcare by VC/Government



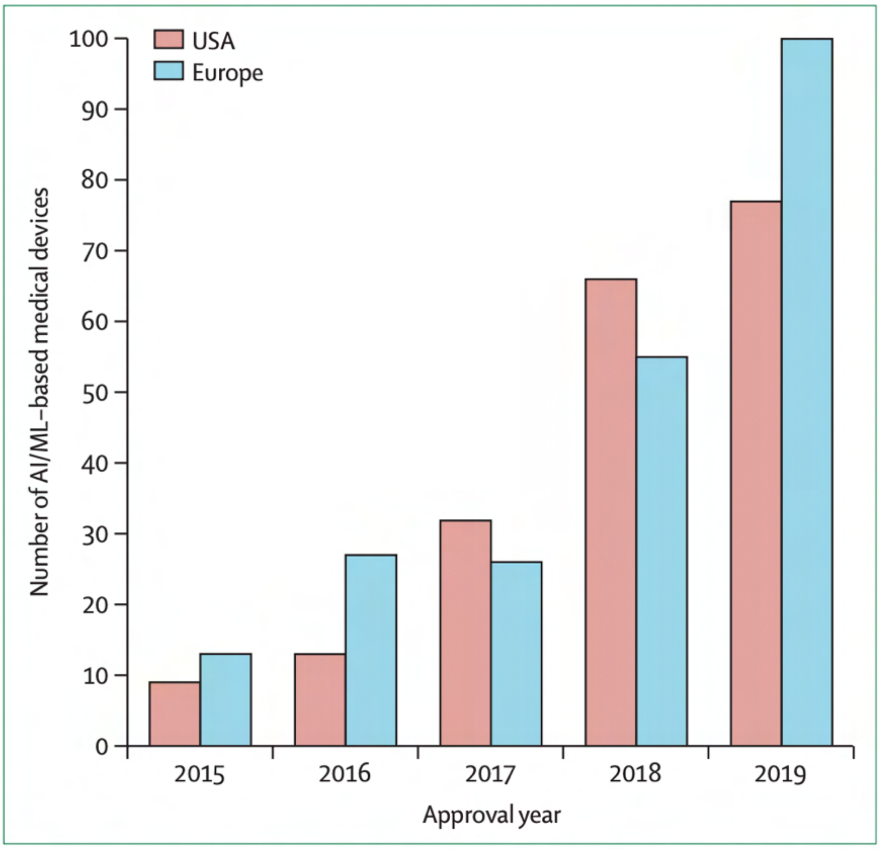


Source: Deloitte analysis of Rock Health's Digital Health Funding Database.

In 2019 investors provided $4 billion in funding for artificial intelligence in healthcare companies, across 367 deals, which was up from nearly $2.7 billion invested in healthcare AI in 2018 across 264 deals. The artificial intelligence in healthcare market is projected to grow from USD 6.9 billion in 2021 to USD 67.4 billion by 2027, it is expected to grow at a CAGR of 46.2% from 2021 to 2027 (https://www.marketsandmarkets.com/Market-Reports/). In the first quarter of 2021 US investors provided $ 2.5 billion in founding to 111 start ups, up 140% year over year increase (CB Insights).
In 2019 among healthcare AI startups, there were 17 M&A deals and two IPOs.

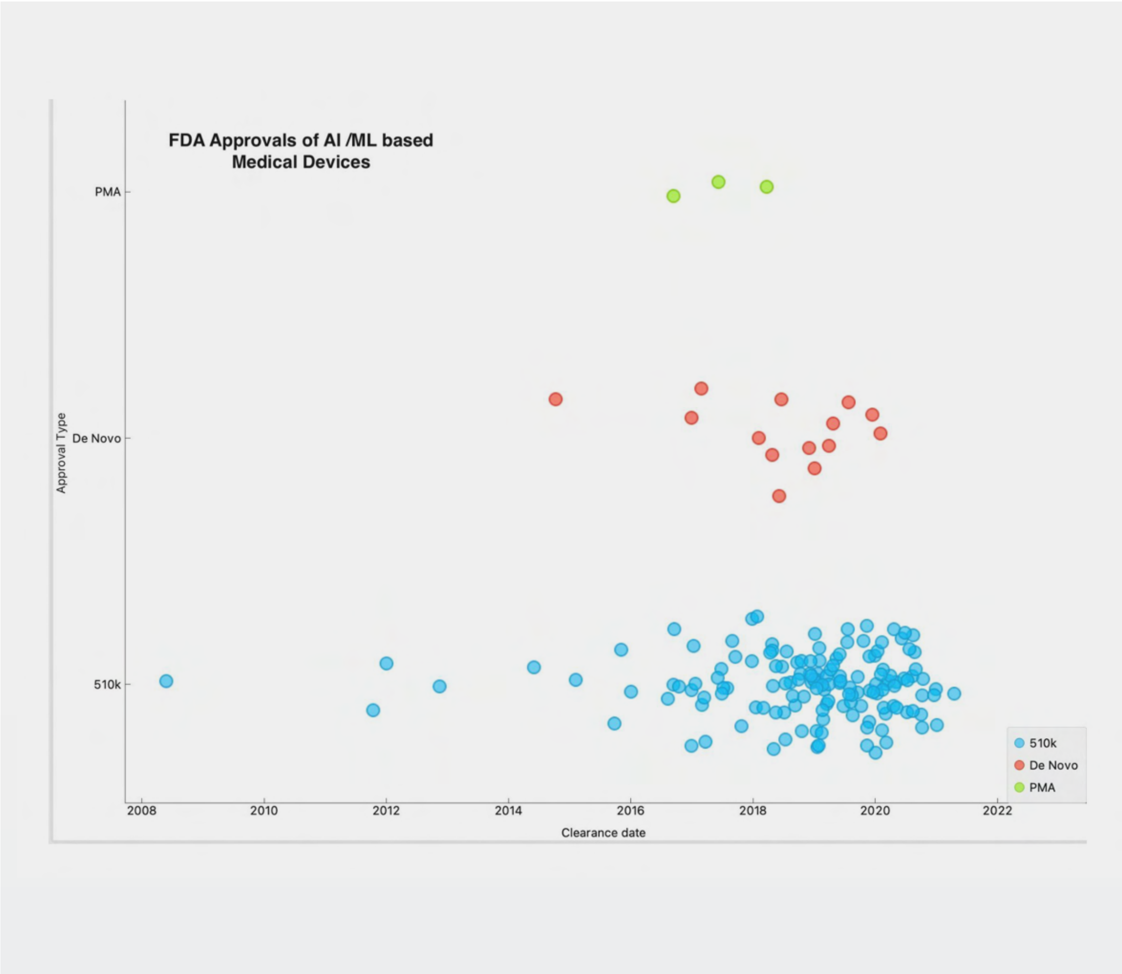
FDA Algorithms Trends Data and Graph

Figure 2



Number of approved (USA) and CE-marked (Europe) AI/ML-based medical devices between 2015 and 2019.

With increased submissions of the AI based solution for regulatory approval FDA put forward a framework to facilitate innovation through AI medical based solutions while providing the appropriate oversight and regulatory structure. According to a recent publication (Lancet Digit Health 2021; 3: e195–203) between 2015 and March 2020, 222 devices were approved in the USA and 240 devices in Europe, majority through 510(k) (92%), de-novo (7%) and PMA (only 1%.) pathways. Majority of the AI/ML-based medical devices - 129 (58%) were approved for radiology, followed by 40 (18%) cardiovascular devices, and 21 (9%) neurological devices. Interestingly, 172 (77%) AI/ML-based medical devices were marketed by small companies (operations of less than US$38·5 million in annual revenue or fewer than 500 employees) and 50 (23%) by big companies. The majority of manufacturers were based in the USA during the time of approval (126 [57%] of 222 devices), followed by Israel (16 devices [7%]), Sweden (ten devices [5%]), England (nine devices [4%]), and France (eight devices [4%]. 189 (85%) of the 222 FDA-approved medical devices were intended for use by health-care professionals, whereas 33 (15%) were intended for use by the patient.



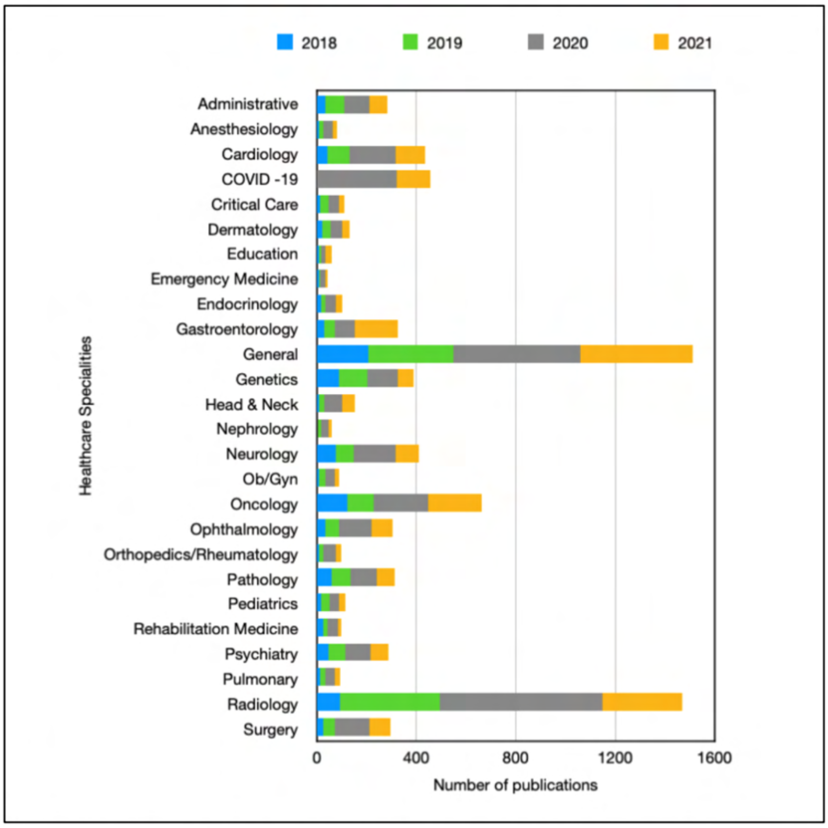


Figure 1. Number of publications for artificial intelligence per speciality (per year)

BrainX Community Year in Review Trends and Data

> Same trend of dynamic growth is visible in the number of scientific publications, with the greatest increase in the medical specialities which rely on image analysis such as radiology, pathology, cardiology(Figure 1,2).
>
> **Ref: Mathur P, Mishra S, Awasthi R, Cywinski J, et al. (2022). Artificial Intelligence in Healthcare: 2021 Year in Review. 10.13140/RG.2.2.25350.24645.**

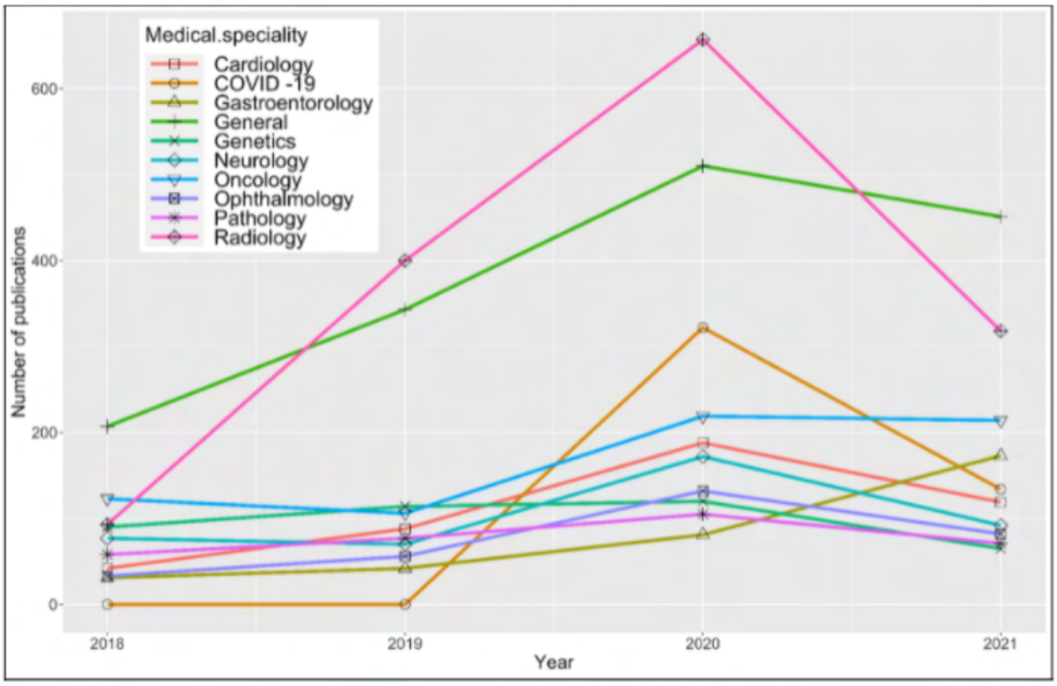
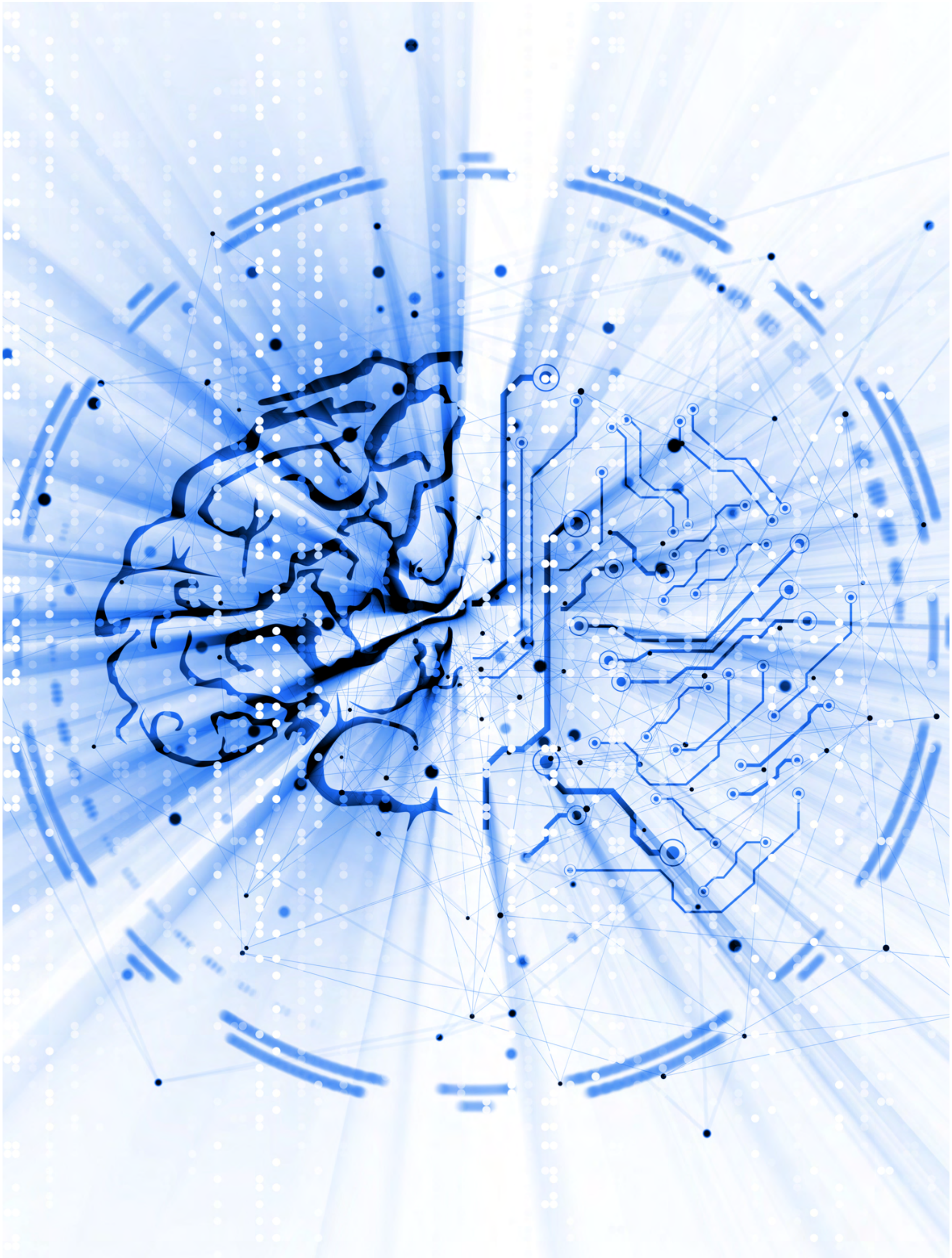


Figure 2. Trends in number of AI in healthcare publications for the top 10 most published specialities (2018 - 2021).

The following report presents in broad strokes BrainX views on the current state of AI in healthcare, future opportunities for AI implementation as well as some limitations and barriers to widespread use of this promising technology.



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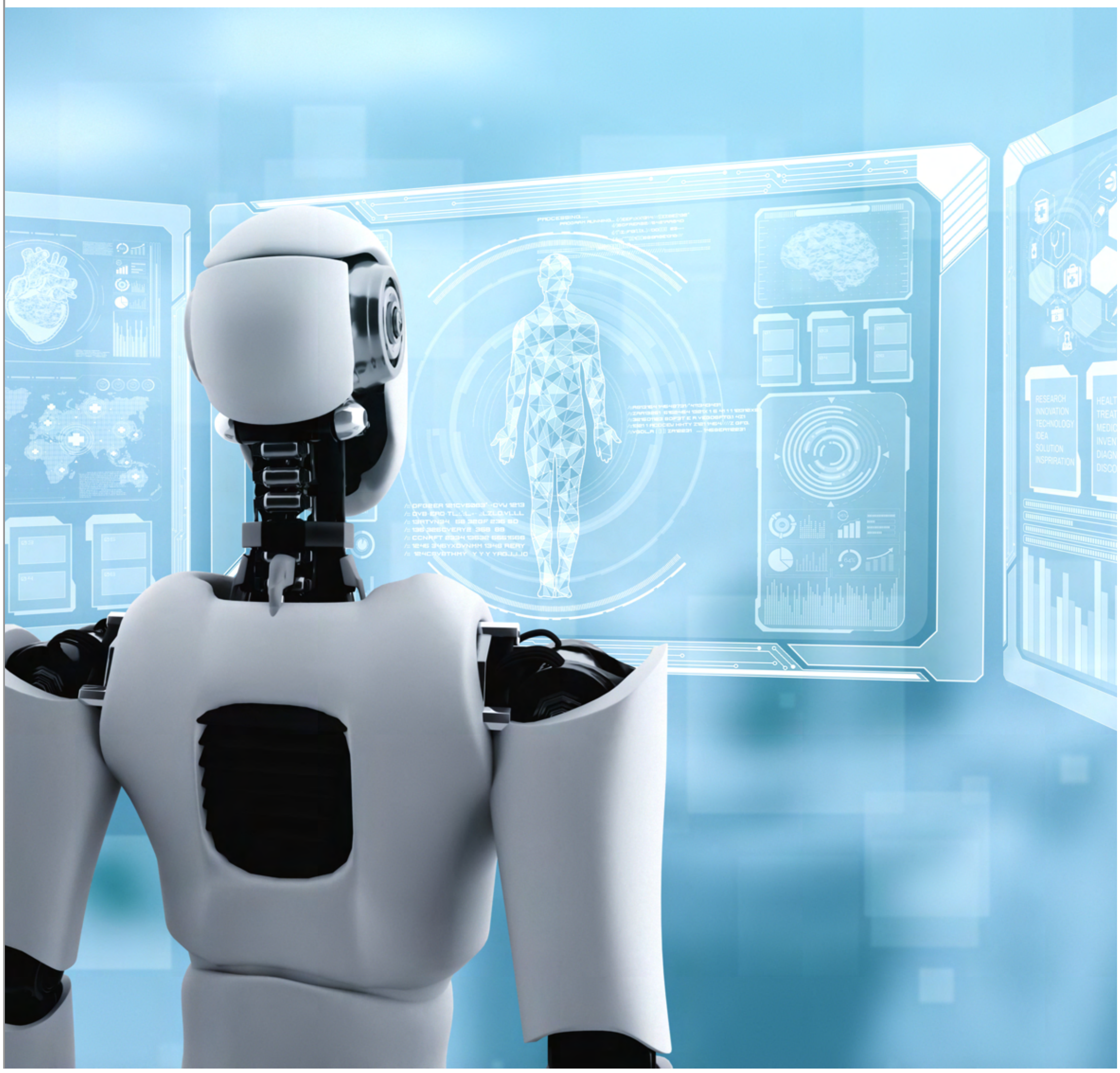
1

Trends in Application of AI in Healthcare

With an aging population and increased complexity of medical needs, health care will need to shift from episodic care delivery to longitudinal care with risk modeling and preemptive interventions.



1.1 Risk Prediction and Personalized Treatment

With an aging population and increased complexity of medical needs, health care will need to shift from episodic care delivery to longitudinal care with risk modeling and preemptive interventions. Dynamic analysis of large population data will help predict individual patient health trajectory and help to decide on the choice of intervention/treatment based on the risks, benefits, and cost.

A preemptive approach to the management of chronic conditions supported by the analysis of the population data will allow control of the healthcare cost as some of the long-term complications may be avoided. The biggest challenge now is the implementation of the AI-driven risk prediction models into clinical workflow, predictive models alone are unlikely to improve outcomes unless they are linked to effective interventions. This creates a great opportunity for developers, researchers, and regulators.

Another opportunity for AI to improve population health is to utilize data from wearables, smart devices, and mobile health applications. In just 4 years, between 2014 and 2018, the proportion of U.S. adults reporting that they use wearables increased from 9 percent to 33 percent, the use of mobile health applications increased from 16 percent to 48 percent. Consumer interest is high (~50 percent) in using data generated by apps, wearables, and IoT devices to predict health risks (Accenture, 2018). In the future, it will be important to regulate how the data from wearables and other consumer devices integrate with the individual health record. Privacy, veracity, and portability of the health data meshed together from different sources will need to be addressed as well as who is allowed to monetize from collected data.

Currently, patients are often treated according to the diagnosis without consideration of other important factors affecting the efficacy (or lack of it) of prescribed treatment. There is a great need for AI-driven precision medicine that will enable clinicians to tailor medical treatment to the individual characteristics of each patient, putting the diagnosis into the context of the individual.

There is a big hope that AI models developed on large and diverse populations will help select the best treatment options for complex diseases such as cancer, mental illness, or multiple medical conditions with competing therapeutic goals.

Predictions of the response to different therapies and quantification of inherent risk and benefits may provide an excellent platform for shared decision making involving the patient, family, and clinical team, providing a patient-centered approach to medical decision making.

1.2 Diagnosis Support

Making a diagnosis is a key clinical activity and often delayed or inaccurate due to incomplete or inaccessible information. AI may help clinicians make quick and accurate diagnoses by providing contextual information at the correct decision points. Accurate diagnosis enables the development of precise, personalized, and timely treatment plans which improve outcomes.

AI technologies which can integrate and analyze diverse types of diagnostic data and provide a point of care clinical decision support will be particularly helpful considering the volume of medical information. A complete picture of a patient's health in the form of a relevant summary and the ability to search for critical information effortlessly will help make a quick and accurate diagnosis and precise treatment recommendations. Unfortunately, AI-aided diagnostic systems have not lived up to expectations, including IBM Watson. It seems that data needed to arrive at the correct diagnosis are too disparate, located on multiple platforms, lack standardized terminology, and often unstructured, further complicating the data analytics.
he development of successful AI solutions will require collaboration among clinicians and Ttechnology companies as well as the unification of data structure and health platforms data sharing.

For now, the realistic goal of AI is not to provide a precise diagnosis independently but to narrow down the differential to aid appropriate clinical care decisions.

The development of tools for a contextual understanding of data across different formats, especially with specialized high volume data, would be extremely helpful for AI-aided diagnosis systems. Unsurprisingly medical specialties, which heavily rely on image interpretation like radiology, cardiology, pathology, dermatology, and ophthalmology experienced a significant number of AI solutions based on pattern recognition.

Advances in image recognition technologies and large (and often publically available) libraries of digitized image databases for training AI models have accelerated this development. AI-powered systems are efficient in high-throughput screening of the medical images, comparing old and new images, or highlighting

abnormal findings for the clinician review.
For example, medical image-based AI systems can diagnose retinopathy with eye fundus images, detect lesion-specific ischemia on head CT scans, identify pathology on chest x-ray and predict node status after positive biopsy for breast cancer.

Image recognition techniques can differentiate among competing diagnoses, assist in screening high-risk patients, and guide treatment decisions like radiotherapy or surgery planning. It is unlikely, nor needed, to replace clinicians with diagnostic AI but automated image classification may provide more time to radiologists, dermatologists, pathologists, and cardiologists for complex and collaborative decision making.

Combining output from AI diagnostic imaging prediction with physician input will reduce diagnostic error.

Histopathologic diagnosis has seen similar gains, for example, cancer classification from tissue samples and the analysis of body fluid to find bacteria, viruses, or proteins that could indicate an illness.

1.3 Image Analysis

Digitized medical images are probably one of the biggest portions of all healthcare data. Among the most promising clinical applications of AI are image analysis, detection and classification of a wide array of clinical conditions. Large datasets of digitized medical images (radiologic, pathology, retina scans, etc.) allow training and fine-tuning models, which in some cases are at least as accurate as an experienced clinician.

Studies have shown excellent accuracy, sensitivity, and specificity for the detection of small radiographic or pathologic abnormalities, with the potential to improve screening for health conditions and unload the work of clinicians. The biggest advantage of AI image recognition solutions is high throughput which can potentially help process more diagnostic studies in a shorter period of time and alert clinicians about abnormal findings.

The biggest question however is if AI solutions will make radiologists or pathologists obsolete and provide an equally accurate diagnosis. In the near future, it doesn't seem to be the case, most likely AI solutions will be implemented to screen medical images and flag abnormal findings for clinicians to verify. It remains unknown if the implementation of AI solutions in image recognition will have an impact on meaningful clinical outcomes such as survival, earlier disease detection, need for treatment, or cost-effectiveness (number of lives saved).
Assessment of AI imaging studies is commonly defined by lesion detection while ignoring the type and biological aggressiveness of a lesion, which might create a skewed representation of AI's performance. While this approach may be statistically sound, the true value and benefit of AI-driven image diagnostics remain to be established.

Medical specialities such as Gastroenterology and various surgical specialities are seeing increasing R&D of solutions for real time guidance using AI for lesion diagnosis. Multi-center trials and FDA approved algorithms embedded in endoscopes,laparoscopic and robotic devices are increasing at an exponential pace.AI performance should be assessed by looking at the patient and system-centered outcomes, such as the added value of detection of abnormal findings, cost of the follow-up, and overall effect on the patient's health trajectory.

1.4 AI in Perioperative Medicine

More than 300 million surgeries are anually performed worldwide. Safe anesthesia techniques and minimally invasive surgeries are the biggest advance in the last century. Now the focus is shifted on coordinated care of patients before, during and after the surgery with the goal to improve outcomes and provide high value care.

Algorithms which identify high-risk patients, predict complications, and guide timely and appropriate treatments will be extremely useful in improving perioperative care. Also, solutions which help optimal utilization of expensive resources in the operating room, human resource management, care coordination and patient education are needed.

Precise delivery of anesthetic drugs with the use of semi-closed or closed loop systems will further increase anesthesia safety. For example, automated blood pressure and fluid management systems are now available for clinical use. Similarly, automated assessment of pain or anaesthetic depth will help in appropriate anesthesia delivery.

Large and complex data available in perioperative medicine makes it the right place to build AI solutions.

1.5 Managing burnout among Healthcare Providers

Burnout or physical and emotional exhaustion [ICD-10-CM diagnosis code z73.0] among healthcare providers is a significant clinical problem adversely affecting productivity and personal health. Productivity pressures and increased administrative work reduce direct contact with the patients who are increasingly old and sick. Furthermore, many providers work in isolation in super-specialized areas of modern medicine reducing the perceived reward. Around one-fourth of healthcare providers suffer from depression and anxiety and an even higher number (one third) suffer from insomnia. (PMID: 32437915). The burnout problem is well recognized now, but unfortunately, solutions are not clear.

Paradoxically introduction of electronic health records did not change this situation but according to many surveys added to the already existing problems. One of the unintended consequences of electronic health records is the volume and the speed of medical data accumulation. AI can be extremely helpful for taking over routine, repetitive, and largely administrative tasks like documentation, which absorb significant time of doctors and nurses.

Also, AI-aided, contextual extraction of the relevant medical data will save time and add accuracy at each patient healthcare provider contact point. Tools like natural language processing (NLP) which can interpret and contextualize written or spoken text may help to find and present needed information in health records and eliminate the need for the physicians to use a computer keyboard to enter information. That will free up providers' time for more time to be sent with direct patient care.

Current data warehousing and care coordination solutions mainly use structured data taken from the structured sections of EHRs and claims. While structured data is undoubtedly valuable, an estimated 80% of the clinical data stored in EHRs is in an unstructured format—and thus difficult to analyze on a large scale. Typically, the unstructured data contains a wealth of clinical information based on physician narratives; pathology, radiology, and discharge reports; and, increasingly, patient-reported information.

1.6 Operations Management

Artificial Intelligent strategies can be used to advance healthcare provider operations and performance through improved healthcare administration, management and operations through the use of machine learning methods in an overall effort to improve healthcare system revenue cycles. Across the country, healthcare providers are experiencing ongoing pressure from declining revenues and increasing complexity in prior authorization by third party payers and government agencies (Medicaid and Medicare). Payers are under increasing pressure to contain costs and adjust actuarial risks in an ever changing population. The implementation of healthcare reform through the Patient Protection and Affordable Care Act (Public Law 111-148) will further exacerbate this issue. These and additional demands to combat waste, fraud and abuse are creating mounting pressures to achieve ‘perfection’ in all phases of healthcare billing and reimbursement authorization for hospitals and independent healthcare providers such as physicians and medical group practices. In order to ensure that payments are appropriate, payers must ascertain that there is proper verified documentation of care prior to reimbursement and in an appropriate time period. Providers must be diligent and timely in maintaining proper documentation to receive the correct payment and avoid a delay or loss of revenue.

The opposing pressures of payers and providers call for the use of machine learning algorithms for decision support/screening methods, to better manage the billing and revenue cycle and detect inconsistencies in coverage, care/service documentation and payments, and to guide financial and clinical personnel through this process. Specifically, the use of machine learning strategies can create models for screening billing information for inconsistency automatically and verify accuracy of input patient data.

1.7 Simulation and Digital Twins

A digital twin is a virtual depiction of a physical object or the organization of a system that can stretch its life cycle which is interminably fed with real-time data, employing simulation, machine learning and artificial intelligence to prognosticate the subsequent events of their corresponding physical counterpart. In simple terms, it is the conceptualization of a highly complex identical digital version (twin) of a physical object(thing) or psychosocial physiological being. This replication of a physical object helps in decision making. This computational technology is set to transform the healthcare system in a multitude of ways starting from diagnosis, disease treatment, follow-up, streamlining preventive measures and promoting new approaches for planning and implementation of healthcare facilities.

Artificial intelligent technologies are accelerating the creation of super-advanced “virtual twins”. Which open to data-driven models capable of preventing disease and offering more efficient health systems. In the case of healthcare initiatives, digital twins are digital representations of human physiology built on computer models in which data relating to both the individual and the population are introduced. The use of digital twins in healthcare is revolutionizing clinical processes and hospital management by enhancing medical care with digital tracking and advancing modeling of the human body. These tools are of great help to researchers in studying diseases, new drugs and medical devices. In the future may also help physicians optimize the performance of patient-specific treatment plans. In the short term, however, digital twins will help the healthcare system bring ife-saving innovations to market faster, at lower costs and with greater safety for the patient. Digital twin simulations can then be performed to find out how different people would react to different treatments. But digital twin technology can also be used to represent the genome, physiological characteristics and lifestyle of an individual to personalize medicine fully. A digital twin of a human body will allow physicians to discover the pathology before the disorders are evident, experiment with treatments and better prepare for surgery. However, the key to translating digital twins’ value into real impact lies in large-scale implementation: making the technology widely accessible in the clinical routine, innovating key clinical processes using digital simulations, and improving medical care.

1.8 Drug Discovery

The diverse range of AI applications being explored could help tackle the fundamental challenge that developing new drugs, from target identification through clinical trials, requires years of time and billions of dollars. Recognizing this potential, and hoping that the new technology can also help them develop more-effective and better-targeted drugs, pharmaceutical companies are building up their own in-house AI teams, as well as investing in and collaborating with these companies.
Where it might have taken the traditional discovery process 4–5 years to come up with the drug candidate has been achieved in a much shorter duration using AI. For e.g.,an A2 receptor antagonist designed to help T cells fight solid tumors was found in 8 months by harnessing Exscientia’s ‘Centaur Chemist’ AI design platform which would have otherwise taken many years. This helps cut down large estimated price tags of US$ 2.6 billion for developing a treatment significantly,especially knowing that 90% of the candidate therapies fail somewhere between phase 1 trials and regulatory approval. (https://www.nature.com/articles/d41586-018-05267-x)

Accelerated by ground breaking research such by Google’s AI subsidiary, DeepMind, announced that its AlphaFold program could deliver computational predictionsof protein structure that approach the quality of those provided by gold-standard experimental techniques such as X-ray crystallography. (Callaway E. ‘It will change everything’: DeepMind’s AI makes gigantic leap in solving protein structures. Nature 2020; 588: 203–204.) Many companies applying AI in drug discovery have raised $100-500 million for IPO offerings or partnered with existing companies in large deals. (https://www.nature.com/articles/d43747-021-00045-7). According to Markets and Markets, AI in drug discovery represents a market that will attain a global value of $1.4 billion by 2024, up from $259 million in 2019, reflecting a compound annual growth rate of 40.8%. In a 2020 article, Henstock cited projections indicating that the pharmaceutical industry could boost earnings by more than 45% by making strong investments in AI.(Henstock P. Artificial Intelligence in Pharma: Positive Trends but More Investment Needed to Drive a Transformation. Arch. Pharmacol. Ther. 2020; 2(2): 24–28.)

1.9 Software as Medical Device (SaMD)

International Medical Device Regulators Forum (IMDRF) defines SaMD as "software intended to be used for one or more medical purposes that perform these purposes without being part of a hardware medical device." Many AI based solutions or decision support systems will be marketed as SaMD. For example, image processing software can differentiate between malignant or benign skin lesions. Such software needs to pass through appropriate scrutiny like other medical drugs and devices to ensure patient safety and benefit. Regulators need to provide a safe environment for AI innovations so that promising technologies can be brought to market quickly while minimizing associated harm. This is a complex task and would require dedicated independent funding for regulatory organizations to build expert teams to evaluate ever-increasing AI technologies. Also, robust validation and approval processes (similar to medical equipment or drugs) will help to earn the trust of healthcare providers and patients in AI-driven solutions.

2

Limitations and Barriers of AI Application in Health Care

One of the biggest challenges to the successful implementation of AI models is poor generalizability outside of the populations represented in the training and validation data sets.

2.1 Regulatory, Medico-Legal, and Bias

One of the biggest challenges to the successful implementation of AI models is poor generalizability outside of the populations represented in the training and validation data sets. Disregarding this fact can have significant unintended consequences on care, the patient-clinician relationship, and overall trust in the AI solution. Therefore, there is an urgent need for the development of large and robust clinical datasets, which will allow the development and testing of AI algorithms to assure generalizability and validity. Unfortunately, as of now, due to regulatory barriers, it will be difficult to develop publicly available datasets which are big enough and contain a wide array of clinical data. Furthermore, underrepresentation of certain populations in the datasets used for AI model training can lead to inherent biases adversely affecting healthcare delivery and outcomes. For example, with a limited dataset AI may deliver superior predictive performance, but it could also compound inequalities

The consequences of AI-aided medical decisions can be substantial and affect morbidity and mortality, and as such, there is significant resistance in the healthcare community to implement AI systems without proper validation and explainability. It is hard to imagine that major treatment decisions will ever be based on “black box” systems, which lack reasonable clinical explanations and accountability. Ethical and legal ramifications of the decisions based on AI algorithms are just getting attention and need appropriate regulations. FDA recently developed a framework for the approval process of “Software as a Medical Device”, which will provide a robust evaluation and transparency to the validation process. A strict regulatory environment is also a key barrier to the adoption of AI, which differs by country and institution, however, authorities are trying to change this, and understand the risks and benefits of AI technologies.

2.2 Interchangeability and Portability of Healthcare Data

Large, complete and real-time data is essential for AI solution development. Health care data sets operate in silos, making it impossible to pool large and diverse population data for the analysis.

Proprietary electronic health record companies' monopoly, lack of standardization, antiquated patient privacy law and data sharing regulations, and willingness of the individual institutions to share data all are barriers to interoperability. We are also rightfully concerned about inappropriate data use and the lack of robust safeguards to prevent misuse.

As AI requires data pulled from multiple health systems a significant effort and resources will need to go to assure data security, data sharing agreements and interoperability.
Establishing accessible large databases with proper safeguards and governance will allow us to build novel AI solutions. Patients will play a unique and essential role in devising new rules guiding data usage and sharing. Many experts, including us, believe that health care data sharing should be patient-centric.

Patients should have easy access to all health data and should be able to share with anyone as per their preference. The recent development of personal health record solutions is a step in the right direction.

Standards for health information data exchange have been developed for years to facilitate portability of the health records, however requirements of AI put new challenges on interoperability and standardization.

FHIR (Fast Healthcare Interoperability Resources) is a standard for exchanging healthcare information. FHIR combines the best features of previous standards into a common specification while being flexible enough to meet the needs of a wide variety of use cases within the healthcare ecosystem. FHIR focuses on implementation and uses the latest web technologies to aid rapid adoption.
Healthcare organizations and electronic health record companies increasingly share health data with the patients and other organizations, however, the progress is slow.

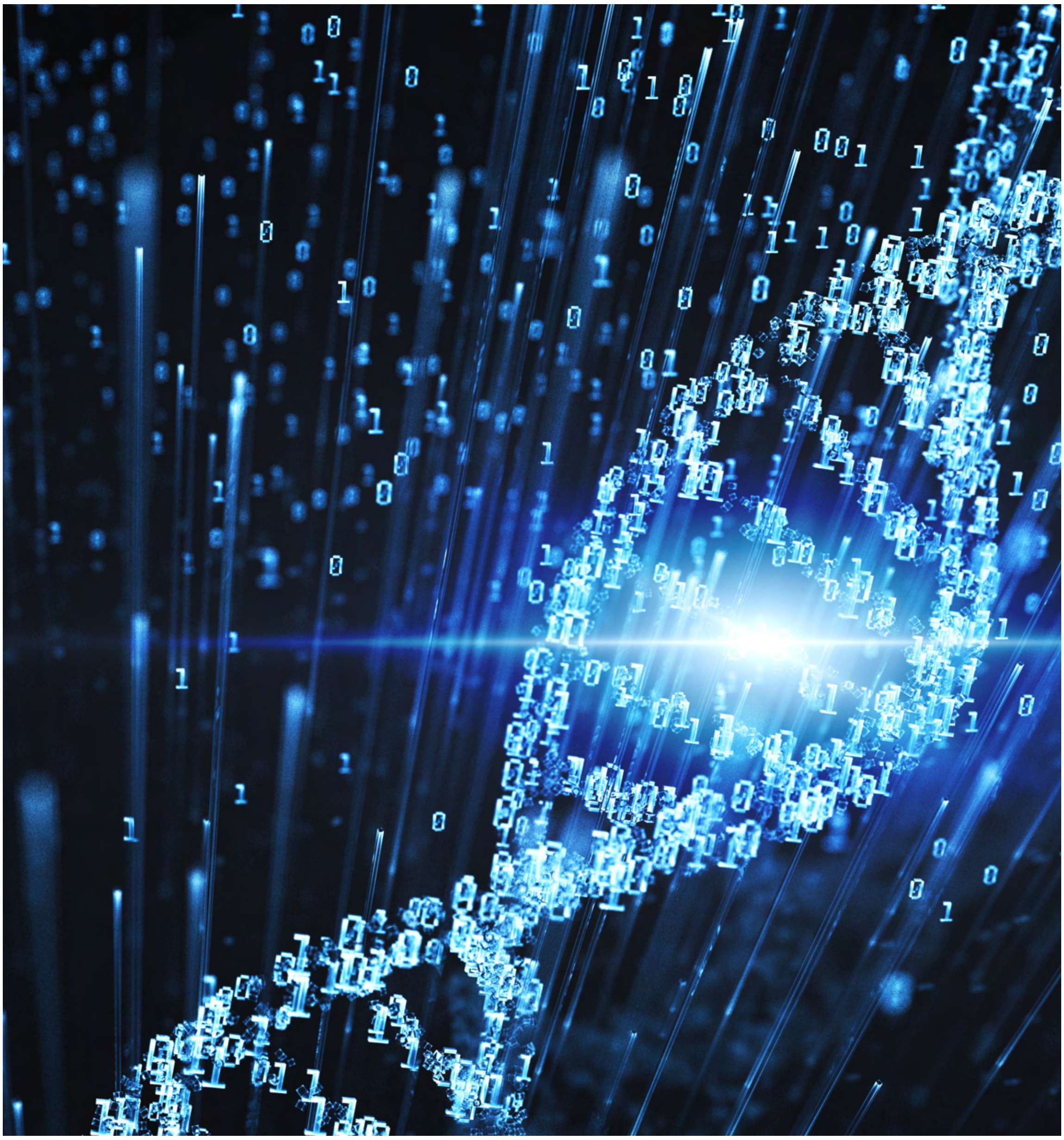
In the past few years, large tech companies (Google, Microsoft, Amazon etc.) developed HIPAA compliant cloud storage, which offers integrated AI tools for data analytics.
This solution may prove to be more accessible for healthcare systems to integrate EHR data. Unquestionably creation of large population data lakes combining EHR data from multiple health systems will allow development of more robust and generalizable models.

2.3 Providers and Patients Trust in AI-Driven Decision Making

Ultimately broad adoption of AI in health care depends on the confidence and trust of providers and patients in new solutions. Unfortunately, that takes time and for now, maybe one of the most important limiting factors of AI implementation. There are a few pillars to build trust upon in AI applications for healthcare: data validity, generalizability, and governance, explainability of the results and management of the related risk.

Data validity and generalizability remain an important factor to gain trust and expand the adoption of AI in healthcare. Transparent data governance needs to be established to assure that the models are developed and validated on trustworthy and unbiased data sets. The patients need to be assured that AI-driven management is scrutinized, ethical, and has strict quality improvement mechanisms built-in. It also remains to be determined who and how manages the ownership of the data i. This aspect is particularly important when patient data is used to develop commercial solutions which profit developers.

AI applications that operate as a “black box” which does not provide explainability of results will not be easy to introduce into the clinical practice. Trust of both providers and patients must be earned and at this time healthcare AI solutions are not reliable enough to make treatment decisions, which have high penalty for incorrect choice, operate without human supervision and understand decision-making logic.



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3

Future of AI Integration in Health Care

An enormous amount of population medical data collected in electronic medical health records can be leveraged by AI to predict the health trajectories of individuals.

3.1 Longitudinal Follow Up

Population health management has been one of the biggest challenges of modern healthcare. Currently, most of the care is provided on “as needed” basis when the patients develop health conditions. This approach is costly and may not mitigate the complications of chronic medical conditions which drive the health care expenditure to unsustainable levels. An enormous amount of population medical data collected in electronic medical health records as well as data from personal electronic devices and the internet of things (IoT) can be leveraged by AI to predict the health trajectories of individuals. This approach may shift healthcare from being reactive (treat disease when it occurs) to proactive and preventive (institution of interventions focused on preventing the development of health conditions altogether). The longitudinal preventive strategies could potentially be individualized and modified as needed based on the models developed on robust and diverse datasets. Successful implementation of AI-driven preventive longitudinal follow up depends on a few prerequisites, such as robust and diverse data for model training, governance of the data and continuous assurance of data veracity and implementation strategies of AI-derived recommendations. Trust of providers as well as patients and regulatory bodies must be earned for smooth integration within the current healthcare framework.

3.2 Portability of Personal Health Records (PHR) and Blockchain

Blockchain technology was introduced through Bitcoin in 2008 and may change in the future how individual patients' health information is stored and shared. Conventional data management of Electronic Health Records (EHR) rely on on-premise data servers or third-party cloud services; they incorporate centralized repositories of all patients receiving treatment within a given healthcare system. On the other hand blockchain’s distributed ledger technology offers a novel alternative to store, share and manage Personal Health Records. PHRs are unique in that patients themselves can access, manage, and share all of their health information. The benefits of PHRs include patient empowerment, which in some studies showed improved outcomes and reduced health care costs. Although interest in PHRs has been increasing, their adoption remains rather low and significant concerns related to privacy and security. Unique property of blockchain technology which relias on decentralized storage, distributed ledgers and smart contracts, puts data ownership in the hands of individual users making it more portable and useful from the perspective of the patient.

3.3 Integration of Internet of Things (IoT) into Algorithmic Decision Making

Value-based health care, personalized medicine, and patient-centricity have been reshaping how medical care is delivered and paid for. The Internet of Things (IoT), which links people, IT systems, and devices, enabling two-way transfers of data through a network, without human-to-human or human-to-computer interaction.

Devices with smart sensors (wearables and medical devices can capture patient vitals and other data in real-time – then data analytics technologies, including machine learning and artificial intelligence (AI), can be used to realize the promise of value-based care. Collected and analyzed data can help establish faster and more accurate diagnoses and a more patient-centric, scientific determination of the best therapeutic approach to supporting better health outcomes.

IoT in healthcare can improve patient care and safety in many ways: smart, connected monitoring devices that are linked to patient records, pharmacy systems room location, nursing staff schedules powered by AI can assist clinicians to choose the best treatment for the patients at the right time. Sensors in the smart devices collect data, which is then integrated with other medical device and then analysed to find whether to trigger a silent alarm for a noncritical event or an audible alarm for a life-critical event. In this way, patients are kept safer and providers' alarm fatigue can be decreased. The biggest leap IoT can provide is by allowing to collect granular patient data not only when people are sick or in a hospital, but where people live and work. This data can be combined with behavioral, physiological, biochemical, genetic, genomic, and epigenetic data and more to make predictions about the disease course and possible interventions needed. As the data accumulates, algorithms will be able to detect new, previously unknown patterns and relationships between data points, diagnoses, treatments, and patient outcomes.

BrainX Expertise

BrainX provides consulting services and expert opinions on topics related to artificial intelligence, database research, and their application in healthcare.

With the unique expertise of founders and a vast network of consultants and subject matter experts, we can help develop a vision, strategy, and design for the implementation of AI solutions in healthcare.

BrainX founders have in depth expertise in applications of AI solutions in perioperative settings such as surgical patients risk stratification, analysis of perioperative physiologic parameters, augmented reality and surgical navigation. Multiple quality improvement and research projects have been successfully led by BrainX founders, leveraging large healthcare datasets and AI tools to improve and maximize efficiency of patient care.

BrainX has also been very active in promoting AI education, with the focus of implementation of AI solutions in healthcare. In webinars, podcasts and web based meetings invited experts share their expertise and opinions about the current state and the future of AI.

BrainX: Our Story

BrainX (www.BrainXAI.org) was co-founded by Drs. Piyush Mathur and Francis A. Papay in 2017. Dr. Mathur is an anesthesiologist and intensivist, and Dr. Papay is a plastic surgeon and chairman of the Dermatology and Plastic Surgery Institute at the Cleveland Clinic. They have a vision for an organization that would collaborate, engage, develop and produce new technologies, promote new research, and create platforms for artificial intelligence in healthcare. Soon after Drs. Ashish Khanna, Kamal Maheshwari and Jacek Cywinski, all of whom are clinician-scientists with an established national and international reputation in respective fields, joined BrainX as founding partners. In essence, BrainX offers expertise and know-how for handling large datasets, research, and applications for artificial intelligence, driven by the expertise and passion of five physician-scientists with a niche area of expertise of their own.

An early collaboration that exemplified this vision was with researchers at Carnegie Mellon University (CMU) where the group developed a multimodal machine learning model to predict ICD-10 diagnostic codes. Over the last few years BrainX has aligned with the vision of delivery of education using innovation and technology much like Project ECHO. BrainX community serves as a unified platform to foster education and collaboration for AI applications in healthcare, being one of the world's largest such communities. With a current membership in excess of more than 4000 members around the world, this platform is growing at an exponential rate. In addition, the BrainX community hosts monthly educational sessions which are subsequently posted on its YouTube channel and website. The mission of education, research, development, innovation, and collaboration is now extending out to other parts of the world as well, including a European and Middle East chapter.

In addition, other similar organizations like AIMed,Indian Institute of Technology(IIT),Delhi,Indraprastha Institute of Information Technology(IIIT),Delhi InnovatorMD, Indian Society of Critical Care Medicine, Unofin, have formed engagements with BrainX and have jointly hosted meetings and symposia.

To stay up to date with the latest and greatest research in AI, BrainX Community publishes an annual year-in-review as a collection of a subject specialty-specific sets of literature published in the last calendar year. The BrainX team itself has stayed heavily involved in the advancement of science and each of its core members has published extensively alone or as collaborators.