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Perspective
Impact of Artificial Intelligence on the Healthcare Industry

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Abstract

Background and Objective: The healthcare industry is a large part of the United States GDP and is ripe to be disrupted. The industry is multifaceted and artificial intelligence/machine learning will impact every aspect of healthcare: Treatment, diagnosis, administration and research. Current research argues the position that artificial intelligence and machine learning will overwhelmingly affect the health care industry and the way it will engage with its stakeholders. **Materials and Methods:** Each of these areas is further subdivided into subcategories. Each of these subcategories was analyzed for how artificial intelligence/machine learning will transform them and increase efficiency and productivity, thus reducing the overall cost of care while improving quality. Also identified are some of the roadblocks the adoption of artificial intelligence/machine learning in the healthcare industry will face. **Results:** While it is apparent that there will be significant impact of AI in health care, one of the most important roadblocks for early adoption of artificial intelligence will be trust in the system by patients and other relevant stake holders. **Conclusion:** Thus, developing trusted AI will become an ever- increasing requirement for future applications of artificial intelligence/machine learning in the healthcare industry and trust should be built into the system by design rather than as an afterthought.

Key words: Artificial intelligence (AI), machine learning, healthcare industry, virtual healthcare, robots

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INTRODUCTION

Artificial intelligence (AI) will overwhelmingly affect the ways in which businesses, institutions and societies will engage with their stakeholders. Almost all walks of life, from self-driving cars to highly advanced genetic diagnostics, are witnessing the impact of AI at various stages. This study documents the impact of AI in the healthcare industry in a holistic manner.

Healthcare spending accounted for 18% of the nation's GDP in 2017 in the USA, close to $4 trillion and healthcare spending is expected to rise nearly 20% of the GDP by 2027[1]. Given the importance of healthcare to global economies as populations age in most countries, an evaluation of the application of AI in healthcare industry is conducted in a rigorous and comprehensive way.

The healthcare industry is multifaceted and AI can be integrated into all aspects of it, such as treatment, diagnosis, medical imaging, personalized treatment, administration and research. Below our insight into these different aspects is discussed in more detail..

AI IN TREATMENT

The major ways the treatment of patients will change because of artificial intelligence include robotics, telemedicine and virtual nursing assistants, and patient monitoring for chronic diseases.

Robots: In terms of the physical applications of artificial intelligence in the treatment of patients, robotics is a special promising area. For example, in Japan, advanced robots known as carebots assist portions of the elderly population suffering from limited mobility or cognitive decline[2]. These robots, as they become more advanced, have the potential for eliminating the need for multiple caregivers in care for the elderly[3].

However, it is robot-assisted surgery that represents perhaps the most potential for change in the near future. In a 2017 report from Accenture, robotic surgery is listed with the greatest near-term value of all applications of AI in healthcare at an estimated $40 billion dollars[4]. Robotic surgery offers several advantages compared to conventional surgery, including stabilization of instruments, mechanical advantages, improved ergonomics for the operating surgeons and superior visualization of the operative field[5]. However, robotic surgery should not be viewed as simply another laparoscopic device to be used by physicians. Rather, it has been found that robotic-assisted surgery has a separate learning curve that must be contended with by physicians[6]. Physicians will need to learn these new skills and adapt to the changing nature of the surgical field as robotic surgery is used more and more.

Even in the hospitals that robotic surgery is already in use, changes will need to be made in the future in terms of training and credentialing. Currently, many robotic-assisted surgery credentialing processes require a certain number of operations to be completed before receiving full privileges[7]. However, as robotic surgery continues to spread, whether this is the best practice comes into question. It is proposed that credentialing committees tailor the process to the skill of the surgeon and that cases be selected by matching complexity with surgeons' skill level with robotic assisted surgery[6]. Robotic-assisted surgery is already changing the surgical field and it only stands to evolve more and require further changes as time goes on.

Virtual healthcare: Virtual healthcare is the use of technology such as video, messaging and sensors to deliver health services independent of time or location[8].

One major area of virtual healthcare that has seen recent popularity is telemedicine. Telemedicine, specifically, is the remote transferring medical information through telecommunication technology to perform consultations, examinations and procedures[9]. It can be considered the modern evolution of *in absentia* care[10]. Telemedicine has developed as a response to rising health care costs, a shortage of physicians and an aging population. Costs are reduced by reducing labor intensity while increasing clinical capacity[8]. Yet telemedicine still stands evolve further through AI applications. Tying into the previous section, telepresence robots are being designed using artificial intelligence and computer vision systems for navigation and obstacle detection, allowing the robot to path find with only a destination as input[9]. Such advances will aid in simplifying the implementation and furthering the expansion of telemedicine.

A natural progression from the person-person nature of telemedicine currently is computer-to-person interactions through the development of virtual assistants[11]. According to Accenture, this is the application of AI with the second greatest near-term value of $20 billion[4]. These AI-powered assistants can remotely assess the symptoms of patients and alert clinician's only when intervention is necessary, reducing unnecessary hospital visits and reducing the burden on medical professionals[4]. These virtual assistants can also tackle the issue of noncompliant patients, engaging patients with reminders and alerts to provoke actions at key times[11]. Artificial intelligence can identify patients to prioritize with such interventions and compliance data can be sent to clinicians.

Chronic disease treatment: Artificial intelligence offers promising new models of care for patients suffering from chronic diseases through remote monitoring. Using the appropriate sensors, the distant surveillance of patients can be accomplished and this tele-monitoring finds its use in diseases such as chronic heart failure, chronic obstructive pulmonary disease (COPD) and diabetes mellitus[11]. With COPD, a classification and regression tree method has been validated using data from tele-monitoring[12]. This kind of analysis performed real-time could initiate timely treatment for patients it identifies at risk of imminent exacerbation.

With diabetes mellitus, progress has been taken a step further with the artificial pancreas, combining monitoring and treatment. The MD-logic artificial pancreas system uses fuzzy logic, imitating the reasoning of diabetes caregivers[13]. It uses parameters such as the patient's physical characteristics and insulin delivery regimen while monitoring glucose levels to modulate insulin delivery and minimize high glucose peaks while preventing hypoglycaemia[13]. In the future, a similar strategy can be applied to the delivery of other drugs needed in regular intervals, such as chemotherapy. In determining appropriate drug doses in real-time, artificial intelligence also helps prevent costly overdosing.

AI IN DIAGNOSIS

The major ways diagnostic procedures will change because of artificial intelligence include the automated analysis of medical images and the development of personalized treatment plans.

Medical imaging: Medical imaging is perhaps the area of medicine that has seen the most advances with the application of artificial intelligence. The fields of radiology and ophthalmology in particular have seen great strides in the application of artificial intelligence to image analysis, with radiology enjoying the most FDA approvals for artificial intelligence-based algorithms in medicine[14]. In one study, pulmonary tuberculosis was automatically classified using convolutional neural networks[15]. The scientists used two neural networks and when these classifiers disagreed, the classification was made by a board-certified radiologist, resulting in a sensitivity of 97.3% and specificity of 100%[15]. In ophthalmology, images of the retina have been diagnosed for diabetic retinopathy with sensitivity and specificity above 90% by several groups[16]. The current state of artificial intelligence in medical imaging is one where task-specific artificial intelligence has begun to match the performance of humans, occasionally even out performing humans; in the future, it is expected that artificial intelligence will outperform humans entirely[17]. However, in the present, the manual grading of these images proves to be tedious and time consuming. The automated analysis and diagnosis of the images will eliminate these costs in time and labor, increasing efficiency and reducing errors by providing radiologists with pre-screened images and identified features[17]. This in turn will provide patients with quicker turn-around times on accurate diagnoses and ultimately faster, better treatment.

Personalized treatment: The development of personalized treatment plans is one of the most promising applications of artificial intelligence. The most high-profile worker in this field is probably IBM Watson. In 2016, University of Tokyo doctors reported that IBM Watson had successfully diagnosed a woman with a rare form of leukemia, a diagnosis that had evaded doctors for months[18]. Watson was able to compare the patient's genetic changes with millions of research papers. Once the disease had been identified, treatment could be changed appropriately. This is the ideal of using artificial intelligence in developing personalized treatment plans, to notice and capture trends that may be overlooked by doctor.

Artificial intelligence has also seen success in predictive analytics when applied to electronic health record (EHRs). Applying deep learning to EHR data to obtain general and robust features, followed by a random forest method allowed for the probabilistic prediction of the future development of several diseases[19]. Applying deep learning to EHR data has also allowed for the prediction of inpatient mortality, readmissions and long lengths of stay[20]. Artificial intelligence makes it possible to create models of diagnosis and care far more complex than before. Rather than using one or two simple features, artificial intelligence can consider thousands of these simple features and further combine them to generate deeper features for consideration. Altogether, this allows for the development of treatment plans specific to the patients, based on their data and what can be predicted from it.

AI IN HEALTHCARE ADMINISTRATION

The major ways healthcare administration will change because of artificial intelligence include automated electronic health records and claims management in health insurance.

Electronic health records: Electronic health records (EHRs) have become widely used throughout the world, with many nations seeking to improve access, quality and efficiency of care through such tools[21]. However, despite their promise to improve care, EHRs have attracted criticism and have been shown to have adverse effects on the patient-provider dynamic. Primary care physicians spend almost 2 h on EHR tasks for every 1 h of direct patient care[22]. Nearly half of that time is spent on clerical and administrative tasks[22]. Among medical professionals, it is commonly felt that EHR systems are a major contributor to professional dissatisfaction and physician burnout[23]. To improve physician satisfaction, solutions that reduce physician data entry have been put into play, such as using scribes[24]. Another approach comes from the angle of artificial intelligence.

Using AI-based technologies, such as voice-to-text transcription and natural language processing, administrative and clerical activities like writing chart notes, filling prescriptions and ordering tests can be automated[25]. Using AI for these administrative workflow assistant capabilities represents a significant financial opportunity, with a near-term value of $18 billion[4]. Eliminating the time burden of these activities allows care providers to spend more time engaging in direct patient-care activities. Nuance Communications is bringing this concept to market with its Ambient Clinical Intelligence. Using several microphones and computer vision sensors coupled with a deep learning model, conversations can be turned into clinical documentation[26]. This technology has the potential to eliminate the duplication of effort that is the current system: having a conversation with a patient only to enter all that same information into the EHR. As this technology advances and is adopted, it stands to reduce labour costs, greatly improve physician satisfaction and refocus care onto the patient.

Health insurance: Health insurance as it stands faces enormous amounts of labour due to manual claims management systems. According to a report from McKinsey looking at the German market, as much as 70% of received claims are flagged as unusual for manual review[27]. Furthermore, only about 10% of these cases are successfully intervened[27]. These claim audits take away time and resources at both the health insurers' and providers' ends. An AI-based claims management system would identify those claims where intervention is most likely to be successful and assign priority to them[27]. This would allow for a better allocation of labour. The system could further provide guidance on how to approach the intervention[27]. The end result is a simpler, faster claims management system that benefits all involved. In an extension of the above is the more specific case of healthcare fraud. Healthcare fraud costs in the United States are estimated to be between $100 and $170 billion annually[28]. According to Accenture, fraud detection represents a near-term value of $17 billion[4]. Artificial intelligence solutions can identify likely fraud and collect evidence in cases where fraud has already occurred. Artificial intelligence can help sift through data to verify services provided, identify anomalies to defend against "upcoding" and analyze additional behavioral data alongside transactional data to identify potential fraudsters[29]. Using AI alongside human review has the potential to make a large dent in losses to healthcare fraud as the technology advances.

AI IN HEALTHCARE RESEARCH

The major ways research and development in healthcare will change due to artificial intelligence include the selection recruitment of clinical trial participants and new methods of drug discovery.

Clinical trial participants: In the healthcare field's research and development side, there is a phenomenon known as Eroom's Law, the reverse of Moore's Law from the semiconductor field: "the number of new drugs gaining regulatory approval per billion USD spent has halved approximately every 9 years"[30]. Many new drugs fail to reach regulatory approval due to failures in clinical trials, which suffer in the areas of patient cohort selection and patient recruitment[30]. Artificial intelligence and machine learning can help improve both of these factors. In selecting a patient cohort, artificial intelligence and machine learning methods can reduce population homogeneity through electronic phenotyping, something previously accomplished through hand-crafted rules[30]. Transitioning to AI and ML methods would allow for much more complex phenotyping. ML methods can also be used to approximate key biomarkers from other, less invasive, measurements[30]. Some specific examples of where these methods could be applied are in congestive heart failure and Alzheimer's Disease. Heart failure with preserved ejection fraction is phenotypically heterogeneous without proven therapies[31]. However, artificial intelligence approaches could identify subsets within the disease that could benefit from therapies that failed in clinical trials otherwise[31]. AI has also been shown to be able to accurately predict the onset of diseases such as Alzheimer's[32]. In identifying these individuals at the onset of the disease, they can be easily and quickly recruited into clinical trials aimed at slowing its progression.

Drug discovery: Another approach to the problems faced in the research and development of healthcare targets the initial steps of treatment development: Drug discovery. Many machine learning methods are already used in the drug discovery process, such as support vector machines and random forest approaches[33]. The future will involve more recent advances to the field, particularly neural networks. Deep learning has been applied to property prediction of new compounds and shown to out-perform Random Forest methods[34]. A recurrent neural network was used to develop a generative artificial intelligence that could perform computational *de novo* design[35]. By training on existing compounds, the generative AI model can produce new compounds within the domain of the training data[35]. With these two approaches, new potentially efficacious drugs can be found from known compounds, or entirely new compounds can be formulated. In the coming era of big data analysis, artificial intelligence and machine learning methods will result in faster, cheaper and more efficacious drug discovery.

ROADBLOCKS TO IMPLEMENTATION

Despite the many promises of artificial intelligence in healthcare, there are several roadblocks to overcome before widespread implementation.

First and foremost, patients may not trust artificial intelligence in healthcare. This can be attributed to the "black-box" character of artificial intelligence solutions, especially deep learning neural networks. It is difficult to extract from deep neural networks why they come to their results[33]. The best approach to addressing this roadblock is patient education about how artificial intelligence works and the many potential benefits they stand to enjoy.

Second, healthcare providers also need to trust the algorithms before they will use them. In most cases, this means clinical validation[36]. This problem will solve itself in time as the body of supporting research continues to grow and more studies are done. Artificial intelligence in healthcare is only growing in popularity. There will be, in time, a large enough body of proof to satisfy even the most skeptical.

Third, employees worry that automation and artificial intelligence will put their job security at risk. According to a McKinsey study, the adoption of artificial intelligence solutions will result in a shift in required workforce skills, with increased demand for higher cognitive, emotional and social and technological skills[37]. The solution here is for employers to train their workforce in preparation for these changes. Furthermore, the future is not likely to be exclusively artificial intelligence or humans. Rather, it will be a combination of both, where artificial intelligence serves to augment human capabilities. A prototypical example would be the role of the radiologist, whose responsibilities far exceed the reading and interpreting of images that artificial intelligence stands to perform[38].

Fourth and finally is the problem of government regulation. Before artificial intelligence can be widely adopted, government regulations for artificial intelligence in healthcare need to be developed. This has been slow going on the part of the FDA, with their most recent update on clinical decision support released in September[39]. Furthermore, once regulations are developed, artificial intelligence solutions will need to meet those regulations and achieve approval to be used.

CONCLUSION

The promise of artificial intelligence to transform the healthcare industry is profound. The discussion above shows that all facets of healthcare will be impacted by AI. Currently the integration of AI in certain areas of medicine, such as medical imaging, is quite advanced, benefitting greatly from earlier research in computer vision. In many areas, AI is in the early stages of development and implementation. This is changing quickly as the AI landscape is developing at a rapid space. However, there are some roadblocks as identified above. The most important of them is the need to develop trusted AI. This will take time, as people need to get comfortable with algorithms making decisions for them. But as has been shown in the case of driverless cars, people do develop trust over time and as they become familiar with the processes and outcomes involved. The various risks of AI can be managed as our understanding increases. As AI emerges from research labs and experimentation to implementation and spreads into the mainstream and as humans and machines begin to collaborate more closely, the transformational possibilities of AI for transcending the healthcare industry will become enormous.

SIGNIFICANCE STATEMENT

This study provides a comprehensive perspective by analyzing several related subcategories in health care field for how artificial intelligence/machine learning will transform them and increase efficiency and productivity, thus reducing the overall cost of care while improving quality. This paper furthermore identifies some of the roadblocks the adoption of artificial intelligence/machine learning in the healthcare industry will face. This perspective will help high level decision makers, who lack in-depth knowledge of the technology, understand the overwhelming changes happening in the field and possible future course of action. Thus, more educated decisions on the topic of AI in healthcare can be approached.

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