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Abbas Abd Al Ameer Abd Hussian
Hilla University College, Medical Device Engineering, Iraq

Ahmed Saad Hassan Nahaba
Hilla University College, Medical Device Engineering, Iraq

Corresponding Author:
Abbas Abd Al Ameer Abd Hussian
Hilla University College, Medical Device Engineering, Iraq

An analysis of the market prospects for artificial intelligence in medical imaging: Envisioning a future where intelligent technology revolutionizes the field of medical imaging

Abbas Abd Al Ameer Abd Hussian and Ahmed Saad Hassan Nahaba

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Abstract
Presently, radiologists are experiencing a growing burden of labor. We conducted a poll of radiologists in the United States from various practice settings, and the vast majority indicated a significant rise in their workload. Artificial intelligence (AI), encompassing machine learning, can assist in resolving these concerns. Furthermore, it has the capacity to enhance clinical results and further elevate the significance of medical imaging in ways that have not yet been determined. This article presents current research conducted by McKinsey & Company to analyze the expansion of artificial intelligence (AI) in the field of medical imaging. We emphasize the advancements made in the practical use of this technology in medical settings, the financial support it receives, and the obstacles preventing its widespread acceptance. Additionally, we provide insights on the future trajectory of the market. Artificial intelligence (AI) is poised to significantly influence the medical imaging industry and therefore alter the practices of radiologists. It will assist in reducing scan time, enhancing diagnostic accuracy, and alleviating their strain. Given the growing evidence of AI's effectiveness in medical imaging, it is difficult to see a future where AI does not fundamentally change the field of radiology.

Keywords: Artificial intelligence, cloud computing, investments, machine learning, solutions

Introduction
Presently, radiologists are experiencing a growing burden of labor. Among a group of 50 radiologists now working in the United States, 90% said that their workload has experienced a rise in the past 3 years. Additionally, 28% of the respondents reported an increase of over 20% in their workload (Fig. 1). The main factor, identified by 78% of individuals who reported an increased workload, was the growing quantity of scans. According to the scholarly literature, there is a direct correlation between the number of scans done and the demand for radiologists to read them with both speed and precision [1]. Artificial intelligence (AI), encompassing machine learning (ML), can assist in resolving these concerns. Additionally, it possesses the capacity to enhance therapeutic results and further elevate the utility of medical imaging is yet undefined. This article presents current research conducted by McKinsey & Company to analyze the expansion of artificial intelligence (AI) in the field of medical imaging. We emphasize the advancements made in the practical use of this technology in medical settings, the financial support it receives, and the obstacles that hinder its widespread use. In addition, we provide insights on the future trajectory of the market.
This study expands upon our previous evaluation of emerging technologies in medical imaging, which was published in this journal in 2018. In that review, we recognized AI as a significant trend that will have a profound impact on the future of the medical imaging business [2].

The Advancement of AI in Medical Imaging
Significant advancements have been made in the use of artificial intelligence (AI) across several imaging techniques and treatment domains since our previous evaluation. For instance, a recent research shown that artificial intelligence (AI) successfully recognized and differentiated among four distinct dis-The abnormalities observed in chest radiographs include pulmonary malignant neoplasms, such as primary lung malignancies and metastases, as well as active pulmonary TB, pneumonia, and pneumothorax.

This is a significant advancement considering the widespread occurrence of these diseases and the ability of AI to assist radiologists in identifying and prioritizing patients with the most critical conditions.

Or intricate situations. The study also highlighted the efficacy of AI as a secondary reader alongside a radiologist.

By, for instance, improving the identification of the affected area [3].

A different research demonstrated that AI-powered computer-aided design software identified a lower number of false-positive results per picture in digital mammograms compared to FDA-approved computer-aided design software, without compromising on sensitivity [4]. Furthermore, significant advancements have been made in the field of AI, particularly in the domains of brain tumor treatment planning and the detection of catheters and tubes in pediatric x-ray images [5, 6].

Investments in the space industry are seeing significant growth.

The evident promise of the technology is fueling a significant increase in investments in start-ups and generating heightened attention from larger organizations.

Additional start-ups with lower levels of funding McKinsey's Startup and Investment Landscape Assessment scan, as explained in our earlier article, examines worldwide investments in emerging firms that utilize cutting-edge technology applicable to the medical imaging sector [2]. The most recent analysis revealed that investments in firms specializing in AI-based medical imaging reached a total of $1.17 billion from January 2014 to January 2019. That is.

The amount we reported for the 2012 to 2017 period has doubled, and the number of enterprises in the market category has more than tripled, increasing from 32 to 113. It is important to mention that the median investment has decreased from $6.8 million to $4.8 million, and the average number of investments per firm has decreased from 2.9 to 1.9 (E-supplement Fig. 1). Essentially, there is still a significant interest among investors in funding AI-related projects in the field of medical imaging. However, this high demand has led to the emergence of several new start-ups, some of which are smaller in scale and have limited financial resources compared to those established before 2017. This fragmentation, which we shall address later, may partially account for the sluggish rate at which AI is being adopted in the field of medical imaging.

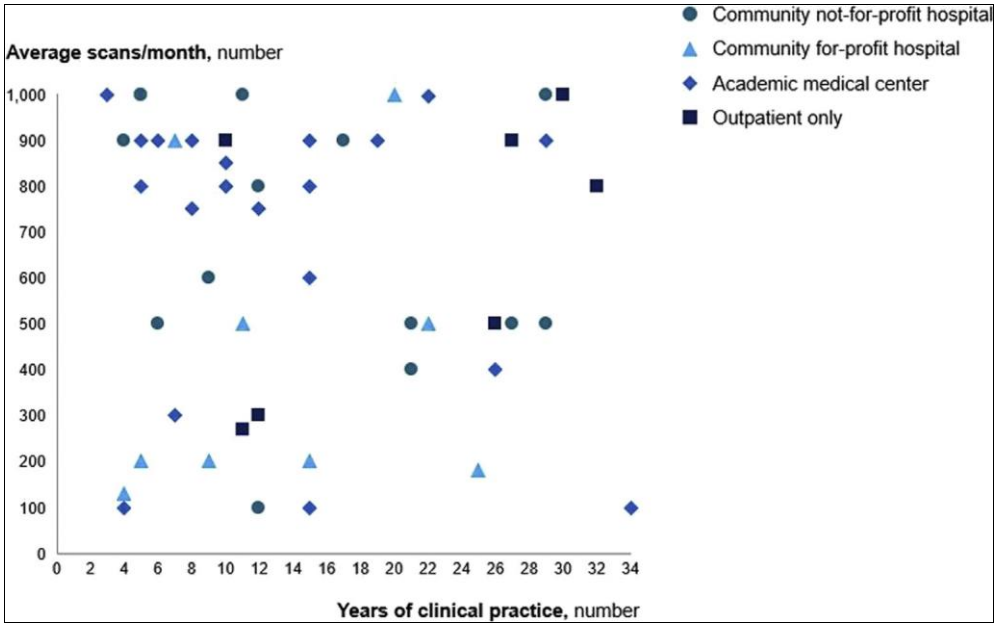

Fig 1: We surveyed 50 radiologists with a range of clinical experience, working in a range of practice settings, with different patient throughputs.

Experienced individuals are joining

Furthermore, prominent diagnostics firms have been actively investing in AI-assisted medical imaging, either by acquiring or partnering with other companies, or by developing their own technological capabilities. In November 2018, Samsung Electronics presented AI devices capable of identifying breast tumors through ultrasound, lung nodules through chest x-rays, and intercranial bleeding using CT scans [7]. The study also shown the potential of AI to enhance the resolution and analysis of MRIs in certain cases, such as knee arthritis. In the same month, Siemens Healthineers unveiled an artificial intelligence (AI) system that identifies and quantifies possible anomalies on a chest CT scan [8]. Simultaneously, GE Healthcare established a collaboration with Intel to utilize artificial intelligence (AI) in several medical imaging formats [9]. In March, Philips purchased Carestream Health's healthcare information.

The systems team has been employing artificial intelligence (AI) to assist in the diagnosis and prioritization of patients with osteoporosis, pulmonary emphysema, coronary calcification, and fatty liver [10].

Several diagnostic firms have expanded into AI-assisted medical imaging after previously investing in cloud infrastructure to acquire storage solutions for large data. This data is crucial for training the algorithms that AI relies on. To clarify, the increase in investments in artificial intelligence (AI) is being driven by the increase in investments in cloud computing. Specifically, there have been over $435 billion invested in cloud-focused medical imaging transactions between January 2014 and March 2019, as reported by our latest Startup and Investment Landscape Analytics (SILA) scan. The majority of

investments in cloud computing are made by well-established corporations in the healthcare industry or by software companies that have not previously invested in healthcare, such as Thermo Fisher, Parexel, or Digital Gateway. However, there are also some start-ups involved in these investments. This amount of investment is sufficient to facilitate the future expansion of artificial intelligence in the field of medical imaging. In the realm of artificial intelligence, the value of cloud-based storage is greatly enhanced. This is because the creation of precise algorithms relies on the ability to store and manipulate extensive datasets, as well as the computational power provided by a cloud platform.

Notably, major IT corporations like Google, Apple, IBM, and Microsoft are shown significant enthusiasm for AI-supported medical imaging. Currently, the majority of people are endorsing the artificial intelligence solutions developed by others. Google has formed partnerships with Zebra Medical Imaging, Change Healthcare, and Kanteron Systems, all of whom are engaged in the utilization of artificial intelligence in the field of medical imaging [11-13]. Google is providing its partners with Google Cloud, which serves as a platform for data storage and machine learning research. Meanwhile, Microsoft has made investments in its artificial intelligence platform for developers in order to enhance medical imaging diagnostics [14, 15]. Additionally, Amazon currently provides an AI-based service that quickly removes identifying information from medical pictures [16]. None of the big IT companies have currently introduced a medical imaging solution. However, their relationships demonstrate a strong desire to get involved in this field.

Radiologists have a reluctance to embrace artificial intelligence, as indicated by our survey findings

Methods

We created a survey consisting of 11 questions that aims to measure the level of knowledge and understanding that radiologists from various subspecialties have regarding artificial intelligence (AI) and machine learning (ML). The survey also seeks to evaluate radiologists' perspectives on the future of AI in medical imaging, explore the potential role of cloud-based solutions in facilitating the adoption of AI among radiologists, and estimate the impact of AI on radiologists' workloads. (or remaining constant). Furthermore, to gain a deeper understanding of our survey participants, we began the survey by asking a set of introductory questions on their medical specialism, the types of imaging techniques they interpret, their main practice environment, the number of years they have been practicing clinically, and the average number of patients they see each month. The whole survey was distributed to a population of American radiologists through SERMO, Inc, a physician networking organization located in New York that specializes in gathering and consolidating physician viewpoints. The poll was conducted using a computer-assisted web interview method, specifically targeting radiologists who have been validated by SERMO. The survey was limited to a maximum of 50 replies, excluding any incomplete responses.

Results

Although there have been notable advancements in utilizing artificial intelligence (AI) for medical imaging and significant financial investments in the associated firms and technology, radiologists have been hesitant to embrace AI in their practice. Only 56% of respondents stated that they currently utilize artificial intelligence (AI) in some capacity. Furthermore, the percentage of individuals who reported exposure to any of the five common use cases of AI ranged from 22% to 38%. These use cases include tagging images to prioritize those for critical patients, optimizing workflow to improve overall productivity, automating a portion of image analysis, providing decision support to clinicians, and enhancing the quality of imaging. Only 10% of the participants considered themselves to be "very familiar" with any of these programs, as seen in Figure 2. What are the current barriers to adoption? The primary obstacle identified was the radiologists themselves. 40% of study participants identified this as the primary obstacle to wider implementation of AI in medical imaging. It appears that their concern stems from the idea that AI may supplant them in their conventional positions. Merely 16% of individuals believed that this scenario would occur.

Nevertheless, some individuals have voiced doubt over the present diagnostic capabilities of artificial intelligence, especially when it comes to dealing with intricate patients or illness conditions. The second most significant obstacle identified was the absence of regulatory permission. The primary obstacle was identified by 32% of the participants.

While radiologists currently perceive the absence of regulatory clearance as a significant obstacle to the use of AI- and ML-based software as a medical device, this situation might be altered if more algorithms receive permission or if the FDA revises its regulatory framework for improvements to such software. On April 2019, the FDA acknowledged the significant impact that AI and ML may have on the software and medical device business. As a result, they produced a discussion paper outlining a potential way to reviewing AI- and ML-based software modifications before they are brought to market [17]. The discussion paper suggests a regulatory strategy called "total product lifecycle" to address the adaptive characteristics of AI and ML algorithms. This method aims to guarantee that modifications are made in accordance with specified change processes, prioritize patient safety, and continually monitor performance. In summary, these suggested modifications will enhance the transparency of the authorization procedure for AI and ML algorithms and expedite the implementation of secure and efficient algorithm upgrades. Since the updates mentioned were presented in a discussion document and were not meant to convey the FDA's definite regulatory expectations, it is important for both AI and ML startups as well as established companies to remain informed about changes in the regulatory framework and offer their input to the FDA when it is suitable.

Despite the existing regulatory framework, there has been a noticeable increase in FDA approvals for artificial intelligence (AI) and machine learning (ML) algorithms. So far, the FDA has granted approval to a minimum of 16 apps that utilize artificial intelligence. In late 2016, River Rain Technologies submitted an application to identify lung nodules in CT images. There was only one.

In 2017, there was an increase in approvals, although the rate of approvals has subsequently experienced a substantial jump. Since 2018, a total of fourteen approvals have been granted (E-supplement Fig. 2) [18, 19].

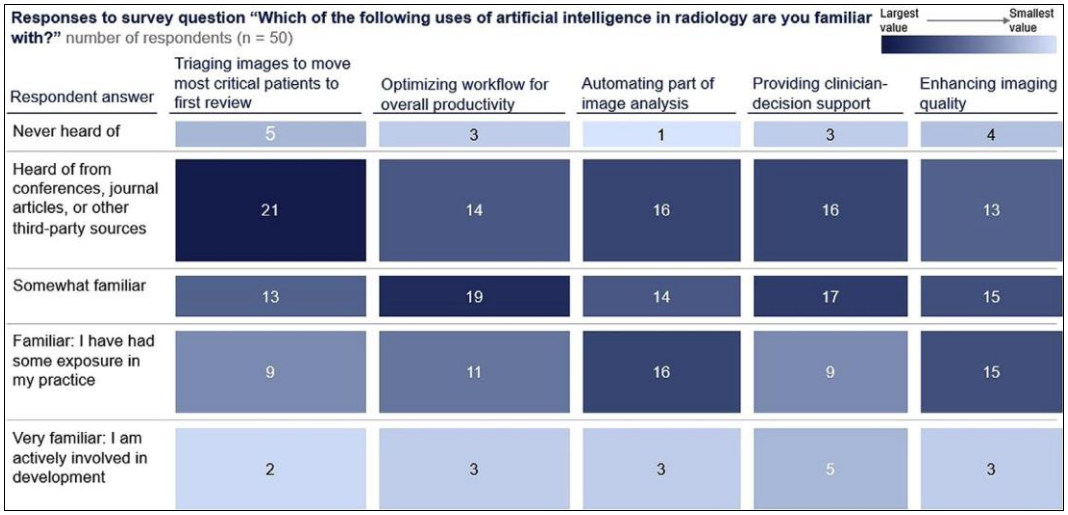

Fig 2: Many radiologists have some level of familiarity with artificial intelligence development, but very few are actively involved in it.

Market development forecast

The insights from our survey replies provide indications on the potential trajectory of the future market for AI in medical imaging. There are three distinct stages of development, or market horizons, which are characterized by advancements in technology and market accessibility (Fig. 3). Additionally, our study provides insights into the specific sorts of apps that are expected to rapidly acquire popularity.

The concept of "Three Horizons"

Currently, several firms provide AI applications for medical imaging in the current market, but none of them do so on a large scale. The fragmentation now hinders the progress of the industry. There is currently no holistic solution available that handles many modalities in different subspecialties and improves efficiency, such as quicker scanning. Moreover, the fragmentation of the market poses challenges for health systems and clinicians in distinguishing and choosing solutions. Physicians' skepticism regarding the potential of AI and the lack of regulatory permission are further obstacles that hinder development. Consequently, while several hospitals and clinics are employing AI in specific limited scenarios, its utilization is not yet prevalent across the board.

In the second horizon, there will be a continued rapid growth in investments in AI-related medical imaging. However, a select few businesses will start to establish themselves as leaders by offering more precise and complete solutions, therefore gaining a significant portion of the market. These entities might include well-established diagnostic firms, major actors in digital technology, prominent healthcare providers, or emerging participants. As firms expand the use of AI to many therapeutic areas, there is a possibility that the FDA may approve more AI devices for medical imaging. As a result, this will enhance the trust and assurance among physicians and other individuals with a vested interest, so facilitating the expansion of market reach.

By the third horizon, the market for AI medical imaging will have reached a state of stability, and the rate of adoption will have seen significant exponential growth. Certain smaller enterprises may have established strategic alliances with larger corporations or have been bought. Others will have failed or been left behind. Instead, well-established companies will provide solutions in many therapeutic fields, either on their own platforms that primarily connect with devices or systems within their own networks, or on open source platforms that connect with all devices and systems.

At this juncture in the market's progression, the FDA's clearance for a growing multitude of algorithms will be crucial.

Facilitated access to reimbursement from health care payers, which is crucial for achieving extensive market access. Currently, there is no reimbursement from CMS or any other payer for AI solutions in medical imaging.

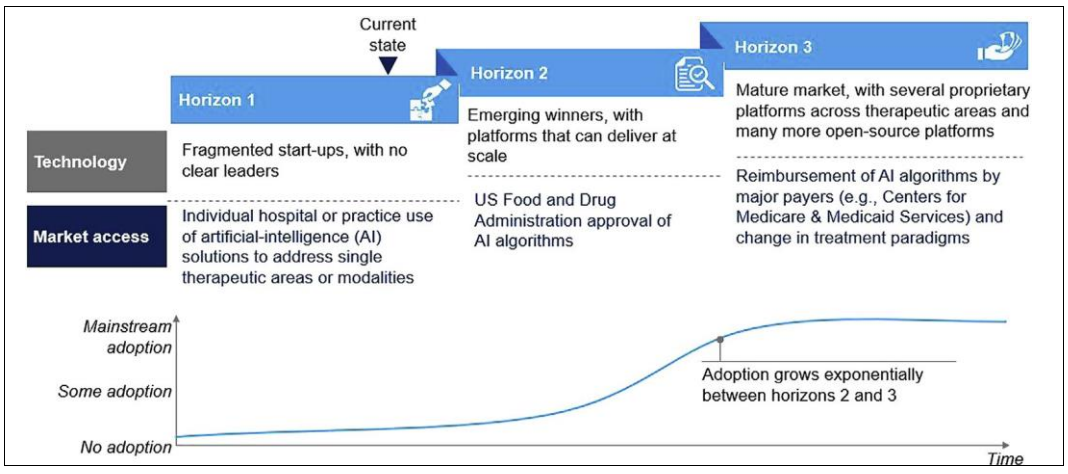

Fig 3: The market for artificial intelligence–based medical imaging can develop in three horizons.

Use Cases for the Frontrunner

We inquired survey respondents about their expectations on the timeframe for particular apps to achieve mainstream status, defined as reaching a minimum of 20% adoption within the field of radiology. The findings are depicted in Figure 4. Respondents believed that the widespread use of AI will mostly occur in the improvement of image quality. 90% anticipated this occurrence within a timeframe of fewer than 5 years. Workflows and clinical decision support would be quickly adopted and implemented.

Regarding imaging modalities, 90% of the survey participants identified CT as the most suitable modality for AI. This is not unexpected, considering the high number of CT scans that are interpreted, the time required for CT data to be uploaded to a PACS, and the substantial quantity of data generated by each scan. Furthermore, the considerable effectiveness of current AI algorithms in analyzing CT scans and the abundance of studies confirming their usefulness, such as the recent approval by the FDA of multiple algorithms for prioritizing intercranial hemorrhages based on CT scan images, indicate that the circumstances are favorable for AI-assisted CT scans to rapidly gain a significant portion of the market. CT was then followed by MRI with an applicability rate of 60%, x-ray with an applicability rate of 56%, and PET with an applicability rate of 50%.

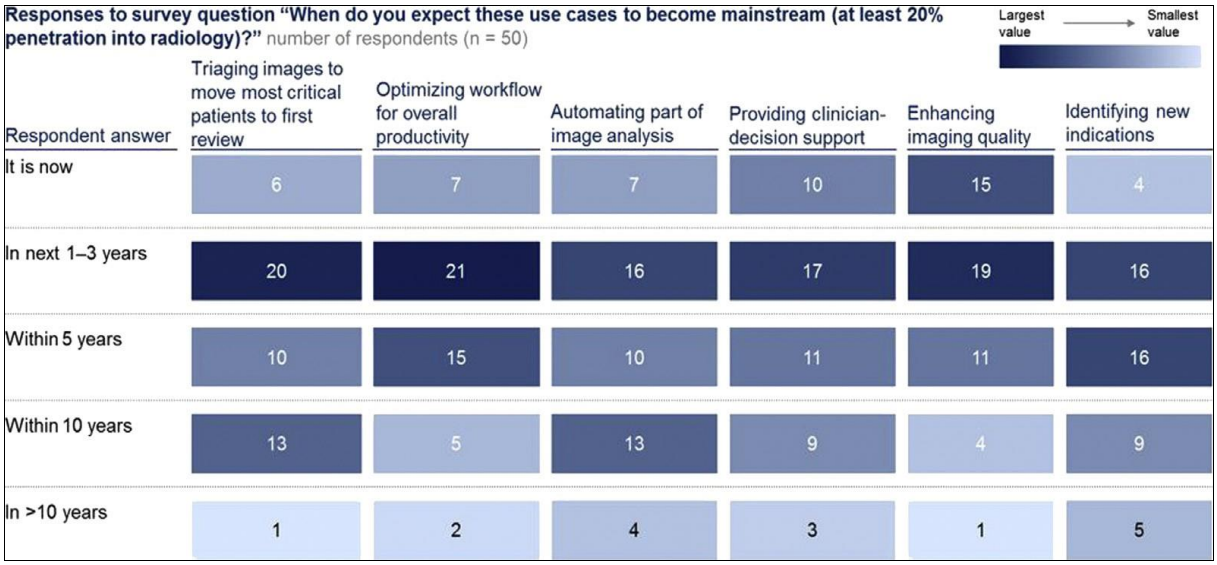

Fig 4: Survey results show that respondents expect image-quality enhancement—followed closely by supporting clinician- decision support, physician-workflow optimization, image triage, and image-analysis automation—to be the artificial intelligence use case making the fastest progress.

Conclusion

Artificial intelligence (AI) is poised to significantly influence the medical imaging industry and therefore, the practices of radiologists. AI may expedite scan time, enhance diagnostic accuracy, and alleviate the strain of radiologists. The final output is expected to yield improved patient outcomes. The speed at which the industry progresses is somewhat determined by the ability to address the mistrust that certain radiologists have towards the capabilities of the technology. AI businesses will need to handle FDA approval and payment from payers as additional obstacles. Nevertheless, considering the growing evidence of AI's effectiveness in medical imaging, it is difficult to see a future where AI does not fundamentally revolutionize the field of radiology.

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