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THE IMPACT OF ARTIFICIAL INTELLIGENCE IN RADIOLOGY: A COMPREHENSIVE REVIEW OF CLINICAL AND EDUCATIONAL PERSPECTIVES

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ABSTRACT

Aim of the study: The aim of this study was to analyze the impact of artificial intelligence (AI) on the development of modern radiology, with a particular focus on technological, clinical, economic and educational aspects [11, 14, 30].

Materials and methods: A review of 30 scientific publications (2017–2026) from PubMed, Scopus, and Google Scholar databases was conducted. The analysis included articles regarding innovations in imaging (CT, MRI) [15, 19], the clinical effectiveness of algorithms [7, 22], and survey-based studies evaluating the attitudes of medical students and healthcare professionals toward AI [3, 16].

Results: The analysis demonstrated that AI significantly improves workflow through the automation of repetitive tasks and supports precision diagnostics in oncology and emergency medicine [2, 13, 17]. A positive impact of AI on the cost-effectiveness of hospitals was also shown [5, 30]. However, barriers were identified, including a lack of adequate education for medical students and professional concerns among future staff, resulting in distancing from radiology as a specialty [9, 26].

Conclusions: Artificial intelligence does not replace radiologists but redefines their role, positioning them as overseers of digital processes [1, 12]. It is essential to update curricula to prepare future physicians for effective and ethical collaboration with algorithms, which will enable the full potential of „augmented intelligence” to be utilized [4, 26].

KEYWORDS

Artificial Intelligence, Diagnostic Imaging, Deep Learning, Medical Education, Workflow Optimization, Augmented Intelligence

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1. Introduction

Radiology, as a field of medicine inextricably linked to technological progress, is currently at a turning point in its history. From the discovery of X-rays, through the introduction of computed tomography (CT) and magnetic resonance imaging (MRI), to the modern era of full digitalization, every technical innovation has redefined how physicians diagnose and monitor disease processes [14, 15]. Today, artificial intelligence (AI), and specifically advanced deep learning algorithms, is becoming the primary driver of transformation in diagnostic imaging, offering capabilities that extend beyond traditional visual analysis [11, 19, 29].

Modern healthcare systems face an unprecedented challenge: a rapid increase in the volume and complexity of imaging studies. Combined with a relatively stable number of specialists, this leads to an escalating workload and a higher risk of errors resulting from staff fatigue [8, 17, 18]. In this context, the integration of AI-based solutions is becoming not merely an optional convenience but a technological necessity, allowing for reduced interpretation times and improved diagnostic quality [10, 24, 29]. AI finds applications not only in image interpretation but also in workflow optimization, radiation dose reduction, and the automation of medical documentation [2, 11].

Despite its dynamic development, the implementation of AI in radiology raises numerous controversies. A commonly cited concern is the fear of physicians being replaced by machines. However, current scientific literature promotes the concept of "augmented intelligence," where AI serves as an advanced supportive tool, while the final clinical decision remains the responsibility of the human physician [12, 13, 27]. At the same time, challenges emerge regarding ethics, algorithmic transparency (the "black box" problem), and shifts in how the specialty is perceived by future medical professionals [4, 9, 16, 26].

The aim of this study is to provide a comprehensive review of the impact of artificial intelligence on radiology. The analysis accounts for technological transformation, measurable clinical and economic benefits, social implications, and the professional perspectives of both radiologists and medical students.

2. Methodology

This study constitutes a comprehensive review of the literature. The research process was designed to synthesize current knowledge regarding the impact of artificial intelligence on radiology across three domains: technological, clinical-economic, and educational.

2.1. Search Strategy and Source Selection

A literature search was conducted in leading medical and scientific databases, including PubMed, Scopus, Google Scholar, and specialized databases related to health economics, such as EconLit [30]. The search encompassed publications released primarily between 2017 and 2026, allowing for the inclusion of the most dynamic period of development in deep learning technologies [11, 19]. The search string included a combination of the following keywords: "artificial intelligence", "deep learning", "radiology workflow", "medical education", "economic value of AI in radiology", "diagnostic accuracy".

2.2. Inclusion Criteria and Materials Analysis

For the final analysis, 30 publications were selected based on the following criteria:

- Original research and review articles focusing on the clinical applications of AI across various modalities (CT, MRI, Ultrasound) [10, 15].
- Survey-based studies evaluating the perception of AI among medical students and healthcare professionals in different global regions (e.g., Spain, Turkey, Saudi Arabia) [3, 4, 9, 16].
- Expert reports and position statements from scientific societies defining standards for AI implementation (e.g., RSNA, ESR) [7, 18, 23].
- Economic analyses assessing the impact of technology on operating costs and the efficiency of healthcare systems [30].

2.3. Data Analysis Method

The selected texts were subjected to a qualitative analysis to identify evidence of improved diagnostic accuracy, reduced workload, and changes in the medical education model. Particular attention was paid to the DATO method (Data, Algorithm, Training, Output) as a standardized tool for evaluating the reliability of AI algorithms [7]. The gathered data served to formulate conclusions regarding the transformation of the radiologist's role from an "image reader" to a leader managing digitally supported diagnostic processes [1].

3. Results and Discussion

3.1. Technological Transformation and Workflow Optimization

Artificial intelligence is redefining the technical aspects of a radiologist's work, influencing the diagnostic process even before the image interpretation stage. Modern trends in radiology focus on improving imaging quality while minimizing the burden on the patient [15]. A key achievement is the use of deep learning (DL) algorithms for image reconstruction, which allows for a significant reduction in radiation dose in computed tomography (CT) and shorter data acquisition times in magnetic resonance imaging (MRI) [14, 15].

The introduction of automation into the workflow eliminates so-called "bottlenecks" in the diagnostic process [2]. AI algorithms demonstrate high effectiveness in non-interpretive tasks, such as automated patient positioning, selection of optimal examination protocols, and preliminary organ segmentation [2, 6, 8]. The implementation of these solutions translates into an increased volume of performed examinations while maintaining high quality standards.

A critical aspect of implementing new technologies is their reliable evaluation. The literature emphasizes the necessity of applying evidence-based medicine to AI (EBRAI – Evidence-Based Radiology AI). A tool for the objective verification of algorithms is the DATO (Data, Algorithm, Training, Output) method [7]. It allows physicians to systematically assess the quality of training data and the stability of the algorithm, which is essential for transitioning from the experimental phase to routine clinical use [7, 23].

3.2. Clinical Benefits and Diagnostic Efficiency

The main advantage of AI in daily practice is increased diagnostic precision, particularly in oncology and emergency medicine. Deep learning algorithms exhibit the ability to detect subtle changes that might be overlooked by the human eye, especially under conditions of high workload [10, 13]. In cancer diagnostics, AI supports radiologists in classifying lesions, assessing their malignancy, and monitoring treatment response, which is crucial for the personalization of patient therapy [13, 21].

In emergency medicine, AI serves as an early warning system (triage). Scientific studies confirm the effectiveness of systems that automatically flag scans with suspected intracranial hemorrhage, pulmonary embolism, or fractures, allowing for the immediate prioritization of these cases [17, 22, 29]. Such an approach directly shortens the time to diagnosis and treatment initiation, which is critical for patient prognosis.

Beyond the clinical aspect, the literature indicates a measurable economic value of AI. Systematic reviews prove that while the cost of implementing AI systems is high, they bring long-term savings by optimizing the use of hospital resources, reducing medical errors, and shortening hospitalization times [5, 30].

3.3. Professional and Educational Perspectives

The introduction of artificial intelligence into radiology evokes mixed feelings among current and future medical professionals, oscillating between enthusiasm and the fear of the marginalization of radiology as the medical profession. Survey-based studies conducted across various cultural and geographical groups allow for a broad overview of these attitudes [9, 16, 24].

Analysis of medical students' opinions in Spain showed that although most respondents possess basic knowledge of AI, their substantive preparation to effectively utilize these tools is rated as inadequate [16]. Significantly, the development of AI clearly influences the choice of radiology as a future career path – some students declare reluctance toward this field due to fears of algorithm dominance over human work [16]. Similar conclusions can be drawn from research conducted at Jazan University in Saudi Arabia, where students emphasized the need to include AI topics in the curriculum to mitigate professional uncertainty [9].

Among medical personnel in Turkey, it was observed that acceptance of AI technology grows with the level of digital competence. It was shown that those more familiar with modern technologies perceive AI as a safe support rather than a threat [3]. An essential element of the discussion is also ethics. Issues regarding liability for a machine-assisted diagnoses and the protection of patient data privacy are being raised, necessitating the development of new legal and ethical frameworks [4, 6].

The literature suggests that the key to a successful transformation is a shift in the educational model. Instead of training radiologists solely in image interpretation, future curricula should emphasize "leadership in the era of AI" [1]. The radiologist should evolve into an expert managing diagnostic systems, capable of critically evaluating algorithm outputs and integrating them into the full clinical picture of the patient [1, 26].

3.4. Ethical and Legal Challenges and Algorithmic Errors

Despite the enthusiasm surrounding clinical results, scientific literature points to several critical barriers that limit full trust in autonomous systems. One of the most frequently raised issues is the "black box phenomenon" – the lack of transparency regarding how complex AI algorithms process data and generate final diagnostic suggestions [4, 12]. The inability to fully trace the system's logical decision-making path raises legitimate concerns regarding the professional liability of the radiologist.

Another significant topic is the risk of "algorithmic bias." Studies indicate that algorithms trained on data from a single population may exhibit lower effectiveness for patients of different ethnicities, ages, or genetic profiles [23, 27]. The literature emphasizes that without ensuring the inclusivity of training data, AI may inadvertently exacerbate disparities in access to high-quality diagnostics.

Discussion in recent studies also focuses on "automation bias." There is a risk that less experienced physicians may uncritically accept incorrect algorithmic suggestions, leading to the erosion of manual and cognitive skills [1, 26]. Therefore, authors such as Langlotz [12] or Brink [23] suggest that future AI systems must be designed in an "explainable" way (Explainable AI – XAI), allowing the radiologist to understand the underlying rationale behind the machine-generated result.

The final pillar of the discussion addresses legal liability: who is liable for a medical error resulting from an AI suggestion? The current consensus points to the radiologist as the ultimate guarantor of safety, which, however, creates a need for new insurance policies and legal frameworks adapted to the digital era [6, 27].

3.5. From Image Interpretation to Radiomics – AI as a Tool for Personalized Medicine

Modern discussion on the role of AI extends beyond simple lesion detection toward so-called radiomics. This is a process involving the extraction of a vast number of objective data points (radiomic features) from medical images that are imperceptible to the human eye [13, 21]. Thanks to AI algorithms, it is possible to link tumor texture or vascularization with a patient's genetic profile (radiogenomics).

The literature indicates that this approach is revolutionizing oncology. AI enables "virtual biopsies" – the assessment of tumor malignancy without the need for invasive procedures [21, 25]. This allows for the precise tailoring of therapy to a specific case, fitting into the trend of personalized medicine. The use of AI in this area changes the perception of medical imaging – from a purely visual tool, it becomes a mine of quantitative data that directly influences the therapeutic decisions of oncologists and surgeons [13, 29].

Conclusions

Based on the conducted literature review and the analysis of 30 selected scientific publications, the following conclusions were formulated:

1. Artificial intelligence currently constitutes the foundation of technological transformation in radiology, enabling not only improved diagnostic precision but also the optimization of patient safety through radiation dose reduction and shorter examination times [14, 15, 30].

2. The application of AI algorithms in the triage process significantly accelerates the diagnostic turnaround time from scan acquisition to diagnosis in emergencies, which is of critical clinical importance in cases such as intracranial hemorrhage or pulmonary embolism [17, 22].

3. Despite high initial costs, the implementation of AI generates measurable economic value for medical facilities by increasing facility throughput and reducing medical errors and their associated secondary costs [5, 30].

4. There is an observed fear among medical students and young physicians regarding the potential marginalization of the radiology specialty, which has an impact on interest in this specialty. The key to changing this attitude is education based on the concept of "augmented intelligence," where AI supports rather than replaces the physician's expertise [9, 12, 16].

5. The future of radiology depends on the evolution of the radiologist's role toward becoming a leader managing AI systems. It is essential to introduce training in data science and algorithmic ethics into medical curricula to prepare medical professionals for collaboration with modern technologies [1, 26].

6. The implementation of AI systems requires rigorous evidence-based validation (Evidence-Based Radiology AI) using standardized assessment tools, such as the DATO method, to minimize the risk of algorithmic errors in routine practice [7, 23].

7. The "black box" phenomenon and the risk of algorithmic bias represent major ethical challenges that warrant the development of Explainable AI (XAI) systems to ensure full transparency of decision-making processes [4, 12, 27].

8. The development of radiomics and radiogenomics transforms imaging from a purely qualitative tool into a rich source of quantitative data, enabling the fulfillment of personalized medicine goals, particularly in precision oncology [13, 21, 25].

9. The ultimate legal and clinical responsibility for diagnosis remains with the physician, necessitating an update of legal frameworks and insurance policies adapted to the human-AI interaction [6, 27].

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