Unraveling the Nexus of Artificial Intelligence and Cancer: A Systematic Review of Challenges and Opportunities

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Introduction

- Amidst the burgeoning landscape of AI applications, its role in oncology stands as **a beacon of hope**, promising to augment clinical decision-making, enhance precision medicine approaches, and ultimately, improve patient outcomes.
- By synthesizing empirical evidence, theoretical frameworks, and expert insights, this review aims to provide a holistic understanding of the current state-of-the-art, facilitating informed discourse and guiding future research endeavors.

Introduction

- AI algorithms exhibit unparalleled capabilities in discerning intricate patterns, extracting meaningful insights, and predicting patient-specific outcomes.
- AI holds immense potential in expediting drug discovery and development pipelines, streamlining preclinical screening, accelerating target identification, and facilitating rational drug design.

Introduction

- However, the realization of AI's transformative potential in oncology is beset by a host of challenges and limitations.

- concerns regarding data privacy, security breaches, and regulatory compliance underscore the imperative for robust governance frameworks to safeguard patient confidentiality and mitigate ethical risks associated with AI deployment in healthcare settings.

Introduction

- the **"black box"** nature of AI algorithms exacerbates interpretability challenges, impeding clinicians' trust and understanding of AI-generated recommendations.

- In conclusion, this systematic review underscores the imperative for a nuanced understanding of the challenges and opportunities inherent in the intersection of AI and cancer.

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Methodology-Literature Search

- In the present research; systematic review, meta-analysis, and PRISMA application were respectively used to report the findings. To this end; the databases of Embase, PubMed, Web of Science, ScienceDirect, Scopus, IEEE, and Google Scholar were searched. The research articles were searched through mesh standardization and use of proper keywords based on different strategies (Table 1).
- **Keywords:** Artificial Intelligence, Cancer, Neoplasm,Challenges, Opportunities

Database	**Search Strategy**
PubMed	*((“Artificial Intelligence”[TITLE-ABSTR-KEY]) AND (“Neoplasm”[TITLE-ABSTR-KEY]))*
Web of Science	*TS= (“Artificial Intelligence”) AND TS= (“Neoplasm”)*
Embase	*'Artificial Intelligence ':ab,ti AND 'Neoplasm:ab,ti*
Scopus	*TITLE-ABS-KEY (Artificial AND Intelligence) AND TITLE-ABS-KEY (Neoplasm)*
IEEE	*(Artificial Intelligence)AND (Neoplasm)*
Science Direct	*TITLE-ABSTR-KEY(Artificial Intelligence) and TITLE-ABSTRKEY(Neoplasm)*
Google Scholar	*“Artificial Intelligence” AND “Neoplasm” anywhere in articles*

Methodology-Literature Search

- The review also included research articles in English with no time limits published from **2000 to February 2024** as well as references and international conferences. In total, **1526** research articles were identified according to the search strategy. In the next step, all the research articles were entered into **EndNote** software and then duplicate ones were removed. As a result, **878** studies remained.

Methodology-Study Selection and Eligible Research Articles

- The research articles were selected via two steps. First, two authors reviewed the studies individually. They also considered the inclusion and exclusion criteria based on the titles and abstracts of the research articles and crossed out the irrelevant ones. Secondly, in order to determine the eligibility of research articles, the full texts of the studies remained from the previous step were independently reviewed by each author. Finally, a precise step was taken according to the criteria to reach an agreement and select the final research articles. In general, **32** studies on challenges and opportunities of artificial intelligence and cancer were selected.

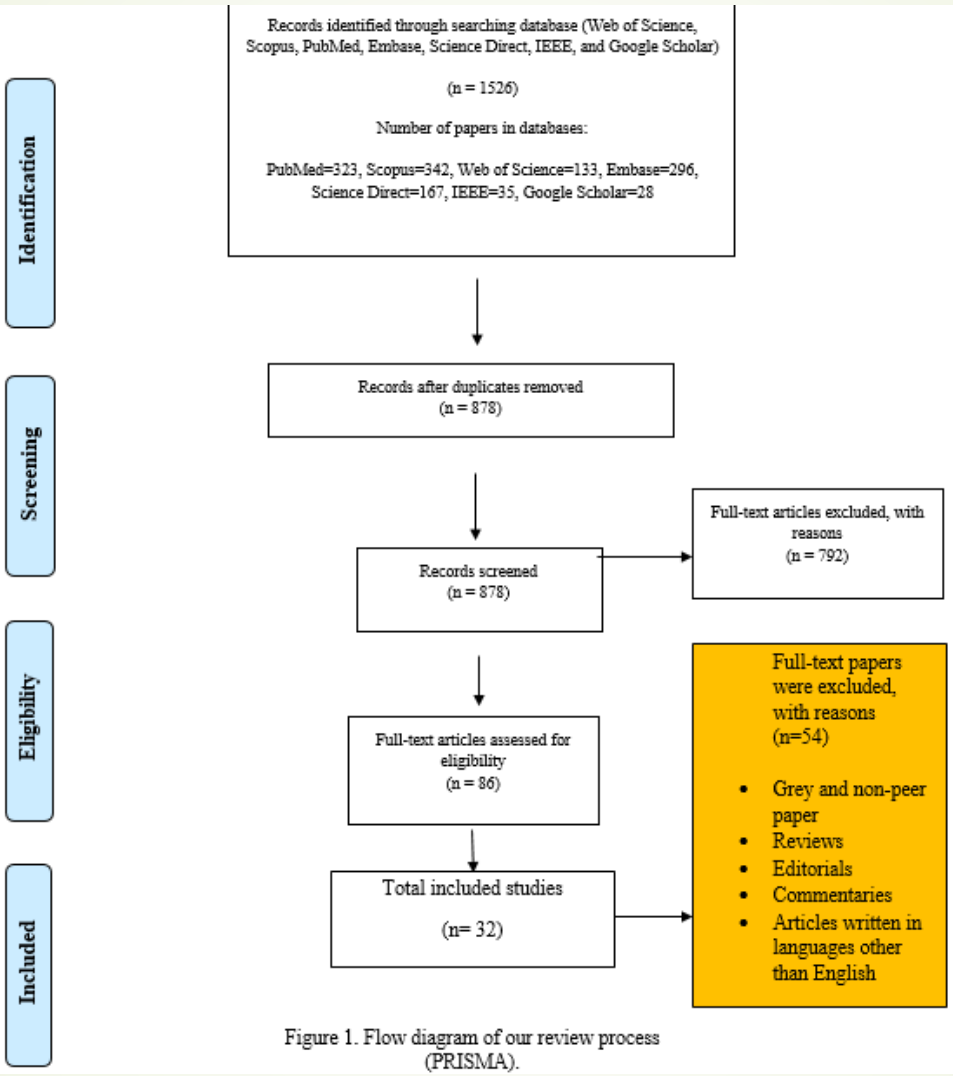

Figure 1. Flow diagram of our review process (PRISMA).

Methodology-Inclusion and Exclusion Criteria

- The inclusion criteria in this study were research articles published in scientific journals in English, international conferences, and full-text original studies on AI as well as opportunities and challenges of these technologies. The exclusion criteria considered in this study were based on the type of studies by which reports, summaries, books, course books, theses and dissertations, surveys, editorials, case records, case studies, prospects, symposiums, posters, short communications, interpretations, invalid published articles, non-English articles, abstract-only articles, articles using AI not related to cancer. In addition, studies whose contents were not associated with the topic of the research or those containing false and ambiguous data or even those not conducted in the domain of healthcare were deleted.

Methodology-Quality of Studies

- In this step, mixed methods appraisal tool **(MMAT)** was used for the assessment of quality of selected research articles which had been also employed in other studies in the domain of healthcare information technology. The MMAT is as a comprehensive tool for assessment of quality of qualitative, quantitative, and combined studies. For each research article, total quality was calculated using the MMAT. Accordingly, the quality of these studies was assessed by two authors independently; moreover, any difference of opinion about the quality of research articles was resolved through discussions by the third author if necessary.

Methodology-Data Extraction

- An initial data extraction form was developed. Therefore, data elements were extracted from each research article and then classified into two groups including general items (author, year of publication, name of country, type of journal, journal title, and objectives) and special items (AI challenges in cancer, AI opportunities in cancer, and AI sub-systems). Moreover, difference of opinion between authors was settled by the third author if needed. In the next step, the results were analyzed in a descriptive manner. The topics were also grouped and they were examined through meta-analysis. These items were illustrated in the findings section of this study. In addition, the research articles were reviewed and discussed by two authors to assure the correctness of item extraction process. In the final step, the selected research articles were summarised and the given items were extracted.

Methodology-Results

- **Cancer Imaging and Opportunities for AI:**
- Imaging has a paramount role in oncology, including early detection of the disease, assessment of changes in tumors with disease progression, monitoring of the disease complications and treatment, analyzing complex datasets, developing personalized therapeutic approaches, and aiding in prognostication, and treatment decision-making.

- In fact, AI and ML have changed conventional practices through understanding the molecular structure of cancer cells and the analysis of multi-omics data including **genomics, proteomics, and transcriptomics**. Using machine learning and deep learning algorithms can also lead to better knowledge of **cancer biology, detection of novel biomarkers, clarification of existing mechanisms**, and development of tailored-based treatment strategies through gaining insights from large-scale genomic data

Methodology-Results

- The evolution of AI in cancer imaging made significant strides in digital decoding of radiographic images into quantitative descriptors of shape, size, and textural patterns which was a great help in enhancing the qualitative expertise of clinicians, through an increased computational power and using accurate quantitative techniques.

- Detection, characterization, and monitoring of tumors highlights another paramount clinical task of AI methodologies which refers mainly to: 1) highlighting suspicious regions in radiographs; 2) providing tumor descriptors in order to depict the intra-tumoral heterogeneity and abnormality in terms of 2D or 3D assessments, 3) classifying abnormalities as malignant or benign tumors, 4) staging the disease course based on the response to treatment strategies, 5) imaging genomics for comprehensive tumor characterization; and 6) monitoring of tumor changes over time.

Methodology-Results

- Through analyzing large volumes of patient data, AI is able to extract relevant information and detect genetic abnormalities, particular biomarkers, and molecular signs associated with tumor features to predict individual treatment responses.

Methodology-Results

- **Cancer Imaging and challenges for AI:**
- Accordingly, the ethical concerns of AI including data security and privacy, can be tackled properly. Furthermore, there is a necessity for an effective collaboration between clinicians, researchers, and AI technicians to develop reliable AI models relying on high-quality data and ensure data interoperability and compatibility between diverse datasets.
- Lack of sufficient data decreases the efficacy of the system, leading to data inaccuracy. AI algorithms are also susceptible to some sorts of biases in terms of validation that might lead to poorly developed algorithms with improper generalization.

Methodology-Results

- There are also some technical and infrastructural issues such as inappropriate data storage, and data cleaning mechanisms which not only threaten the ethical aspects of data but also endanger the use of big data in medical field. To tackle the issue, it is necessary to improve big data management with an emphasis on real-time data collection, analysis, and visualization of the results.

Discussion:

- AI has become a widely used tool referring to different methods such as Machine Learning and Deep Learning that helps cancer diagnosis in many aspects including lesion segmentation, detection, and characterization as well as digital pathology, radiology, and genomics.

- An efficient analysis of large-scale genomic data, assist researchers to interpret the cancer genome landscapes and uncover genetic variations through effective collaboration with AI specialists and geneticists, to confirm truthful perceptions that result in practical outcomes. Furthermore, the capability of real-time data-analysis in AI models helps healthcare professionals reach out evidence-based decision-making concerning treatment procedures, medication plans, and the revision of therapeutic interventions as necessary.

Discussion:

- With a developing trend towards the use of electronic patient records in many healthcare settings, a considerable number of research and commercial groups have struggled to apply deep learning in the analysis of digitised text-based health records and develop algorithms that predict the development of different cancers from reviewing a large scale of data.

- AI can clearly help hospitals train junior doctors in clinical decision-making, diagnostic and therapeutic approaches .

- In terms of economic benefits, using AI technology has proved to reduce laboratory expenses, improve operational efficiencies, increase productivity and lead to better treatment decisions .